

Identifying Levers to unlock Clean Industry

Summary Report



WIFO

ÖSTERREICHISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG AUSTRIAN INSTITUTE OF ECONOMIC RESEARCH



The information and views set out in this study are those of the authors and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

ET-04-16-650-EN-N DOI: 10.2873/03460 ISBN: 978-92-79-60890-2

© European Union, July 2016.

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs Unit 01 — Economic Analysis Contact: Beatriz Velazquez E-mail: Beatriz.Velazquez@ec.europa.eu

Reproduction is authorised provided the source is acknowledged.





ÖSTERREICHISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG AUSTRIAN INSTITUTE OF ECONOMIC RESEARCH





Identifying Levers to unlock Clean Industry

Summary Report

Prepared for:

European Commission DG for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW)

Brussels, June 2016

Authors of the report (*) and other team members:

Dr. Valentijn Bilsen* (IDEA Consult) Pieterjan Debergh* (IDEA Consult) Sebastiaan Greeven* (IDEA Consult) Dr. Birgit Gehrke* (NIW) Katrin John* (NIW) Annika Lemmel* (NIW) Fabian Unterlass (WIFO) IDEA Consult NV/SA Avenue des Arts 1-2, box 16 B - 1210 Brussels T: +32 2 282 17 10 F: +32 2 282 17 15 info@ideaconsult.be

www.ideaconsult.be

The information and views set out in this Summary Report are those of the authors and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

ABSTRACT

This study aims to identify the levers to unlock the EU Clean Industry sector. The study will feed into the European Commission's Energy Union Research, Innovation and Competitiveness Strategy (EURICS). Clean Industries are defined as specific sectors or segments within the economy that are directly responsible for supplying technologies, products and services that have measurable environmental benefits in terms of their abilities to reduce GHG emissions and to improve both energy and resource efficiency. A workable taxonomy of the Clean Industry sector has been elaborated, containing 44 sub-sectors, of which 12 were selected as priority sectors for policy actions to unlock growth and jobs potential in these industries. In addition to completing detailed analyses for each of the 12 priority sectors on their relative competitive position, export potential, barriers and levers, the interrelations between these sectors were assessed and an intra-Clean Industry value chain was identified which allowed for the prioritisation of policy actions along a roadmap, creating leverage effects both upstream and downstream the Clean Industry value chain.

The study recommends unlocking the EU Clean Industries by simultaneously focussing on the standards in the measuring and monitoring industry and in the Advanced Manufacturing Technologies (AMT) sector, as well as optimising the regulatory framework conditions for smart grids, wind energy and thermal energy and, finally, overcoming barriers with respect to capital and financing constraints in the downstream Clean Industry sectors - Energy Efficient Homes and Buildings, and Cleaner Transport Solutions. The latter helps create a home market for the other Clean Industry sectors that are positioned further upstream in the value chain, such as measuring and monitoring, AMT, wind energy and smart grids. Yet for these it is essential that the hurdles blocking further growth and job creation are solved simultaneously as this would provide a mutually reinforcing leverage effect.

RÉSUMÉ

Cette étude a pour but d'identifier les leviers susceptibles d'assurer le déploiement du secteur de la Clean Industry en Europe. Cette étude entend nourrir la nouvelle stratégie énergétique intégrée de l'Union, élaborée par la Commission européenne, en matière de recherche, d'innovation et de compétitivité. Les Clean Industries se définissent comme des secteurs ou segments spécifiques de l'économie qui sont directement chargés de fournir des technologies, des produits et des services offrant des avantages environnementaux mesurables en termes de réduction des émissions de GES ainsi qu'en termes d'amélioration de l'efficacité énergétique et de l'utilisation rationnelle des ressources. Une classification exploitable du secteur de la Clean Industry a été élaborée. Celle-ci comprend 44 sous-secteurs, dont 12 ont été sélectionnés comme prioritaires dans le cadre des mesures stratégiques à mettre en œuvre pour libérer le potentiel de ces industries, tant en termes de croissance que d'emplois. En complément des analyses détaillées de chacun de ces 12 secteurs prioritaires et qui ont trait à leur position concurrentielle relative, leur potentiel d'exportations ainsi que leurs barrières et leviers, les interrelations entre ces secteurs ont également été évaluées et une chaîne de valeur propre à la Clean Industry a été identifiée. Cela permet une priorisation des potentielles mesures stratégiques sur base d'une feuille de route permettant de générer des effets de levier tant en amont qu'en aval de la chaîne de valeur de la Clean Industry.

L'étude recommande de libérer le potentiel des Clean Industries en Europe en se concentrant simultanément sur les normes dans l'industrie de la mesure et du contrôle ainsi que dans les industries TFP, sur l'optimisation des conditions du cadre réglementaire applicable aux réseaux énergétiques intelligents, à l'éolien et au thermique, ainsi que sur les obstacles relatifs aux contraintes capitalistiques et de financement qui grèvent les secteurs aval de la Clean Industry, à savoir les logements et bâtiments énergétiquement efficaces ainsi que les solutions de transport plus propres. Cela contribuera à créer un marché domestique pour les autres secteurs de la Clean Industry qui sont positionnés plus en amont dans la chaîne de valeur, tels que, par exemple, les secteurs de la mesure et du contrôle, des TFP, de l'éolien et des réseaux énergétiques intelligents. Cependant, pour ce faire, il est essentiel que les obstacles qui entravent la croissance future et la création d'emplois soient résolus simultanément afin de générer des effets de levier qui se renforceraient mutuellement.

EXECUTIVE SUMMARY

This study on "Identifying Levers to Unlock Clean Industry" aims to feed into the European Energy Union Research, Innovation and Competitiveness Strategy (EURICS). In order to reach the overarching goal of creating growth and jobs, the competitiveness of the EU28's manufacturing industry needs to be improved. This is, in part, possible via a stronger diversification of traditional industries in the production of clean solutions (partly due to their own high energy demand), thereby increasing growth and export potential. Moreover, these clean solutions can proliferate into other industries and thus generate efficiency gains and competitive advantages for the users of these technologies.

Thus, the central aim of this study is to identify the levers to unlock the untapped growth potential of the EU Clean Industry. In order to reach this goal, intermediate study objectives which had to be fulfilled included:

- 1) defining the scope of the Clean Industry;
- 2) identifying 12 priority sectors or activities within the Clean Industry that should be the focus of policy actions aiming to foster Clean Industry in the EU;
- assessing for each of these priority sectors the opportunities, threats, strengths, weaknesses and risks as well as the export potential; and
- 4) identifying the barriers that hinder the further development of the EU Clean Industry and formulate suggestions for policy actions to unlock EU Clean Industry's growth potential.

Notably, the definition of "Clean Industries" within the context of this study refers to specific sectors or segments within the economy that are directly responsible for supplying technologies, products and services that have measurable environmental benefits in terms of their abilities to reduce GHG emissions and to improve both energy and resource efficiency. In view of a compilation of a workable taxonomy, we considered and synthesized the existing taxonomies to gain a comprehensive definition of Clean Industries that is suitably segmented to be able to select the priority sectors. The proposed taxonomy comprises six main categories, namely: Clean Energy (production, storage and distribution), Energy-Efficient Buildings & Appliances, Clean Mobility, Clean Production and Environmental Protection and Measuring and Monitoring. Each of the six main categories was further subdivided into segments and sub-segments, totalling 44 Clean Industry segments.

In order to identify the 12 Clean Industry priority sectors for which focused policy actions should be determined, a systematic literature review and, where possible, self-conducted trade analysis were completed for all 44 subsectors of the taxonomy. In order to rank these sectors the following four selection criteria were used:

- clean potential, in terms of low carbon, energy and resource efficiency potential
- absolute growth potential, reflecting the economic relevance in terms of value added, number of jobs, and growth potential
- technology leadership, reflecting EU technology and innovation leadership and relative technological advantage
- comparative advantage

Using a systematic and iterative selection process including sensitivity analyses and robustness checks, a final selection was made in cooperation with the Commission, which allowed for the inclusion of policy priorities as well as a few sector specific considerations. The following figure gives an overview of the Clean Industry taxonomy and indicates the 12 priority sectors. The numbers indicated refer to the rank resulting from the selection procedure.



Source: IDEA Consult and NIW

Each of the 12 priority sectors was analysed in further detail. This process involved literature reviews, data analyses and in-depth interviews with business organisations, experts and policy makers. We explored the interrelations between the 12 selected Clean Industry sectors in terms of barriers and levers. Given that these sectors can be considered as the most promising ones in the Clean Industry, the resulting barriers and levers can be viewed as important elements for designing policies that promote Clean Industry in the EU.

The most prominent barriers across the examined sectors relate to investment financing and the regulatory framework. These often occur in conjunction with one another, where an inadequate regulatory framework diminishes the potential for value creation and therefore reduces the attractiveness for capital. This is the case for the sectors on smart grids, wind energy, thermal energy storage, district heating and cooling and thermal insulation. Indeed, all sectors that target housing suffer from the well-known owner-tenant dilemma. It is frequently unclear how the costs and benefits of a refurbishment project shall be shared between the owner and the tenants paying the energy bill. Moreover, apart from the financing of the purchase and use of clean solutions, companies in Clean Industries also face internal financial challenges. It should be noted that in the sector providing technologies for the realisation of efficiency gains in vehicle powertrains and in the rail sector the low

operating margins in combination with high product development cost (including compliance with various regulations) are a threat for maintaining the technological lead of the EU. In the case of the wind energy sector, the uncertainty about the stability and predictability of government support schemes weakens the investment climate. Sudden, and occasionally retroactive, changes in legislation (i.e. Romania, Spain) make it difficult for investors and developers to plan investments. Particularly the offshore segment, which requires especially high capital expenditures, considers reliable, continuous expansion more important in the long term than any one-off regulatory initiatives. For smart grids, Member States' existing regulatory frameworks for the energy market are not fully adapted to boost potential business opportunities and therefore generate a sense of uncertainty for incumbent and new investors alike.

Other identified common barriers relate to standardisation – especially on interoperability – differences in the regulatory frameworks across Member States and deficits in technology, R&D and innovation. For example, in underground thermal energy storage, technologies are fairly well developed, however their optimal integration in the energy system (heat, electricity grid) is far from straightforward. Also, in the case of smart grids several challenges relate to the coordination of the new roles of various actors in electricity production and consumption, requiring novel business models to support these developments. The interoperability of traffic control systems and the continuity of ITS-related traffic-management and freight-management services across borders is extremely difficult and complex. Sector specific regulation barriers reflect the incapability of regulations to adapt to the new possibilities and requirements that are associated with the growth of clean industries. For example, in the area of district heating, existing regulations still tend to favour on-site solutions rather than collective solutions. Regulation also impedes the use of geothermal district heating as the licenses for deployment of discovered resources is not given in all Member States. Also, (underground) thermal storage legislation is not adapted to the new possibilities in all cases, e.g. in some Member States it is forbidden to inject hot water into the ground.

In order to explore the cross-sectoral interdependencies we have ranked, for each of the priority sectors, to what extent it requires the other sectors as an input for its production. From a value chain perspective, a need is defined as upstream inputs that are necessary for production. The thin lines in the figure below represent weak cross-sectoral interdependencies and the thick lines represent strong ones. The size of the circles corresponds to the driving power of the sectors, which indicates the extent to which other sectors are dependent on that sector.



Based on a careful interpretation of the cross-sectoral interdependencies it is possible to identify intra-sectoral leverage effects. The leverage effects work in two ways: (i) a sector that is dependent on many other sectors could initiate a rise in demand for products and services from other Clean Industries that serve as suppliers for the dependent sector, or (ii) stimulating a sector that is an important input for a large number of activities can be seen as a driving sector and thus facilitate the development of these other Clean Industries. From this analysis it is clear that within the 12 selected sectors in EU Clean Industry, the measuring and monitoring sector and the advanced manufacturing technology sectors can be considered as driving or enabling sectors, while the NZEB, district heating and cooling, heating and cooling systems, vehicle power trains, traffic control systems and rail can be considered as pulling sectors of the EU Clean Industry that are more situated on the downstream side of the intra-Clean Industry value chain. Thus, taking the analysis a step further, the four main clusters of Clean Industry sectors were identified as:

- Enabling Sectors
- Electric Power and Grid
- Energy Efficient Homes and Buildings
- Cleaner Transport Solutions

The underlying intra-Clean Industry value chain, as they are grouped, is displayed in a visualisation below:



Aligning policies along the intra-Clean Industry value chain helps develop a roadmap for unlocking the EU Clean Industry. Policies targeted at the Enabling Sectors can be perceived as supply-side policies for the Clean Industry as a whole, even if particular measures for the sectors have a demand-side nature. Similarly, policies targeted at the Energy Efficient Homes and Buildings and Clean Transport Solutions clusters can be perceived as demand stimulating policies for the Clean Industry sector as a whole.

Given the cross-sectoral and cross-country interlinkages that were found, an integrated policy approach for the EU Clean Industry is preferred, providing leverage to both the supply-side and the demand-side of the Clean Industries. In other words, an integrated policy would both foster market creation for Clean Industries by providing leverage for the Energy Efficient Homes and Buildings and for Clean Transport Solutions, and simultaneously help to overcome the supply-side related barriers in the Enabling Sectors. In terms of a policy

roadmap, this implies that sequencing and prioritising policies is not necessarily related to the position of the sector upstream or downstream of the intra-Clean Industry value chain but rather requires a cross-sectoral approach, focussing on the most important barriers and levers for each of the sectors.

In order to unlock the EU Clean Industries the way forward would therefore begin by simultaneously focussing on: (i) improving the standards in the measuring and monitoring and AMT industries, (ii) by optimising the regulatory framework conditions for smart grids, wind energy and thermal energy and (iii) overcoming the barriers with respect to capital and financing constraints in the downstream Clean Industry sectors of the Energy Efficient Homes and Buildings and Cleaner Transport Solutions. Focussing on overcoming the capital and finance problems in the downstream intra-Clean Industry sectors helps create a home market for the other Clean Industry sectors that have a more upstream position in the value chain. For the latter it is essential that the hurdles that block further growth and jobs are solved simultaneously as this would provide a mutually reinforcing leverage effect.

RÉSUMÉ EXÉCUTIF

Cette étude intitulée « Identification des leviers susceptibles de libérer la Clean Industry » a pour but de nourrir la nouvelle stratégie énergétique intégrée de l'Union, élaborée par la Commission européenne, en matière de recherche, d'innovation et de compétitivité. Pour parvenir à l'objectif primordial que constitue la création de croissance et d'emplois, la compétitivité de l'industrie manufacturière de l'UE28 doit être améliorée. C'est notamment possible sur base d'une intensification, au sein des industries traditionnelles, de la production de solutions propres (étant donné, entre autres, leur demande énergétique élevée), ce qui en renforcera le potentiel de croissance et d'exportation. En outre, ces solutions propres peuvent se propager à d'autres industries et générer ainsi des gains d'efficacité et des avantages concurrentiels pour les utilisateurs de ces technologies.

En conséquence, l'objectif central de cette étude est d'identifier les leviers en mesure de libérer le potentiel de croissance inexploité de la Clean Industry au sein de l'UE. Pour atteindre ce but, certains objectifs d'étude intermédiaires devaient être atteints, en l'occurrence :

- 1) définir la portée de la Clean Industry ;
- 2) identifier, dans la Clean Industry, 12 secteurs ou activités prioritaires sur lesquels se concentreraient les mesures stratégiques visant à encourager le développement de la Clean Industry au sein de l'UE ;
- 3) pour chacun de ces secteurs prioritaires, identifier les opportunités, les menaces, les forces, les faiblesses et les risques, de même que le potentiel d'exportation ; et
- 4) identifier les obstacles entravant la poursuite du développement de la Clean Industry au sein de l'UE et formuler des propositions de mesures stratégiques pour libérer le potentiel de croissance de cette Clean Industry.

Dans le cadre de la présente étude, la définition des « Clean Industries » se réfère notamment à certains secteurs ou segments spécifiques de l'économie qui sont directement chargés de fournir des technologies, des produits et des services offrant des avantages environnementaux mesurables en termes de réduction des émissions de GES ainsi qu'en termes d'amélioration de l'efficacité énergétique et de l'utilisation rationnelle des ressources. Afin de pouvoir établir une classification exploitable, nous avons pris en considération et synthétisé les classifications existantes pour obtenir une définition détaillée des Clean Industries qui soit correctement segmentée pour permettre la sélection des secteurs prioritaires. La classification proposée comporte six catégories principales, en l'occurrence les énergies propres (production, stockage et distribution), les bâtiments et appareils économes en énergie, la mobilité propre, la production propre et la protection de l'environnement, et enfin la mesure et le contrôle. Chacune de ces six catégories principales a ensuite été subdivisée en segments et sous-segments de la Clean Industry, répertoriés au nombre de 44.

En vue d'identifier les 12 secteurs prioritaires de la Clean Industry sur lesquels doivent se concentrer les mesures stratégiques, nous avons procédé à un examen systématique de la littérature et, chaque fois que cela s'avérait possible, à notre propre analyse économique des 44 sous-secteurs composant la classification de base. Cela a permis d'ordonner la classification de base en fonction de quatre critères de sélection :

- le potentiel de propreté, exprimé en termes de potentiel d'émissions carbone faibles, d'efficacité énergétique et d'utilisation rationnelle des ressources ;
- le potentiel de croissance absolu, reflétant la pertinence économique en termes de potentiel de valeur ajoutée, de nombre d'emplois et de croissance ;
- le leadership technologique, reflétant le leadership en matière de technologie et d'innovation au sein de l'UE ainsi que l'avantage technologique relatif ; et
- les avantages comparés.

Après avoir eu recours à un processus de sélection systématique et itératif reposant sur des calculs de sensibilité et des contrôles de robustesse, nous avons procédé à un choix final en collaboration avec la Commission, en tenant compte des priorités politiques ainsi que de quelques considérations sectorielles spécifiques. La figure cidessous illustre synthétiquement la classification de la Clean Industry et identifie les 12 secteurs prioritaires. Les numéros renvoient au rang découlant de la procédure de sélection.



Source : IDEA Consult et NIW

Une analyse détaillée de chacun des 12 secteurs prioritaires a été menée. Cette analyse s'est basée sur une revue de la littérature, sur une analyse de données ainsi que sur des entretiens approfondis avec des organisations représentatives des différents secteurs, des entreprises, des experts et des décideurs politiques. Les interrelations entre les 12 secteurs prioritaires ont été analysées en termes de leviers et barrières. Étant donné que ces secteurs s'avèrent être les secteurs les plus prometteurs au sein de la Clean Industry, les barrières et leviers identifiés, pour ces secteurs, peuvent être vus comme des éléments importants à prendre en compte dans la conception de politiques visant à prévoir la Clean Industry en Europe.

Les principaux obstacles grevant ces secteurs prioritaires portent sur la capitalisation et le financement, d'une part, ainsi que sur le cadre réglementaire, d'autre part. Les deux aspects vont souvent de pair au sens où un cadre réglementaire inadapté restreint le potentiel de création de valeur, ce qui réduit alors l'accès au capital. C'est le cas dans le secteur des réseaux énergétiques intelligents, de l'éolien, du stockage d'énergie thermique, des réseaux urbains de chauffage et de climatisation et de l'isolation thermique. Les secteurs liés à la location de logements souffrent du dilemme propriétaire-locataire. En effet, un manque de clarté est fréquemment noté en ce qui concerne les règles de partage des coûts et des bénéfices d'un projet de rénovation entre le propriétaire et les locataires payant la facture énergétique. De surcroit, en plus du financement de l'achat et de l'utilisation de solutions propres, les entreprises dans les Clean Industries font face à des contraintes financières internes. Il faut noter que dans le secteur fournissant les technologies permettant la réalisation de gains énergétiques pour les véhicules motopropulseurs ainsi que dans le secteur ferroviaire, les faibles marges d'exploitation combinées avec un coût élevé de développement de produit (en ce compris le coût de conformité avec les différentes règlementations) forment une menace pour le maintien de l'avance technologique de l'EU. Dans le cas du secteur de l'éolien, l'incertitude qui plane sur la stabilité et la prédictibilité des mécanismes de supports gouvernementaux affaiblit le climat d'investissement. Des changements soudains et, occasionnellement, rétroactifs dans la législation (par exemple en Roumanie ou en Espagne) rendent difficile la planification des investissements pour les investisseurs et développeurs. Cela est particulièrement le cas dans le segment 'offshore', qui nécessite des dépenses en capital particulièrement élevées et pour lequel les expansions continues et fiables sont considérées comme étant plus importantes dans le long-terme que les initiatives ponctuelles. En ce qui concerne les réseaux énergétiques intelligents, les cadres réglementaires existants dans les Etats Membres ne sont pas complètement adaptés au soutien et au développement de nouvelles opportunités et entrainent donc un sentiment d'incertitude pour les entités en place ainsi que pour les nouveaux investisseurs.

D'autres obstacles importants se rapportent à la standardisation – en particulier pour ce qui a trait à l'interopérabilité et au fonctionnement du marché -, aux différences qui existent entre les cadres réglementaires des divers États membres et aux défis représentés par la technologie, la R&D et l'innovation. Par exemple, en ce qui concerne le stockage souterrain de l'énergie thermale, bien que les technologies soient relativement bien développées, leur intégration optimale dans le système énergétique (chauffage, réseau électrique) est loin d'être évidente. Aussi, en ce qui concerne les réseaux énergétiques intelligents, plusieurs défis ont trait à la coordination des nouveaux rôles joués par les différents acteurs actifs dans la production et consommation d'électricité et requièrent de nouveaux plans d'affaires qui supportent ces développements. L'interopérabilité des systèmes de contrôle du trafic et la continuité des services de gestion du trafic et du fret, liés au STI, sont extrêmement difficiles et complexes. Des barrières réglementaires propres au secteur reflètent l'incapacité de la règlementation à s'adapter aux nouvelles possibilités et exigences associées avec la croissance des Clean Industries. Par exemple, au niveau du chauffage urbain, les règlementations existantes tendent à favoriser des solutions 'sursite' plutôt que des solutions collectives. La réglementation entrave l'utilisation de chauffage urbain géothermique étant donné que les licences pour le déploiement des ressources découvertes ne sont pas octroyées dans l'ensemble des États Membres. Par ailleurs, la législation relative au stockage thermique (souterrain) n'est pas adaptée à certaines nouvelles possibilités. Par exemple, il est interdit, dans certains États Membres, d'injecter de l'eau chaude dans le sol.

Pour pouvoir explorer les interdépendances transsectorielles, nous avons classé chaque secteur en fonction de l'ampleur de ses besoins vis à vis d'autres secteurs, en termes d'intrants pour sa production. Dans l'optique de la chaîne de valeur, un besoin se définit en termes d'intrants en amont. Sur la figure ci-dessous, les lignes fines représentent les interdépendances transsectorielles faibles tandis que les lignes épaisses illustrent les interdépendances fortes. La taille des cercles représente la puissance d'entraînement des secteurs et indique la mesure dans laquelle d'autres secteurs dépendent de ce secteur en question.



Sur base d'une interprétation soigneuse des interdépendances transsectorielles, il est possible d'identifier certains effets de levier intrasectoriels. Les effets de levier agissent de deux manières. D'une part, un secteur dépendant de nombreux autres secteurs peut initier une hausse de la demande de produits et de services provenant d'autres Clean Industries, lesquelles font alors office de fournisseurs pour le secteur qui en dépend. D'autre part, la stimulation d'un secteur affichant une puissance d'entraînement importante peut générer un effet de levier pour améliorer d'autres Clean Industries. Sur la base de cette analyse, il est clair qu'au sein de la Clean Industry de l'UE, en tout cas en ce qui concerne les 12 secteurs prioritaires, le secteur portant sur la mesure et le contrôle ainsi que ceux en lien avec les technologies de fabrication de pointe peuvent être considérés comme des secteurs moteurs, tandis que les bâtiments à consommation d'énergie quasi-nulle, les réseaux urbains de chauffage et climatisation, les systèmes de chauffage et refroidissement, les chaînes de propulsion des véhicules, les systèmes de contrôle du trafic et le rail peuvent être considérés comme des secteurs tirant la Clean Industry européenne vers le haut tout en étant davantage situés en aval de la chaîne de valeur intra-Clean Industry. En approfondissant l'analyse, nous avons pu identifier quatre agrégats principaux de secteurs relevant de la Clean Industry :

- Les secteurs habilitants
- L'énergie électrique et les réseaux
- Les logements et bâtiments économes en énergie
- Les solutions de transport plus propres

Sous forme schématique, on peut illustrer comme suit la chaîne de valeur sous-jacente propre à la Clean Industry:



L'alignement des politiques au fil de la chaîne de valeur propre à la Clean Industry est propice à l'élaboration d'une feuille de route qui permettrait d'assurer le déploiement du secteur européen de la Clean Industry. Les politiques ciblées sur les secteurs habilitants peuvent être perçues comme des politiques de soutien à l'offre pour l'ensemble de la Clean Industry, même si certaines mesures particulières orientées vers les secteurs revêtent un caractère plus proche de la demande. De même, les politiques axées sur les agrégats « Logements et bâtiments économes en énergie » et « Solutions de transport plus propres » peuvent être perçues comme des politiques de stimulation de la demande pour la Clean Industry prise dans sa globalité.

Étant donné les interrelations transsectorielles et transnationales qui ont été mises en évidence, il y a lieu de privilégier une approche politique intégrée de la Clean Industry européenne, en veillant à produire un effet de levier tant au niveau de l'offre des Clean Industries qu'à celui de la demande. En d'autres termes, une politique intégrée stimulerait à la fois la mise en place d'un marché pour les Clean Industries en générant un effet de levier pour les agrégats « Logements et bâtiments économes en énergie » et « Solutions de transport propres » tout en aidant à surmonter les obstacles existants au niveau de l'offre des secteurs habilitants. Cela implique que le séquençage des politiques ne relève plus tant de la chaîne de valeur propre à la Clean Industry mais requiert plutôt une stratégie politique transsectorielle axée avant tout sur les obstacles et leviers principaux.

Dès lors, la méthode utilisée pour libérer les Clean Industries européennes devrait, dans un premier temps, se concentrer simultanément sur : (i) une amélioration des normes dans l'industrie de la mesure et du contrôle et dans les industries utilisant les TFP, (ii) l'optimisation des conditions du cadre réglementaire applicable aux réseaux énergétiques intelligents, à l'éolien et au thermique, ainsi que (iii) l'élimination des obstacles relatifs aux contraintes capitalistiques et de financement qui grèvent les secteurs aval de la Clean Industry, à savoir les logements et bâtiments énergétiquement efficaces et les solutions de transport plus propres.

Le fait de se concentrer sur la résolution des problèmes de capitalisation et de financement pour les secteurs aval de la Clean Industry facilite la création d'un marché domestique pour les autres secteurs de la Clean Industry positionnés plus en amont dans la chaîne de valeur. Cependant, pour ce faire, il est essentiel que les obstacles qui entravent la croissance future et la création d'emplois soient résolus simultanément afin de générer un effet de levier entraînant un renforcement mutuel.

TABLE OF CONTENTS

1/	Introduction	22
	1.1 Policy context and objectives	22
	1.2 Definition of the scope of Clean Industry	22
	1.3 Selection of the 12 priority sectors	24
2/	Description of the 12 Clean Industry priority sectors	26
	2.1 Wind energy	26
	2.1.1 Sector description	26
	2.1.2 Barriers	27
	2.1.3 Levers and outcomes	28
	2.2 Technologies to realize efficiency gains in vehicle powertrains	29
	2.2.1 Sector description	29
	2.2.2 Barriers	30
	2.2.3 Levers and outcomes	31
	2.3 District heating and cooling	32
	2.3.1 Sector description	32
	2.3.2 Barriers	33
	2.3.3 Levers and outcomes	33
	2.4 Nearly zero energy buildings	35
	2.4.1 Sector description	35
	2.4.2 Barriers	35
	2.4.3 Levers and outcomes	36
	2.5 Advanced manufacturing technologies	38
	2.5.1 Sector description	38
	2.5.2 Barriers	38
	2.5.3 Levers and outcomes	39
	2.6 Heating and cooling systems	41
	2.6.1 Sector description	41
	2.6.2 Barriers	42
	2.6.3 Levers and outcomes	42
	2.7 Measuring and monitoring (instruments, software and services)	43
	2.7.1 Sector description	43
	2.7.2 Barriers	44
	2.7.3 Levers and outcomes	45
	2.8 Thermal energy storage	47
	2.8.1 Sector description	47
	2.8.2 Barriers	47

	2.8.3 Levers and outcomes	48
	2.9 Smart grids and super grids	49
	2.9.1 Sector description	49
	2.9.2 Barriers	50
	2.9.3 Levers and outcomes	50
	2.10 Rail (train, metro and tram)	51
	2.10.1 Sector description	51
	2.10.2 Barriers	52
	2.10.3 Levers and outcomes	53
	2.11 Thermal insulation	54
	2.11.1 Sector description	54
	2.11.1 Barriers	55
	2.11.2 Levers and outcomes	56
	2.12 Traffic control systems	56
	2.12.1 Sector description	56
	2.12.2 Barriers	57
	2.12.3 Levers and outcomes	58
3/	Barriers and levers: interrelations among Clean Industry sectors	60
	3.1 Common barriers	60
	3.1.1 Capital and finance	62
	3.1.2 Market functioning	62
	3.1.3 Regulation	63
	3.1.4 Information & awareness	64
	3.1.5 Technology & innovation	65
	3.1.6 Labour market	65
	3.2 Common levers	65
	3.2.1 Capital and financing	68
	3.2.2 Standards and market functioning	69
	3.2.3 Regulation	70
	3.2.4 Increasing information, knowledge and awareness	71
	3.2.5 Technology, R&D and innovation	72
	3.2.6 Labour market	73
	3.3 Cross-sectoral interdependencies between the 12 selected EU Clean Industries	73
4/	Policy conclusions: levers for unlocking the EU Clean Industry	79
	4.1 Levers along the intra Clean Industry value chain	79
	4.2 A cross-sectoral and cross-country perspective: towards an integrated vision	82
	4.3 Towards an EU Clean Industry policy roadmap	83
	4.4 Boundaries of the study and recommendations for further research	84

5/	Bibliography	86
6/	List of abbreviations	87
AN	NEXES	89
1/	Annex 1: Taxonomy	90
2/	Annex 2: Selection results	92
3/	Annex 3: List of interviewees	93

PREFACE

In the context of the Energy Union Integrated Research, Innovation and Competitiveness Strategy (EURICS), the European Commission arranged for this study to be carried out with the goal of providing insights and policy suggestions that may foster the EU Clean Industry, and as such through the interlinkages with other sectors of the EU economy, may help to transform EU industries towards more competitive and energy and resource efficient sectors. The concept of Clean Industries is not a standard one and consequently providing a clear and workable taxonomy can be considered as a first important value added of this study. The study also provides a thorough and systematic qualitative selection of 12 sectors within the EU Clean Industries that can be viewed as priority sectors for EU policy making in this area. For each of these sectors policy levers have been identified which help unlocking the untapped growth and jobs potential. Another value added of the study is that it uncovers the interactions between the 12 priority sectors and derives the intra Clean Industry value chain on the basis of which a policy roadmap with targeted actions for each of the main Clean Industry clusters has been formulated.

This Summary Report, presents the main findings for each of the 12 priority sectors and focusses on the crosssectoral insights and policy levers. More detail on the definition and selection of the sectors, and on the competitive aspects, market outlook, strengths, weaknesses, threats and opportunities, export potential, barriers and levers can be found in the Background Report.

This study has been the work of a broad team of consultants, each specialised in particular areas of expertise. The analysis was carried out by IDEA Consult (lead partner) and the Niedersächsisches Institut für Wirtschaftsforschung (NIW). The quality control was done by the Austrian Institute of Economic Research (WIFO) in its capacity of leader of the framework contract in which this study was launched. The team of consultants would like to thank all the interviewees for sharing their precious time and providing their views on the various subjects inquired about. We also would like to thank the European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) for their valuable comments and discussions on the draft and final versions of the Summary and Background Reports.

On behalf of the research team,

Dr. Valentijn Bilsen June 22nd 2016

1/ Introduction

1.1 Policy context and objectives

The study "Identifying Levers to Unlock Clean Industry" aims to feed the new Energy Union Research, Innovation and Competitiveness Strategy (EURICS). To reach the overriding goal of creating growth and jobs, the competitiveness of the EU28's manufacturing industry has to be improved. This is in part possible via a stronger diversification of traditional industries in the production of clean solutions (partly due to their own high energy demand), thereby increasing growth and export potential. Moreover, these clean solutions can spread in other industries and thus have efficiency gains and competitive advantages for the users of these technologies.

Therefore the aim of this study is to gain insights in existing and potential markets for Clean Industries both at European and world level. In particular the objectives of this study are fourfold:

- 1) Defining the scope of Clean Industry
- 2) Identifying 12 priority sectors of the Clean Industry that should be the focus of a policy that aims to foster Clean Industry in the EU
- Assessing for each of the priority sectors the opportunities, threats, strengths, weaknesses and risks as well as the export potential, and
- 4) Identifying the barriers for further development and the levers to unlock EU Clean Industry: policy actions for the sector to reach its full potential.

For each of these objectives, the results of the analysis are documented in detail in the background report. However this Summary Report focuses relatively more on the barriers and the policy levers for each of the 12 selected sectors and on the interrelations between them and their common properties in order to obtain a wider, yet thoroughly grounded, view on the levers for the EU Clean Industry.

In the following sections of the introduction the Summary Report first provides a definition and taxonomy of the Clean Industry, followed by a concise description of the selection methodology of the 12 priority sectors and the resulting selection. Chapter 2/ provides an overview of the barriers, and policy levers for each of the 12 priority sectors as well as a more detailed delineation of the sector and its drivers. Chapter 3/ documents the common barriers and levers of the priority sectors and their interrelations. Chapter 0 concludes, focussing on the levers to unlock the EU Clean Industry.

1.2 Definition of the scope of Clean Industry

Notably, the definition of "Clean Industries" within the context of this study refers to specific sectors or segments within the economy that are directly responsible for supplying technologies, products, and services that have measurable environmental benefits in terms of their abilities to reduce GHG emissions and to improve both energy and resource efficiency.¹ In the definition used in this study Clean Industries exclude users-only of technologies and rather focuses on the core sectors supplying the means for a transformation towards a more sustainable economy (supply-oriented approach).

¹ See e.g. Globe Advisors (2012) and the discussion of several definitions in Gittell and Carter (2011).

Markets for Clean Industries could be defined at the level of sectors and subsectors (for both goods and services), thus they should comprise technology providers, clean processes, clean technologies, clean products and related services. Clean Industries are generally not depicted in existing industry statistics like NACE or ISIC. Hence, in order to ultimately identify the levers of Clean Industries, the delimitation of the market segments and a methodology to depict them have to be found in the first place.

In view of a compilation of an own taxonomy, we considered and synthesized the existing taxonomies to gain a comprehensive definition of Clean Industries that is suitably segmented to select priority sectors. For this purpose we primarily used Kachan (2012), Globe Advisors (2011), BMU/RB (2014), Brookings (2011), BMBF (2013), MKULNV NRW (2015) and European Communities (2009, 2015). Emphasis was put on the provision of core technologies, products and services that are responsible for producing measurable environmental benefits, energy savings and decarbonisation. The proposed taxonomy comprises six main categories, namely Clean Energy (production, storage and distribution), Energy-Efficient Buildings & Appliances, Clean Mobility, Clean Production and Environmental Protection, and Measuring and Monitoring. The latter category contains technologies, products and solutions that are applicable in all other categories and therefore can be considered as a 'cross-section' technology. Each of the six main categories was further subdivided into segments and sub-segments as depicted in Figure 1 reaching 44 Clean Industry segments from which the 12 priority sectors were identified.



Figure 1: A workable taxonomy for the EU Clean Industry

Source: IDEA Consult and NIW

Some segments and the respective sub-segments are either not in the focus of the study (for example, waste treatment and management as well as their respective technologies, but also traffic infrastructure as agreed with the Commission) or hardly identifiable. This refers in particular to most of the more energy-efficient products and appliances like energy efficient white goods or consumer goods. It is not possible to differentiate these so-called adapted goods from conventional goods of the same kind with respect to production or trade data.

Specific Clean Industry categories such as storage technologies, efficient networks, energy efficiency gains in vehicles powered by internal combustion engines, mainly describe a process technology that cannot be attributed to particular aligned products.

1.3 Selection of the 12 priority sectors

In order to identify the 12 Clean Industry priority sectors for focussing policy actions to unlock the EU Clean Industry, a systematic literature review was done for all 44 sub-sectors of the taxonomy in order to rank these sectors using the following four selection criteria:

- Clean potential, in terms of low carbon, energy and resource efficiency potential, as a proxy of policy priorities;
- Absolute growth potential, reflecting the economic relevance in terms of value added, number of jobs, and growth potential;
- 3) Technology leadership, reflecting EU technology and innovation leadership, technology advantage;
- 4) Comparative advantage.

Giving equal weights to each of these criteria, this resulted in a baseline selection which was subsequently subjected to a sensitivity analysis testing three alternative views with respect to the criteria weights:

- 1) A stronger focus on the Clean Potential, which is related to the EU policy objectives on GHG emission reduction, energy efficiency and resource efficiency,
- 2) A stronger focus on the economic side,
- 3) A stronger focus on technology leadership.

Special care was taken for obtaining robust results, using a systematic and iterative selection process. Given the results of the baseline selection and the sensitivity analysis a final selection was made in cooperation with the Commission, taking on board policy priorities as well as a few sector specific considerations. The detailed scores for each of the 44 Clean Industry sectors and results for the sensitivity analyses are provided in the Background Report. Table 1 provides an overview of the various subsectors in the final selection.

Table 1: Final selection of priority sectors

N°	Subsector
1	Wind energy
2	Technologies to realize efficiency gains in vehicle powertrains
3	District heating and cooling
4	Nearly zero energy buildings
5	Advanced Manufacturing Technologies
6	Heating and cooling systems
7	Measuring and monitoring (instruments, software and services)
8	Thermal storage
9	Smart grids and super grids
10	Rail (train, metro and tram)
11	Thermal insulation
12	Traffic control systems

In the following chapter the barriers, levers and outcomes for each of these selected Clean Industry sectors will be presented, as well as a concise sector description.

2/ Description of the 12 Clean Industry priority sectors

2.1 Wind energy

2.1.1 Sector description

In 2014 wind energy covered 8% of the European electricity demand and will provide at least 13% by 2020 and is expected to at least double by 2030 according to the EU renewable energy target.² In the global perspective, the EU holds one third of cumulative wind power capacity at the end of 2014 and European turbine manufacturers (onshore and offshore) obtain nearly 45% of the newly installed capacity in this year.³ This underlines the strong international performance of the EU wind power industry that profits from its long experience and high technological and trade competitiveness (first mover advantage). The EU has high competitive strengths in the manufacturing of wind turbines, turbine components and structures, wind farm development, offshore wind foundations as well as cable manufacture and installation. Although offshore wind energy still accounts for less than 10% of total installed wind capacity in the EU, it has grown significantly stronger over the last five years than total wind energy (CAGR of 30% compared to 11%⁴).

The two wind power market segments differ in their competitive situations. In the onshore segment, competition is fragmented because of the high number of major players, yet no manufacturer dominates the world market. Most turbine manufacturers are supported by a strong and growing domestic demand which creates sufficient preconditions to enter foreign markets. Contrast to the onshore market, the offshore wind power market is much more restricted than the onshore segment, as wind farm sites are currently limited to the North Sea, the Baltic Sea and off the British Isles, and so far has not been subject to international expansion. For the time being it is served by only a small number of European companies, with Siemens in a clearly dominating position.

One of the main drivers for the future development of the wind energy market is the globally increasing demand for renewable energies, mostly in Asia, but also in the EU, North America and Latin America. The share of offshore energy will increase significantly because technological developments and improved wind data analysis will reduce LCOE and downtime and make this segment more competitive. Furthermore, increased R&D investments and technology development will drive the development of the internal and global market. They target to cost reduction and efficiency gains as well as to improve grid compatibility, acoustic emissions, visual appearance and suitability for site conditions. Foreseeable trends are e.g. higher towers and lower wind speed turbines for lowland sites (e.g. in Central Europe). In the offshore segment ever larger turbines, downwind offshore turbines, and floating turbines for deeper water locations will gain importance, setting also higher requirements on foundation manufacture and installation equipment. Besides, retrofitting will be an important driver of the European demand for onshore wind turbines, as many of the existing wind farms are older than 15 years. Their capacity can be massively increased, because modern turbines are more reliable and have lower maintenance costs. Thus lower energy production costs and higher profits are expected and make repowering

² Lacal Arántegui (2016).

³ Eurobserv'Er (2016).

⁴ NIW calculation based on data from EWEA and Eurobserv'Er.

very attractive. To achieve technological synergies, market diversification and to meet rising competition in a mature market, industry consolidation is likely to continue in the next years, both in the offshore and in the onshore segment. Furthermore, European manufacturers will increasingly enter international markets. Yet, rising competition can be expected as Chinese turbine manufacturers will strongly expand into foreign markets.

2.1.2 Barriers

Regulatory uncertainty and the lack of a stable legal framework are the main barriers to the development of the EU wind energy industry. Even though new energy performance targets for 2030 have been announced in 2014 there aren't any binding national targets in place at present. Some Member States lack long term vision, which is partly caused by a lack of knowledge about the effective capacity of wind energy in their home country or pursuit of national interests in favour of fossil fuels.

In general, government support mechanisms for wind energy in the EU are shifting towards market-based schemes such as Feed-in Premiums (FiP) instead of Feed-in Tariffs (FiT). Furthermore, an increasing number of Member States use auctions to achieve high cost efficiency due to price competition as well as volume and budget control. Those schemes are being introduced in Poland (2016) and Germany (2017), while already been used for some years in Denmark, Italy, the Netherlands, Latvia, Lithuania, Portugal and Great Britain. In this case only selected wind energy generators benefit from the governmental support tariff or premium and the level of support is based on the prices indicated during the auction process. Thus, the investment risk for bidders is less predictable than before and may slow down future development of community and citizen ownership models. Furthermore, sudden and sometimes retroactive legislative changes in a number of Member States (i.e., Romania and Spain) make it hard for investors and developers to plan investment in new wind energy assets as well as in repowering and retrofitting existing assets. Particularly the offshore segment considers reliable, continuous expansion more important in the long term than any one-off records.⁵

Administrative barriers, e.g. building permits or delays in analysing critical aspects of projects, the number of parties involved, land ownership and increasing public rejection are other issues in many Member States, because they make the wind farm development process long (and thus expensive) posing a high risk in the project development phase. This reduces the amount of projects that reach the final investment decision milestone. Particularly in the offshore wind sector, project developers and manufacturers are faced with particularly high capital costs that are also attributed to limited market competition in this segment.

Growing wind energy production is characterized by an increasing variability of supply, that requires innovative storage solutions and an improved grid connection, particularly for offshore wind firms, both not being sufficiently available. Resulting from insufficient grid interconnectivity, operators in some Member States continue to suffer from overcapacities that have a negative impact on the profitability of their production facilities.

Industry experts see a lack of suitable programs to support the time-to-market process for wind power innovations, because the permitting procedures of the existing programs are much too long. Another obstacle is the insufficient support for demonstration projects.

⁵ GWEC (2016, 49).

Along with the extension of wind turbine capacity, employment in the wind energy sector in Europe is prospected to grow to 334,000 to 366,000 in 2030⁶. However, an increasing shortage in skilled labour is expected. Following a study conducted by the European Wind Energy Platform (2013), there is currently a shortage of 7,000 qualified personnel each year that could increase to 15,000 by 2030. Particularly occupations for project developers; service technicians; data analysts and electrical, computer, mechanical and construction engineers will be hard to fill. With respect to single tasks, especially the employment in operations and maintenance is expected to rise driven by the growth in cumulative wind capacity in Europe. This may hamper the growth potential of the EU wind industry.

2.1.3 Levers and outcomes

First of all, Member States need to grant their commitment regarding renewable energy deployment and set up stable, reliable long-term market and regulatory frameworks with respect to individual national circumstances and wind power potential. In order to drive investment in wind and other renewable energies, taxes and subsidies should take the total life-cycle costs of energy sources into account and apply appropriate carbon pricing.

The stronger implementation of EU energy market integration can help to resolve variability issues, because intensified cross-border exchanges of renewable energy allow higher shares of wind energy in the EU power system. Financial support for Projects of Common Interest can help to ensure that Member States reach their interconnectivity targets. Besides, transmission system and grid operators should be encouraged to strengthen regional cooperation and predictable grid connection regimes. Supported by more accurate wind forecasting, this will facilitate the allocation of responsibilities and cost recovery mechanisms. Smart grids can help to improve load management and prevent system failures. In the medium term, the variability issue may be resolved if utility-scale storage technologies become commercially competitive and widely deployed.

In order to keep its technological competitiveness in wind energy, the EU should maintain its current R&D funding to realize cost reduction and efficiency gains. However, for high technology readiness levels, supporting programs should be strengthened in expediting time-to market of innovations and in maintaining demonstration projects.

To improve administration procedures and social acceptance of wind power projects the EU funded WISE project has implemented an interactive platform (one-stop-shop) for information-sharing which allows groups and individuals to have a say in the siting and expansion of wind projects. By providing a diverse set of best practices, it aims to foster public support for onshore wind power in order to at least halve the average permitting time for a wind farm. The project has a strong focus on alternative financing, such as community and cooperative funding of wind farms as a method to broaden local engagement. A better coordination among different authorities will furthermore in particular be needed with regard to cross-border offshore projects that also concern marine spatial planning and wildlife conservation. If the effort (and cost) that it takes to develop a project is reduced, more projects would enter the pipeline and eventually are realized.

To ensure the availability of qualified personnel for the EU wind industry, a greater transfer of knowledge between the industry and academic institutions should be promoted and further multidisciplinary postgraduate training programs should be offered which include project development and technical skills particularly in the O&M area. For many jobs in the wind industry a qualification in STEM subjects is a prerequisite, hence STEM skills

⁶ EWEA (2012).

of employees should be improved through targeted courses. Furthermore, the cross-sector mobility should be encouraged, as a lot of competencies required e.g. in the growing offshore wind in coastal regions can take advantages of skills and man-power available from the oil and gas industry. Furthermore, specific vocational training programs aimed at the needs in those EU Member States and regions, which are in the early phases of development of wind energy, are necessary and can be done most effectively through partnerships with the existing knowledge centers in other regions. In general, the standardization of vocational education and training across the EU to common quality standards can help to secure the supply of qualified personnel and is also seen as being beneficial in order to increase workforce flexibility within the EU.

2.2 Technologies to realize efficiency gains in vehicle powertrains

2.2.1 Sector description

The sector technologies to realise efficiency gains in vehicle powertrains can be widely interpreted and it is therefore important to propose clear boundaries. In this report we have limited the analysis to road transport, and more specifically to cars and light commercial vehicles (thus excluding non-road vehicles, trucks, busses, trailers etc.). Setting these boundaries allowed us to perform a more thorough sector specific analysis and to identify more sector specific strengths, weaknesses, barriers and policy suggestions. Within the scope of cars and light commercial vehicles, we do not consider electric or semi-electric vehicles. Electro-mobility is explicitly left out of the analysis due to the fact that plug-in hybrid electric vehicles and battery electric vehicles sectors have not been selected as one of the 12 priority sectors.

Between 1990 and 2011, carbon dioxide emissions from road transport had increased by 21%, and the sector was responsible for 23% of all CO₂ emissions in the EU. In response to this problem, the EU implemented legislation setting mandatory emission reduction targets, with a short-term target for average new car emissions to be below 130 grams carbon dioxide per kilometre (g CO₂/km) by 2015, and a long term target of 95 gCO₂/km by 2021. The sector "technologies to realise efficiency gains in vehicle powertrains" encompasses several technologies which allow vehicle powertrains (in our scope cars and light commercial vehicles) to consume less energy and reduce emissions. In this report we use fuel efficiency, the ratio of distance travelled per unit of fuel consumed, as a measure for the energy efficiency and thereby emission reductions of vehicles. Fuel efficiency can be increased in several ways: by optimising internal combustion engines, reducing weight, reducing friction, or improving aerodynamics (and by further electrification of the powertrain, which is left out of the scope of this analysis). Technologies to increase fuel efficiency in cars and light commercial vehicles derive from the automotive industry as incremental improvements, with innovation mainly driven by the major Tier 1 suppliers and the OEMs of the automotive industry. Generally speaking, European car manufacturers are strong in developing fuel-efficient and high performance internal combustion engines, particularly in the area of diesel engines. Asian car manufacturers however are stronger in developing hybrid and fully electric vehicles. Even though we excluded electro-mobility from our analysis, developments in the field of electro-mobility impact the fuel efficient car industry.

The sector is subject to some major changes, which might significantly impact the power positions in the industry. In terms of market outlook, a distinction can be made between trends that positively and negatively influence the position of the EU industry with respect to the fuel efficient car industry. A positive trend is the shifting customer preferences towards smaller, more fuel efficient and low emitting vehicles, given the technological leadership of the EU industry in this area. Possibly the largest challenge however is Europe's

relatively weak position in key areas of electro-mobility such as hybrid technology and battery development. The internal combustion engine will likely continue to feature in the majority of vehicle sales till at least 2030, but eventually Europe's leading position may be challenged by the increasing share of electric vehicles. As a result, the strength of the European industry of fuel efficient cars will eventually decline, if no further action is taken. Other trends, such as increasing global competition and a saturating internal market further contribute to challenging the traditional leadership of Europe in the automotive industry. It is paramount for the European automotive industry to carefully identify its strengths and weaknesses, as well as opportunities and threats following from such a market outlook.

2.2.2 Barriers

One of the biggest barriers in this sector is capital and finance. In the current industry, you would have to be a fairly big and profitable OEM or supplier in order to remain competitive given the low operating margins. The margins of the automotive industry are pressured on many fronts on which manufacturers have to make expenses, ranging from adhering to regulatory standards to research and development on the areas such as self-driving cars. In order to remain competitive while attempting to realise efficiency gains, it is therefore essential to have access to sufficient capital and financing.

Several sources have mentioned that Europe is characterised by slow decision making processes, a lack of coordination and a less uniform market place compared to other key automotive markets, properties that negatively influence the industry. Slow decision making processes regarding standards hamper the uptake of new technologies. Furthermore, the significant variations in the policy frameworks of the various Member States of the EU impose difficulties for car manufacturers on the European market. On paper the European market should be characterised as an internal market, however, the major elements of consumers' decisions are influenced by national policies, and those policies are not always harmonised. There are too many fragmented, isolated markets with different policies. With these differences in policies it is difficult to operate, since these policies have implications on business decisions regarding cost structure, scale economics, marketing, et cetera.

A final barrier relates to the uncertainty about the prevailing technologies of the future in the automotive industry and the possible lock-in of the European automotive industry in the internal combustion engine technology. Pathdependencies could eventually result in a threat to the leadership of the European automotive industry on fuel efficiency once the demand for electro-mobility will overtake the demand for traditional internal combustion engine powered vehicles. Significant investments are required for OEMs and their suppliers who will have to develop alternative powertrain technologies for lower-emission vehicles without knowing for certain what will end up being the prevailing technology of the future. If the European industry wants to enter the electro-mobility market, it may face some resource dependencies, for example on China regarding batteries and rare-earth materials.

While the first and last barrier are sector specific, due to the characteristics of the sector or the technologies applied in the sector, the second barrier is a more common barrier, that might also apply to other industries. Even though the impact of the lack of harmonised policies across the various Member States in Europe might be higher towards a large industry such as the automotive industry, lessons could be drawn on the implications of this barrier for sectors that have a large economic growth potential. The barrier related to technological path-dependencies, could also be interesting for the development of other sectors were various technological possibilities might prevail. An example would be the wind energy sector, where besides within the sector (onshore vs. offshore) there are also technological substitutes such as solar energy that might eventually prevail.

2.2.3 Levers and outcomes

Europe should centre its policy around the following elements in order to maintain leaders in the field of fuel efficient cars:

- Ambitious yet realistic regulation
- Owning the standards
- Regulatory harmonisation
- Sustained technology leadership
- Forward looking policy
- R&D support

In the sector of fuel efficient cars, technological leadership is mainly driven by regulation and standards. Europe is one of the most ambitious regions in the world with respect to fuel economy and CO₂ emission standards for cars and light commercial vehicles around the world. Stringent technology-forcing policies can strengthen the innovation capacity of the automotive industry and further drive the rapid penetration of advanced technologies. This regulatory environment should therefore remain ambitious, yet realistic. One of the identified barriers are the low operating margins in the industry, and the costs that come along with a stringent regulatory environment should not drive towards players leaving the European automotive industry. However, according to an economic assessment study by Cambridge Econometrics and Ricardo-AEA in 2013 on the effects of CO_2 legislation on the automotive industry, robust fuel efficiency standards for cars could create up to 443,000 new jobs by 2030 and add €16 billion per year to Europe's GDP. The report also indicated that efficiency improvements would add an extra €1,000-€1,100 to the cost of an average car in 2020, but that this would be offset for consumers by fuel savings in the long run. Furthermore, according to a 2015 study on transport emissions reductions, ambitious new vehicle emissions targets (2025 standards of 70g CO₂/km for cars and 100g CO₂/km for vans) could save European drivers €350 per year, and pay back the cost of the technology within three years. Also on Member State level, the uptake of efficient vehicles can be influenced through national taxation systems, including vehicle registration tax, circulation tax and fuel tax. Therefore a proper balance should be found between pursuing ambitious objectives and maintaining jobs and value added in Europe.

Europe should also aim to become the leader in terms of standards with respect to fuel efficiency and emissions. Since Europe is a world leader in many technologies in this area, this would bring Europe competitive advantage, and in this way Europe can ensure their OEMs and suppliers to be able to sell their technology abroad. Regulatory harmonisation is one of the key ways that the EU can profit from developments in different technologies. At the same time, it has to be made sure that companies are not constrained by regulation, and technology neutrality should be pursued. Furthermore, efforts towards regulatory harmonisation will contribute towards overcoming the barriers experienced regarding the fragmented markets which are still in place in the various Member States in the EU.

Fostering the industry in the EU will be a challenge, but the main game is about having technological leadership in a number of areas. A combination of forward looking policy, aimed at the mid- and long-term and sustained R&D support would contribute to this objective. In order to avoid a lock-in situation in ICE technology, Europe should consider betting on other technologies besides the internal combustion engine. Due to the fact that the potential improvements in the internal combustion engine are narrowing down, the potential for comparative advantage is limited in the long run. Bigger opportunities lie within technologies related to for example partial electrification and recovering waste energy, since it is expected that the market will eventually converge towards hybrid vehicles. Other technology areas in the automotive industry that should be stimulated are electronics, connected or automated vehicles, or light-weighting. A main reason for investing in the development of these technology areas is their applicability regardless of the type of powertrain, making them technology neutral. While it may take time for the internal combustion engine to be replaced, learning effects and first mover advantages may prove decisive once the shift takes place. A possible way of entering the electro-mobility market is to form joint ventures or close partnerships for example with Japanese or South Korean battery manufacturers. More radical transformations are also possible: an example is the case of Solaris, a Polish family-owned bus manufacturer, which successfully adopted an aggressive, high-risk strategy of targeting a new unexplored market niche for buses with an alternative powertrain.

Additionally Europe should find innovative levers to maintain its technological leadership in the field of efficiency gains in vehicle powertrains by valorising its strong position in Advanced Manufacturing Technologies (AMTs) and other Key Enabling Technologies (KETs), which have been identified as one of the priority areas of European industrial policy. An example is the application of femtosecond laser micromachining for the cost-effective production of highly complex parts such as fuel injection nozzles, having enabled the switch from port fuel injectors (PFI) to the more efficient gas direct injectors (GDI) engines.

2.3 District heating and cooling

2.3.1 Sector description

District heating and cooling distributes thermal energy via underground pipes from a central point of generation to a multitude of consumers. In case distances of transport are not too long and pipes are well isolated this provides an efficient way of delivering thermal energy since central power plants often have a higher coefficient of performance than technologies installed in single buildings or flats. In light of Clean Industry the sector encompasses the construction as well as the operating of the network.

Europe is leading in expertise in district heating and cooling and is able to export it addressing the increasing demand from countries outside the EU. The existing network within the EU is large and growing urbanization improves the suitability of network solutions since a higher density of connections makes district heating and cooling more profitable. Overall, district heating and cooling is growing, albeit with varying and sometimes even negative growth rates across Member States. Scandinavian, Baltic and Western European Member States expand their networks. By contrast, some of the Eastern European Member States where district heating traditionally plays a large role struggle to modernize their networks and lose consumers as a consequence of the unreliability of their services.

Besides network efficiency gains, the most crucial point with respect to the decarbonisation goals in the EU is that district heating and cooling offers a good opportunity of integrating renewable energies. One option is to use solar or geothermal energy directly. Another is to use heat pumps to transform renewable electricity (e.g. from wind) to thermal energy which is then fed into the district heating and cooling network. Thereby fluctuations in supply of renewable electricity can be absorbed and used as thermal energy for heating and cooling purposes. Increasing shares of renewable electricity can hence be seen as a driver for district heating and cooling in general and renewable district heating and cooling in particular.

Following from the ability to integrate renewable energies, district heating and cooling networks can work as a smart grid. Regarding the future role of buildings as actors in the energy system, thermal networks like district heating and cooling provide an enormous amount of flexibility when demand response increases. This flexibility is further increased due to the ability to use excess cold from the district heating network to supply cold.

Another possibility to decarbonize the economy via district heating and cooling is to use waste heat as a feeding for district heating and cooling networks this way reducing primary energy needs at large scale. So far, cogeneration is the most widely used generation form for district heating and cooling but an increasing awareness of the existing waste heat potential can work as a driver for the district heating and cooling sector as well.

2.3.2 Barriers

While district heating and cooling offers an efficient heating and cooling solution and an extension is technically feasible, there are various barriers to further growth. The most important one is related to regulation as well as market functioning. In the case of numerous consumers of heat or cold, a network solution is per se always more difficult to establish than individual solutions. This aspect is mitigated in case of development areas since here, local authorities have the chance to establish the network before individual planning and decisions take place. Even though the suitability of network solutions has been recognized by the EU institutions – it is, for example, stated clearly in the Energy Efficiency Directive (EED) – existing regulation tends to favour on-site solutions. Regarding retrofitting of individual heating and cooling solutions, it is difficult to establish district heating and cooling as a valid alternative. Regulation also impedes the further use of geothermal district heating since security of licenses for deployment of found resources is not given in all Member States.

Another important barrier relates to the capital requirements of district heating and cooling. Initial investment in new networks is high. This is particularly true for renewable district heating and cooling where large solar thermal plants have to be built or expensive drilling has to be accomplished in the case of geothermal district heating. Furthermore, public funding resources for district heating and cooling are smaller than for the energy sector even though heating (and cooling) demands account for the majority of primary energy demand. Also related to capital is the envisaged use of waste heat. Companies expect a fast return on investment and therefore are hesitant to sell their waste heat which requires larger initial investments.

In addition to regulative and capital barriers, lack of information has to be mentioned as another barrier carrying weight. This refers to all stakeholders and extends to neighbouring occupations like urban planning or architecture. Continuing with waste heat as a potential source of thermal energy for district heating and cooling, companies often do not have specialized staff for efficiency technologies in general and waste heat technologies in particular who could point towards selling waste heat to district heating and cooling operators. Moreover, knowledge of increasing cooling demands is not wide spread.

Among the remaining barriers, it is worth mentioning that availability of suitable sites can be an issue. Since district heating and cooling is most economical in densely populated areas, district heating and cooling is in competition for suitable sites with demand for residential or commercial use.

2.3.3 Levers and outcomes

Possible solutions to the mentioned barriers that could work as levers for the district heating and cooling sector and Clean Industries in general encompass the following. Regulatory/market functioning barrier impeding network solutions, more emphasis could be placed on heat planning. While cost-benefit-analysis for individual heating and cooling and district heating and cooling solutions is already required by the EED, "efficient district heating and cooling" is the benchmark with which individual solutions are to be compared. This refers to district heating and cooling "using at least 50 % renewable energy, 50 % waste heat, 75 % cogenerated heat or 50 % of a combination of such energy and heat" (EED; Article 2). Such a benchmark may lead to choosing individual solutions that have a higher share of cogeneration or renewable energy sources but not necessarily with the same (potential!) efficiency. Similarly, existing networks may yet perform poorly compared to new individual solutions but discarding the option to modernize existing networks disregards flexibility for later increases of the share of renewable energy carriers in the cost-benefit-analysis. Therefore, we suggest emphasizing district heating and cooling further. Besides a decrease of the required level of efficiency for district heating and cooling in cost-benefit-analyses, this could be accomplished by allowing municipalities more competencies in establishing networks especially in existing residential areas. Heat planning could in particular show designated areas for district heating and cooling and should be part of climate concepts that municipalities design. When district heating and cooling is foreseen as a solution by municipalities, individual owners are nudged to use it. Furthermore, exchange on experiences in district heating and cooling, in particular with different forms of ownership, can be further supported with the aim that heat planning is oriented towards best practice examples.

Similarly to municipalities, district heating and cooling operators can be granted special rights in order to allow them to extend district heating and cooling networks. This could, for example, be a prior claim on property for the operation of a CHP plant feeding into district heating and cooling networks or a drilling place for geothermal district heating. Such quasi-governmental rights would lower project risks which in turn facilitate access to and costs of capital.

Since the newest building generation with very low energy requirements creates a different kind of heat and cold demand (less heat of lower temperature and more cold), district heating and cooling networks have to adapt to these new demand. Hence, support of demonstration projects of district heating and cooling for NZEBs or similar low emission buildings is another important lever for district heating and cooling. Once feasibility is attested, planning for development areas with NZEBs can be adapted to provide district heating and cooling.

So far, we argued that flexibility of district heating and cooling should be further emphasized and may be valued above certain individual (renewable) heating and cooling solutions. Similar to the so-called "White Certificates" in place in some Member States, district heating and cooling operators should be incentivized to increase efficiency and to reach a high share of renewable energy in the long run. This can be accomplished, for example, by improving CHP plants. Such a pathway would leave sufficient autonomy to the operators while advances in efficiency/sustainability are made. Similar advances can be required from private households only in the form of increasing efficiency standards or shares of renewables whenever new equipment is purchased. In combination with the granting of special rights to district heating and cooling operators and a more district heating and cooling-friendly municipal heat planning, district heating and cooling will be stimulated from the supply as well as the demand side which is a desirable feature when designing policy measures.

Limited knowledge could – among others – be addressed via a more integrated training of urban planners, architects and alike securing that a holistic approach within cities is pursued. With regard to waste heat as an input to district heating and cooling, it is suggested to include waste heat as a particular category in the companies' energy management system regulated by EN16001 standards in order to call attention to potentials. Moreover, industry associations can advertise the selling of waste heat to their members and provide assistance and communication platforms thereby increasing awareness.
2.4 Nearly zero energy buildings

2.4.1 Sector description

NZEBs target a massive reduction in energy requirements of buildings while the remaining energy demand has to a large extend be ensured by renewable resources. Gradually tightened building codes over the last decades will cumulate in mandatory NZEB standard for new buildings from 2019 onwards for public buildings and 2021 onwards for private buildings (EPBD). Member States put in place specific NZEB definitions to take into account different climatic conditions. To reach the ambitious reduction in CO₂ emissions from the building sectors, a corresponding transformation of the existing building stock to NZEB standard is necessary, since the majority of buildings in the EU will still be standing in 2050. The EPBD requires Member States to provide policies and measures to stimulate this refurbishment.

The two markets – new built and renovation – differ in no small measure. The market for new built NZEB is becoming more and more established and is dominated by companies specialized in the construction of industrialized new houses. By contrast, the renovation market to NZEB standard is just emerging and not yet a volume market. Here, installers and small contractors play an important role in the value chain.

The position of the EU with respect to NZEBs can rely on the pioneering role of the EU in energy-efficient buildings, its comparative strength in renewable energies, technology leadership in smart management systems related to NZEBs as well as a comparative advantage in trade with prefabricated buildings. The essentially local market of construction activities is expected to grow, mainly driven by the tightened legislation but also due to low interest rates. The renovation markets' value chain is further deemed to transform since the rise of renovation concepts, prefabricated renovation modules, renovation shops offering one-stop solutions and energy cooperatives. While these new developments are hoped to lead to higher renovation rates, they all affect the role that installers and small contractors play in the renovation markets driven by the increasing role that buildings play in a smart grid.

2.4.2 Barriers

Since the major challenge consists in the renovation of the existing building stock to NZEB standard, analysis of barriers and suggested actions refer to this market only. Regarding the barriers of deep renovation (refurbishment to NZEB level) there are barriers to the supply as well as to the demand side. Considering the latter, the most important is clearly financial. It involves the generally high upfront costs as well as difficulties to access capital, the cost of capital and the unwillingness to take up a loan. Another demand side barrier of high relevance, although with varying degree at the Member States level, is high shares of owner-occupied dwellings. This goes along with many refurbishment projects being staged do-it-yourself not necessarily aiming at a deep level of renovation and possibly causing lock-in effects. Since these high shares of owner-occupied dwellings further can go along with below EU average household incomes as in Romania or Bulgaria, preconditions for costly refurbishment to NZEB level remain even more challenging.

Other very important demand side barriers are the lack and/or mistrust of information as well as missing quality guaranties of accomplished works. The mistrust may well be related to the issue of quality regarding products, design, execution, and monitoring. The low collaboration between different actors in the sector complicates the matter since all quality aspects are related to different actors in the system.

National Energy Performance Certificates (EPC) schemes have created a demand-driven market for energy efficient buildings by providing information on their energy performance. However, the role of the EPCs has been limited, despite the information that EPCs provide on effective ways to improve buildings and building systems through renovation works, and hence contributes to stimulating higher renovation rates. This could be due to lack of enforcement of good quality EPC schemes and to the absence of appropriate accompanying measures in some MS.

On the supply side there are three main barriers to the major uptake of refurbishment to NZEB level. The main barrier is the lack of a defined and easily identifiable product which is visible to the consumer. In this line there is a need to bring nearer to the market ready-made or off-the-shelf (available) solutions, possibly based on 'one-stop-shop' approach for the consumer (e.g. integrator or market player) that integrates the results of all the involved trades/parties and a sufficient coverage of demonstration of success stories at 'business case' level for the different categories of buildings. This would imply 'new' profiles of companies whose core business would be similar to the one of an ESCO (e.g. ESCO for refurbishment to NZEB level) with commitments on the energy performance results ex-post (e.g. EnPC contracts). This could inspire and build on similar and existing approaches like `turn-key' contracts in the industrial sector (e.g. conventional power plants contracts signed in the last decades) that might as well cover obligations under the operational phase.

Another barrier is that the sector's main actors primarily consist of small companies (contractors and installers) lacking the resources for larger product innovations and often also lacking knowledge on holistic refurbishment approaches. In the same vein, range and quality of services of small actors is often worse than that of larger actors. Thirdly, the non-existing formulation of a mandatory renovation target is a barrier to a large scale energy renovation. Particularly private owners have no guidance as to which energy saving level they should invest.

Besides, there is a high amount of red tape hindering renovation incentives. For example, spatial planning regulations regarding the look and size of buildings may impede certain renovations because these would not fit the regulations. Moreover, Member States-specific definitions of NZEBs can provide additional regulation barriers especially in smaller countries or regions like in Belgium where three different NZEB definitions exist. Regarding the production of prefabricated components, lack of harmonization is also an issue since it requires higher flexibility in manufacturing of these products which is generally more costly.

2.4.3 Levers and outcomes

Large-scale market uptake of refurbishment to NZEB level is the key to address most of the barriers since it above all involves a cost reduction of deep renovation. The first suggestion to reach this goal is mostly regulatory in character and addresses demand side reluctance. It is deemed attractive to tie refurbishment obligations to the change of ownership. Such a measure resolves several of the existing barriers at the same time. So far, refurbishment obligations are used sparely since they always are a restriction to ownership rights. This issue would be mitigated when it comes at the time of purchasing property. Often, renovations are carried out anyway after purchasing property. Regarding the barriers related to financial constraints, unwillingness to take up a loan for refurbishment is met by the fact that purchase of property mostly goes along with taking up a loan anyway. Hence the suggested measure timely fits into this window of opportunity. Of course, the financial burden can be much higher when purchasing and refurbishment fall into the same time horizon. This can be cushioned by measures like preferential loans. The suggested measure also mitigates the well-known owner-tenant dilemma where it is unclear how costs and benefits of a refurbishment project shall be shared between the owner and the tenants paying the energy bill. In case that refurbishment is done right after purchasing of property, it is still likely that an owner not wishing to occupy the property himself will pass on occurred costs to tenants. Still, the

conflict is more severe in case of a refurbishment project started during an ongoing rental contract. If the NZEB level cannot be targeted within one renovation project, a staged renovation plan has to be agreed upon (possibly in the course of the purchase agreement). In case the building is sold before the NZEB level is reached, the next owner again is required to refurbish it. The downside of such an approach will be that refurbishment demand in regions with low demand for property may become even smaller.

Another suggested action refers to energy performance contracting (EnPC) as a kind of financing deep renovation. An EPC involves that a contractor finances and conducts a refurbishment measure while owners pay on a regular basis like on their energy bill. The contract is profitable via the occurred cost-savings that over an agreed period are assigned to the contractor. EnPC addresses the main demand side barriers: owners shy away from high upfront costs and are unwilling to take up a loan. The important aspect of the measure is that EnPC has to be combined with the NZEB target. This so far has been observed to be difficult since deep renovation incurs very long-term payback periods. Therefore the market for EnPC in this respect is not developed since short-term profitability is missing. It is conceivable that here public support can help to create that market. Initially used in the US with municipal debt as financing the slow uptake of EnPC in Europe can be explained with the missing public funding. This could be provided by any public authority. Importantly, large-scale information campaigns would have to highlight the stabilizing role of public support for these contracting instruments. Financing is possible via different ways. With the aim to trigger a higher rate of refurbishment via a higher price of fossil energy, a carbon tax as present in some Scandinavian countries would put additional pressure on owners' investment decisions. EnPC type of contracting would also help to overcome issues of quality control and related mistrust.

In principle, this suggested action can be combined with the first one. Importantly, introduction has to be accompanied with a large scale information campaign highlighting the stabilizing role of governmental support. A specific form of EnPC was the Green Deal in the UK (already ended). It had the desirable feature that the loan was tied to the property, not the owner so that change of ownership or tenancy was not providing any additional conflicts of interest. Another favourable aspect of the EnPC kind of measure is that collaboration of small actors in the renovation sector is encouraged and new networks are likely to be built and small actors do not carry the risk of large projects.

A best practice example has been found to exist in the Netherlands. The "Stroomversnelling" project brings together demand and supply side to reach large-scale renovation to NZEB level. Social housing corporations have agreed to reach an energy efficiency label B of their building stock by 2020, implemented as a fast renovation using prefabricated modules. Without going into details, the favourable features of the project are that a large-scale demand is generated and innovative concepts of prefabrication for deep renovation are developed. Across a series of similar projects, costs per building go down quickly creating competitiveness in the mass market. Payback is without additional costs to tenants who contribute to pay their usual rent and initial funding is provided by a social bank. Recently the project is also extended to privately-owned single houses and is also carried out in the UK. Hence, this project is similar to the proposed EnPC measure with public support. It is in particular deemed possible, that an initial project like "Stroomversnelling" - bringing together demand and supply side at larger scale - is able to create a demand for EnPC on the larger level, especially when such demonstration projects enable to reduce cost reductions.

So far, the market for energy renovation seems to sustain mainly moderate renovations. As JRC (2014) shows, existing national policy instruments that were made use of in 2013 were mainly targeted at minor and moderate renovation. This evaluation is in line with the estimation of Castellazzi, Zangheri, Paci (2016), where a missing definition of NZEB renovation is assigned to most of the MS National Plans. This is expressed by the fact, that 80% of the existing financial support instruments were unrelated to the ambition level of the renovation.

Therefore policy instruments should put more emphasis on deep renovation. Generally, and in particular with respect to the largely used taxation mechanisms, there is hence a lot of scope to enhance renovation depth by adapting the design of financial instruments. Moreover, assessment of the results did not happen in one third of the examined cases. Policy instruments should therefore be tailored more to (ex-post) performance, in particular to prevent windfall gains, which have been shown to be of relevant size. Another possible driver would be to promote successful demonstration projects. Finally, financial barriers are expected to be tackled in the course of the "Smart Finance for Smart Buildings Initiative" being launched this year.

2.5 Advanced manufacturing technologies

2.5.1 Sector description

Advanced manufacturing technologies (AMT) have been identified along with five other technologies in 2009 as KETs for the EU. KETs are characterized by a high economic potential, through their core industries as well as their enabling role for a wide range of products and services, as well as a high R&D and capital intensity. Specifically, AMTs are defined by the EU Task force on advanced manufacturing as "*manufacturing technologies and production processes which have the potential to enable manufacturing industries to improve productivity (production speed, operating precision and energy/materials consumption) and/or to improve waste and pollution management in a life-cycle perspective".*

AMTs play a dual role in the transition towards a green economy. Firstly, improvements in terms of energy and material consumption in the process they execute provides a direct environmental benefit. Secondly, by enabling novel product characteristics, AMTs indirectly support environmental benefits in downstream industries. It is interesting to distinguish in this respect between applications inside and outside the field of renewable energy. In the field of renewable energy, the role of AMT is evident as it enables the production of clean energy technologies. For example, the production of solar panels overlaps partially with semiconductor manufacturing and has benefitted greatly from evolutions in this area, making photovoltaics based energy production cost competitive nowadays. Similarly, advances in several of the complex components of wind turbines turbine have been enabled by better material processing technologies.

Outside the renewable energy domain, AMT has a considerable impact as well. For example, advances in fuel injection nozzles that have resulted in major improvements in automobile fuel consumption (enabling the switch from port fuel injectors (PFI) to the more efficient gas direct injectors (GDI) engines), have been enabled by developments in the femtosecond laser field. As another example, 3D printing is being applied in the aerospace industry in order to save weight and hence transport fuel costs. As the environmental benefits enabled by AMT cut across many different sectors and applications they are hard to fully quantify, yet it is clear that the AMT sector will be a cornerstone in the transition towards a more sustainable economy.

2.5.2 Barriers

Regulation: a key concern in the machine tool industry, which can boost world class quality products, is the lack of market surveillance. The limited control on imported products which allows for low-quality imported substitutes to gain market share at the expense of domestic producers. This limited market surveillance also hampers the implementation of self-regulation in the context of the implementation of the 2009 Eco-design Directive, proposed by the machine tool industry. This self-regulation on quality and safety control on the machine tools, would require a necessary market coverage of 80% and needs therefore the inclusion of non-European machine tool builders and importers. As there are no sanctions foreseen for not joining the voluntary agreements and there is a lack of market surveillance in the industry regarding the quality of products, creation of a successful initiative faces a serious obstacle.

Capital and finance: the current uncertain economic outlook hampers investments in new equipment. The barriers to investment correlate with the cost of the equipment and the extent to which it can be smoothly integrated in existing facilities and processes. Especially in some process industries (e.g. the chemical or steel industry) the integration of clean technologies is easier when building up a new infrastructure rather than when then replacing existing equipment. This hampers investments in clean technologies. So far, few Member States have undertaken action in order to tackle this barrier. Moreover, payback time for clean technologies depend on the price (including taxation to correct for externalities) of energy and raw materials, which have been fairly low in recent times due to several macro-economic factors.

On the AMT producer side, it needs to be noted that this sector is characterised by a relatively high share of SME and mid-sized companies, specialised in specific niches. These companies, especially those in high growth segments such as 3D printing, need substantial (risk) capital to grow but this is not always available in the current economic context, whereas the US offers more possibilities on this point. A recent study commissioned by the European Investment Bank (EIB) shows that there is a clear lack of finance for KETs companies. This applies especially to companies that have rather high investment needs compared to their (current) income flows, referred to as 'post start-ups' and 'quantum leap companies'. Due to their often entrepreneurial nature, young KETs companies often fail to meet banks' preconditions for debt financing (the most prevailing type of financing used by banks): an adequate track record and collaterals. The banking sector is assessed to be rather conservative and not able to cater the needs of KETs (including AMT) companies.

Market functioning: the AMT sector relies heavily on exports. In the EU machine tool subsector, some 46% of production is exported. European AMT companies experience several tariff and non-tariff barriers when exporting, especially to emerging countries which want to develop a domestic AMT sector. Examples include complicated and discriminatory health and safety regulations, certification requirements, lengthy customs and administrative procedures, frequent changes in government policies, poor IPR rights protection, explicit and implicit government support to local actors, unclear procurement channel, etc.

Another important element of optimal market functioning is the match of supply and demand in the absence of incomplete information. Yet, for many industrial companies, especially SMEs, it is difficult to keep track of the different evolutions in available AMTs and of the precise costs and benefits of adopting certain novel technologies. Such costs and benefits can often only be assessed after in-depth analysis and testing with new equipment. There is however a clear lack of mechanisms that support SMEs in this respect, hindering maximal uptake of AMTs.

Labour market: whereas the skill level of personnel in the EU AMT is very good, companies have troubles finding sufficient employees, which constrains the growth of the industry.

2.5.3 Levers and outcomes

Actions in several domains can further strengthen the EU AMT sector, which are discussed below per domain. As general note however, it is clear that a combination between supply side policies (R&D support) and a regulatory approach (norms and standards) is to be preferred. Standards create a level playing field for all actors in the market, while funding and R&D support sets a ground for development of more `green' and efficient products.

In the field of research and innovation, a key difficulty is the information barriers regarding the costs and benefits of adopting novel AMTs. Especially for SMEs it is difficult to be fully informed on the various existing manufacturing solutions. Government initiatives can help overcome these barriers through programs that support SMEs, providing them with access to expert consultation, self-scans, access to infrastructure where they can test equipment, etc. that help to assess the possibility of adopting novel equipment. A good example of this has been implemented in Belgium in the form of the MADE DIFFERENT program, which provides free expert support for SMEs in developing novel production strategy. Afterwards SMEs poses much better information to make investment decisions.

From an EU perspective, experts who conduct these supporting tasks should be well aware of different manufacturing solutions that exist across Europe, and not only those from the established players. In this respect, it would be best if this could be done in the context of an integrated EU wide network. The Commission is already working along this line, e.g. through the launch of an INNOSUP call in the area of clean AMT, and by planning the funding of an EU-wide network based on the Made Different program approach under COSME 2017.

Ties between AMT producer and user are very important, and innovation develops best at the interface of these two. A major challenge for especially the small/medium-sized machine tool companies is accessing their customers for joint technology development. As a second point therefore, it is important that innovation support involves and benefits also directly the user side. Innovation programs could facilitate this by providing more funding or incentives for 'production chain' type of projects, in which both sides are involved directly. In general, considering the threat of relocation of AMT users to other regions as e.g. happened in electronics, it is important to let these users benefit in the most direct way from support to the AMT industry, by supporting projects that not only increase AMT producer capabilities but also simultaneously increase competitiveness of AMT users.

Thirdly, cooperation opportunities between research institutes (universities, RTOs) and companies are still not fully exploited. It is noted that in countries where there are intermediate structures focused on innovation, such as in Germany and Spain, cooperation between the university and business side is best. Research infrastructures are not always open to SMEs and the sharing of research results and managing of IPR is not always dealt with fluently. Further strengthening this cooperation, through stronger promotion by national government or the EC could be a major improvement for smaller companies in the sector. Cooperation with larger research institutes often also helps in providing them access to public innovation funds.

As a fourth point, it is noted that the internal function of the EU market could be further strengthened, both as regarding research and innovation as well as full scale commercial activities. Actors are often not aware of capabilities that exist in other regions/countries. For example, CECIMO SME members indicate that they have little knowledge about the existence and/or competences of machine tools research centres in other EU countries, and indicate that they almost never receive offers for technology transfer from institutes outside their home country. Mechanisms that promote networking and collaboration across EU actors should therefore be further strengthened.

As regarding market functioning, an important concern is access to emerging economies, notably in Asia, which have become major users of AMT. It is experienced that these countries deploy more protectionist measures as the EU, in the form of both tariff and non-tariff barriers such as health and safety regulations or complex administrative procedures for export. Therefore, it is recommended that the EU tries to guarantee a level playing field with competing countries. As for particular trade distorting product characteristics imposed by other countries, the increased promotion of EU/ISO standards in other countries could provide a way out.

As for the EU market, it is stressed by CECIMO that limited market surveillance on performance of AMT goods is promoting unfair competition with non-compliant machinery being imported and taking market share from EU

producers. This also renders the possibility of a self-regulation measure, preferred by the sector for the implementation of the eco-design directive, very difficult.

As for regulatory aspects, companies can encounter various obstacles that block adoption of clean solutions, e.g. an unintended consequence of environmental legislation that does not allow for certain new solutions. In the Netherlands, the 'Green Deal' initiative has been launched to create a platform where government and companies that face these kind of obstacles can meet and discuss how the obstacle can be eliminated. Inspired on this, the EU Innovation Deals which focus on the circular economy field have been launched. Such initiatives should be further strengthened, and the EC could also play a role as coordinator between Member States, by promoting best practices sharing leading to faster adoption of better regulation.

At the financing level, a recent study conducted by the European Investment Bank (EIB) sheds light. The study concludes that there is a clear need for improving financing conditions for KETs companies. It is recommended that awareness about existing funding mechanisms should be increased and that surrounding advisory services should be expanded. Moreover, it calls for development of instruments beyond traditional debt financing. It may be interesting to better interlink novel financing mechanisms to improvements in the research and innovation area (see discussion above), i.e. making sure that actors involved in successful EU innovation projects are swiftly informed about / brought into contact with (EU) financing instruments relevant for their case, such that the novel technologies are deployed on commercial scale as soon as possible.

The AMT sector also faces a lack of skilled personnel and for several specific position it relies to an important extent on attracting engineers from abroad. Addressing this should be done through a constant revision of curricula and dual learning programmes or apprenticeships (which are a big success in Germany), and through promotion of the benefits of STEM educations.

2.6 Heating and cooling systems

2.6.1 Sector description

The single largest energy demand in the EU comes from heating in buildings. Therefore, the sector of heating and cooling will be regarded for buildings here, only. Different from complete buildings, heating and cooling equipment is replaced in shorter cycles. This offers a good way to reduce primary energy demand as well as emissions of buildings.

Overall, heating and cooling technologies adapt to the increased focus on energy efficiency requiring innovative heating and cooling systems. While technological leadership and comparative trade advantages put the European heating and cooling industry in a good light, its strength in trade outcomes has seen a decline in recent years and is further threatened by Asian actors especially in the cooling sector. The second major trend relates to increased shares of renewable energies for heating and cooling purposes. Both developments are mainly driven by legislation that stipulates higher efficiency levels and in some cases like newly built houses also a mandatory share of renewable heating and cooling. Another relevant development of the sector refers to the diverging nature of heating and cooling demands. While heat demands are increasingly slowed down by efficiency gains and the ongoing transformation of the building stock to near-zero-energy level, cooling demands are growing in the long run. This started from a still small EU cooling market compared to the US or Japan and is fuelled by increasing urbanization, rising disposable incomes in emerging countries as well as by higher levels of thermal insulation.

To seize the chance of decarbonising the European building stock two main goals regarding heating and cooling solutions emerge. One is to use each and every replacement of equipment to install an energy-efficient technology and in the best case one integrating renewable energy sources. The other goal is to trigger replacement of still in use old and inefficient equipment since this is the largest contributor to CO₂-emmissions from heating and cooling.

2.6.2 Barriers

Achievement of these objectives is impeded by several barriers with the most important ones relating to finance, consumer behaviour and technological readiness. High upfront costs, in particular for those technologies that use renewable energies, discourage owners. Furthermore, too little emphasis is put on low running costs compared to capital costs required when purchasing new equipment. Specific consumer behaviour such as last minute purchasing decisions when heating or cooling equipment breaks down is another severe barrier to a higher uptake of more efficient systems. These spontaneous decisions can lead to the choice of known, but less efficient technologies and thereby create severe lock-in effects for years.

And even if purchasing decisions are carefully considered, renewable heating and cooling technologies miss the not yet enough developed storing technologies to become a convincing alternative to efficient technologies using fossil resources. To develop this thought further, increasing shares of renewable heating and cooling without satisfying storing possibilities can either lead to a lower desirability of renewable heating and cooling due to a still high requirement of additional energy sources. Or, in case that electricity is generated from renewables, it leads to higher feeding of the grid. This is also not desired since it will aggravate the so far existing grid capacity issues due to the high variability of renewable energy.

2.6.3 Levers and outcomes

To accomplish a competitive development and higher uptake of efficient (renewable) heating and cooling technologies, different measures can be undertaken. One relates to information. To tackle the barrier of spontaneous consumer choices, mandatory advice could be given during the regularly inspections of heating and cooling equipment. This could refer to suitable follow-up systems to be installed. Moreover, such a consultation can be used to promote efficient network solutions such as district heating or cooling as well as possibilities emerging from energy service contracting. In case a replacement of equipment is necessary, owners may not start from scratch but from an already informed level. They may have chosen a follow-up system beforehand and have planned the financing of it. In the best case replacement of old and inefficient but still functioning equipment is triggered when cost-saving arguments and the concern of a likely breakdown prevail.

From a technical perspective, the rise of combined systems (using several renewable energy carriers or renewable as well as fossil energy carriers in one system) should be encouraged. Since a single renewable energy source is usually not sufficient to supply the complete heat/cold in a building, system solutions including one or more renewable energy sources can provide a good alternative to staying with fossil resources alone. Importantly, turnkey solutions imply user friendliness and allow integrated control and therefore a better harmonization with less efficiency losses. Besides, maintenance is also one-stop and therefore desirable. These aspects can address the increasing complexity of technologies not welcomed by users. Regarding research and development, linkage of these combined systems with storage technologies is the most urgent field of action.

To reach the goal of replacement of inefficient old heating equipment, incentive programs have been successful in different European Member States. It has however to be taken care that not only the lowest level of efficiency

upgrade is used as a windfall gain. Here, requirement of a renewables share favouring combined systems and renewable heating and cooling technologies are a possibility to be sustainable beyond efficiency increases. Besides, incentive programs for single technologies could advertise connection to district heating and cooling when appropriate since these may in the long-run be more efficient and incorporate more renewable energy than technological solutions in single flats or buildings.

Stronger incentives to use renewable energies instead of fossil ones for heating or Cooling can be implemented via a carbon tax as in place in Northern European countries (Finland, Denmark, and Sweden). This implies a higher desirability of technologies using renewable resources since prices are changing. The resulting tax revenues can serve larger infrastructure investments. In the domain of renewable energy this could aim at establishing possibilities for demand response with grids (electricity and district heating or cooling). Similarly, the resulting funds can be used to support retrofitting of heating and cooling equipment in low-income households since these are strained the most by such an imposition.

Another way to increase in particular retrofitting rates lies in the promotion of integrated business models encompassing energy consultations, manufacturers, and related services such as planning, installation, and maintenance. These networks can be initialized and established via demonstration projects where cooperation and learning can take place. Integrated business models, in particular, one-stop shops can also support the above mentioned mandatory information. In case, some equipment breaks down, these contact points can be a good start to prevent lock-in effects. Moreover, they can be a starting point to the aggregation of several retrofitting projects. To increase economies of scale, block-wise supply with heat or cold (e.g. by micro combined heat and power plants, eventually in local heating networks) can be a more attractive solution than individual retrofitting. Information on possible project partners as well as planners and financing schemes can be provided by these renovation shops or energy agencies already in place in some locations.

When (mandatory) requirements for retrofitting become more demanding it has to be kept in mind that old and inefficient heating and cooling equipment can be in place in particular in low income households. Hence, raising awareness will be insufficient to trigger retrofitting. Publicly subsidized (and maybe standardized) energy service contracting could provide a solution. The case of a carbon tax applies here in an equal manner. Low income households would be overly strained when they do not have the means to replace old equipment. Hence, either replacement is supported as stated above or the carbon tax is lowered.

Finally, since cooling is just emerging at larger scale, it is important to set efficiency requirements as high as possible. Installation of cooling equipment in residential buildings should target passive cooling as soon as possible as a mandatory standard to avoid lock-in effects in a widely emerging market. Once, conventional cooling is installed, this existing equipment is difficult to be replaced.

2.7 Measuring and monitoring (instruments, software and services)

2.7.1 Sector description

The measuring and monitoring industry is a cross-sector providing solutions for sensing, monitoring, controlling and automating. While improving productivity, efficiency and safety, it is a lever for many economic sectors, particularly for Clean Industries. As energy efficiency and the broader usage of renewable energy sources and CO₂ savings gain more and more importance worldwide, the demand for energy-intelligent, energy-efficient and climate-friendly measuring and monitoring solutions will further increase. Typical application markets with respect

to the Clean Industry taxonomy used in this study are Factory and Business Automation in manufacturing industries (in terms of "clean production"), Home and Buildings (e.g. automation, safety, energy management, construction), Electric Power and Grid (e.g. generation, transport, and distribution; focus renewable energy, smart grids, metering), and Clean Mobility (e.g. embedded solutions for e.g. ABS braking, air conditioning, engine control, traffic control).

The European measuring and monitoring industry is comparably strong with several leading global players and a high amount of innovative SMEs in a broad range of applications. The EU reveals a high technological competitiveness and long experience in complex and high-quality measuring and monitoring solutions. Particular strengths lay in embedded applications (e.g. vehicles, buildings), factory automation as well as energy power and grid solutions, based on strong experience in technological development and implementation of application-oriented measuring and monitoring products and services. In spite of high production costs, European products are strongly and increasingly successful in the EU as well as on international markets and - in contrast to other manufacturing industries - the number of jobs in measuring and monitoring products (2013: 387,000) has been growing over time (+50,000 since 2008). According to recent market estimations, North America and Europe usually account for the largest markets for measuring and monitoring, although other regions, specifically Asia Pacific, but also the Middle East and Latin America are expected to reach higher growth rates in the near future, thus prospecting further export potential for the EU measuring and monitoring industry.

Measuring and monitoring as a cross-sector is more or less relevant for all Clean Industry sectors. Thus on the one hand, growing demand for innovative Clean Industry solutions will also stimulate the demand for measuring and monitoring products and related services. From this perspective, key drivers are energy performance regulations, rising energy prices and savings from energy efficiency, but also incentives and rewards to install energy saving respective energy efficient technologies. Another important driver is technological development, such as rising automation requirements and more complex solutions. Technology and production development of meters will be highly complementary to high-tech grid components, power system automation, interfaces, and mano-electromechanical systems and of silicon measuring elements, multi-sensors for mass application, direct sensor-actuator coupling, more robust process coupling, lower measuring uncertainty and increased long-term stability. Key research fields in sensor technology concern e.g. smart and interconnected sensors, or real time measurements. Moreover, end user demands relying on changing attitudes towards the benefits of energy saving, safety or comfort will push the demand for energy-saving and energy-efficient technologies combined with innovative measuring and monitoring solutions.

On the other hand, innovative measuring and monitoring solutions will improve the efficiency, safety, and comfort of specific Clean Industry applications (e.g. smart grids and smart metering, smart building applications, traffic control systems), thus making them more attractive for potential use in households, industry, utilities or communities. In general, the demand for measuring and monitoring services is expected to grow much faster than the demand for equipment. This is driven both by price pressures and technological improvements, as well as by increasing demand from individuals, companies and governments related to increased safety, security, energy or environment concerns as well as increasing complexity of technologies.

2.7.2 Barriers

Since measuring and monitoring solutions enable energy efficiency as well as the application of new technologies in all dominant Clean Industry applications, all barriers hindering the development of those markets in principle also impede the demand for measuring and monitoring products and services. Economic or financial reasons are a decisive barrier for innovative, energy-saving technologies with embedded or related measuring and monitoring solutions, e.g. if the installation costs are higher compared to traditional solutions or if purchasing decisions are rather based on total installed costs than on long term benefits. This is particularly important with respect to the adoption of new technologies of home automation systems by the mass-market. Furthermore, regulatory and institutional barriers like the lack of regulatory enforcement, differences in regulatory frameworks across countries and a slow acceptance of new technologies by regulators play a major role. Less strict environmental or energy regulations in foreign countries can also hinder the development of the global market for smart environmental or energy protection technologies. Another barrier can be that end-users show a lack of environmental awareness and reluctance to adopt new technologies. Furthermore, technical barriers can hinder the installation of new technologies e.g. in the case that they require a certain pre-existing infrastructure. The lack of compatibility and standardization between products can be an important barrier for the mass market uptake of technology, particularly in home and buildings applications and between countries.

Moreover, the measuring and monitoring industry requires a large amount of high-skilled workers with typical STEM skills. In order to meet growing global competition, the demand for STEM workers will increase in all industries across Europe, so that the already existing gap between supply and demand is estimated to rise.

Besides, the following restraints particularly apply to selected Clean Industry applications: Barriers for innovative measuring and monitoring solutions in manufacturing industries (clean production) mainly refer to the complexity of the systems (simulation, modelling and optimization) and high development and installations costs. The main barriers for the stronger distribution of innovative measuring and monitoring solutions regarding electric power and grid are financial constraints for long term investments, legacy systems with long life cycles, a large number of actors to be convinced e.g. in installing new interregional grid structures and the lack of networking solution standards for the distributed generation of energy. Obstacles referring to more automation and ICT in vehicle systems particularly concern network security and customer's behaviour (lack of adoption), also including the still low market penetration of electric vehicles in the EU that require more and high-quality electronic control than conventional vehicles.

Barriers to measuring and monitoring solutions in home and buildings are very similar to those already listed under other priority Clean Industry sectors concerning "Energy efficiency in buildings" (thermal insulation, heating and cooling, NZEBs). Innovative solutions have high prices in comparison to incumbent technologies, preventing end-users to use new technologies, and investors to apply new technologies to retrofitting projects. Furthermore, knowledge and information deficits have to be considered: Architects and designers tend to focus on what technology is capable to do rather than customers' demand and their capacity to use the devices, and electricity installers often are not educated for complicated solutions. Moreover, home automation and energy issues are not a priority for households to date.

2.7.3 Levers and outcomes

All kinds of energy-intelligent, energy-efficient and climate friendly solutions need measuring and monitoring. Thus the strict implementation of the EU's energy performance targets combined with financial support for investors and users will directly push the demand for measuring and monitoring. On the other hand, innovative measuring and monitoring solutions can contribute decisively to energy savings and efficiency gains in all Clean Industry sectors, thus improving the cost-benefit ratio of investments as well as reducing CO2.

Levers for measuring and monitoring applications in Clean Industry comprise all actions already mentioned in the context of the other analysed Clean Industry sectors. Especially incentives to overcome the cost barrier (e.g.

financial support in form of grants for users) that impedes the distribution of new technologies are highly important for the broader implementation of innovative and sustainable measuring and monitoring solutions. For this purpose regulatory targets have to be combined with financial incentives for investors and users (e.g. financial support in form of grants). The necessary funding could inter alia be provided by carbon taxes as already used in some Northern European countries.

Other suggestions refer to the awareness towards the direct and indirect benefits of energy-efficiency. In this context instruments to improve information and knowledge of all actors involved (e.g. information campaign, training for on-site workforce etc.) play a major role.

A more explicit relation to the measuring and monitoring industry itself is applied to the development of European and global standards, removing market entry barriers and stimulating competition and innovation between measuring and monitoring suppliers within the EU and worldwide. To achieve this target, the EU should on the one hand push the development of EU wide standards in all Clean Industry application fields. On the other hand the EU should promote the use of EU/ISO standards in trade. This helps to avoid export barriers, especially vis-avis emerging economies.

Furthermore, the challenging technological competition with the US, Japan and – continuously progressing – China, will require more R&D investments and high-skilled employment. The education and availability of these STEM workers (e.g. electrical engineers and technicians, IT specialists and technicians) will be essential for assuring that the European measuring and monitoring industry will be able to participate in domestic and global growth opportunities. Albeit a recent study⁷ depicts that actually only a small subset of European firms face genuine skill deficits. However, the affected firms are particularly dynamic, internationally oriented EU companies that have greater and more demanding skill needs that can be found particularly in specific economic sectors including the measuring and monitoring industry and other selected Clean Industry sectors such as the wind industry, AMT, smart grids or cleaner mobility. Highlighting STEM as a priority for education in the EU in general and increasing the understanding of career pathways of STEM graduates in measuring and monitoring (as well as in other growing Clean Industry fields) could contribute to stronger attractiveness for this study field. Furthermore, a mix of human resource policies by companies and policy-makers, creating the right incentives and institutional frameworks would strengthen the employers in developing and implementing vocational education and training arrangements. Examples are the offer of better and stable jobs and high quality apprenticeship places, a greater cooperation between companies, employer associations, and education and training institutions, exploiting the talent of females and older workers, etc. Further measures address the improvement of transnational and cross-sector mobility between businesses, education and training institutions and research institutes, e.g. by stimulating lifelong learning, fostering joint education and training projects and programs across Europe, and strengthening the mutual recognition of qualifications as well as harmonizing the assessment of learning outcomes.

⁷ Cedefop (2015).

2.8 Thermal energy storage

2.8.1 Sector description

Thermal energy storage offers the opportunity for effective and efficient generation and utilisation of heat where heat supply and heat demand do not match spatially and in time. The future electricity grid will integrate more renewable energy, especially wind and solar including decentralised supplies. So supply and demand must become more flexible, through wider use of demand reduction, demand response mechanisms and energy storage. Linking heating and cooling with electricity networks will reduce the cost of the energy system – to the benefit of consumers. For example, off-peak electricity can be used to heat water in lagged tanks which can store energy for days and even weeks.

Thermal energy storage promotes both more effective thermal management in such as sectors heating and cooling as well as process heat and power generation and enables an increased utilisation of renewable energy. Heat storage is currently by far the largest single energy storage application field in Europe, making it a key enabling sector in the transition towards a more sustainable economy.

Thermal energy storage can be stored as sensible heat (whereby the stored energy is proportional to the generated temperature difference of the storage medium), latent heat (whereby heat is stored in the process of phase change (e.g. melting) of a material) or as thermochemical storage (whereby heat is adsorbed in the form of chemical compounds created by an endothermic reaction). Most applications are currently based on sensible heat storage (with water being an evident storage medium, both in residential and industrial applications), however latent heat applications are rising. Thermochemical applications, while very promising because of very high energy density potential, are still largely in research phase.

Examples of thermal energy storage value chains include the underground thermal energy storage (UTES) (e.g. hot or cold water stored in a borehole, pit or aquifer), storage of thermal energy prior to dispatchable electricity generation in concentrated solar power (CSP) plants, and use of phase change materials (PCM) for energy saving applications e.g. for air-conditioning and/or heating purposes in buildings. This study zooms in on these three specific value chains.

2.8.2 Barriers

Regulation: for UTES, some legislative frameworks make it difficult to realise thermal energy storage projects. As an example, in some countries it is not allowed to inject water warmer than 25 degrees into the ground. On the other hand, the negative influence of potential regulation such as capacity markets is expected to be limited with respect to thermal energy storage.

In general, development in thermal storage largely depend on the regulatory framework and in particular on the incentives for renewable energy. So far, most policy focus (with an exception for the Scandinavian countries) has been laid on renewable electricity, while more than 50 % of the final energy demand in the EU is used for generating heat and already now heat storage is utilised in water-based systems for domestic and district heating.

There are still large environmental gains to be reaped in the heating market, in which thermal energy storage can play a key enabling role by supporting various renewable energy sources. For instance, combined generation of heat and power (CHP) with ad-hoc thermal energy storage increases the efficiency of CHP as heat production can be stored rather than curtailed if not needed at that moment. Currently the European Commission is looking into rules to integrate thermal energy storage (in buildings and district heating) into flexibility and balancing mechanisms of the grid and will study in particular how to expand the use of thermal energy storage in the electricity system.

Capital and finance: the business case for energy storage is currently not always strong enough due to the low energy prices and capital costs. In order to make energy storage economically viable one needs energy price fluctuations. Some types of energy storage require considerable investments with rather long payback times.

R&D and innovation: UTES does not yet fit in existing paradigms, actors in the energy market are not yet used to storage installations and the uncertainties in the subsurface that are involved. While public resistance is overall very low and many projects have been implemented so far in NW Europe, it remains however important to involve stakeholders (competent authorities, public, local organisations etc.) early in the process. The energy sector in the EU is not yet very actively embracing the concept of thermal energy storage, however it is perceived by stakeholders that this is gradually improving.

Several demonstration projects in UTES show that the different storage technologies (pit storage, borehole storage, and aquifer storage) are not all suitable for the same purpose: some technologies are well-suited for short term flexibility, but have limited capacity, whereas other technologies are exactly the other way around. The technologies by itself are fairly well-developed, with TRL scales around 6, 7 or 8, however integrating them optimally in the energy system (heat, electricity grid) or the building stock is a different story and needs a balanced approach with a forward looking perspective.

In the PCM market, a key challenge is to reduce the costs of these materials. Currently PCMs are still too expensive to be used as heat storage media on large scale, while large scale storage would be needed for a complete breakthrough of thermal energy storage. A key challenge in this respect is to increase the storage density of thermal energy storage based on PCM or TCM (Thermochemical Materials) in order to enable the implementation of thermal energy storage in applications with less available volume and to enable the cost-effective long-term (up to seasonal) storage of renewable heat. Hence, barriers are here largely technology related, but also increasing the overall awareness about potential of PCM is a key challenge.

2.8.3 Levers and outcomes

As a general remark, all policy actions that stimulate renewable energy technologies and energy conservation (e.g. waste heat utilisation) indirectly stimulate storage technologies, due to the strong interdependencies involved. In order to let the thermal energy storage sector flourish, the value of the storage function should be properly rewarded. Investment in stand-alone thermal energy storage or renewable energy projects with thermal energy storage integrated avoid other balancing measures to compensate for intermittent renewable energy production (e.g. costs related to investment in flexible natural gas fired power plants), and these societal benefits should be well embedded in the public incentive schemes.

Generally, it is felt that the idea of storing thermal energy, especially underground, is still looked at rather reluctantly by the energy sector, although this is gradually improving. In this respect, it should be stressed that both the EC and the Member States have a very important signalling function. One the one hand, this can be done in very practical support measures (e.g. removing regulatory obstacles, promoting R&I in thermal storage, creating investment incentives) but also by providing a long term vision to the sector in which thermal storage has its place.

Cross-country learning can be very useful in this respect. For example, in Denmark an example exists of agreements between thermal storage parties (implemented in district heating) and the TSO and DSO's in the

electricity grid, simplifying the exchange of electricity and heat and providing flexibility to the electricity grid. These kind of new forms of business models and organisation should be further explored.

Growth of thermal storage could be also promoted by addressing some particular regulatory aspects. For UTES, there are a number of technical constraints in deploying this technology. Policies that impede use of the underground for thermal storage functions should be eliminated. Also related to these regulatory issues, it would be very relevant to promote best practices sharing between Member States, as some have a good history in promoting UTES, while others are still in early stage of development.

In some countries there are measures to reduce uncertainty related to investments in geothermal energy, which always bear a certain level of uncertainty as it is not fully predictable what the precise underground conditions will be found after (expensive) drilling. For example, in The Netherlands there are certain funds for geothermal energy that cover companies when the results are below expectation. These insurance policies help covering the risks involved, something that is necessary given the fact that it is often SMEs and regional authorities that are involved with these projects. Such de-risking policies could also be applied to UTES projects, as similar uncertainty aspects apply there.

Policies concerning the discharging of waste heat can also be very important for promoting thermal energy storage. If companies are not allowed or discouraged to discharge waste heat, they have to start thinking about how to better use this waste heat. This can bring many other advantages as well (e.g. less heat pollution of rivers, higher operating flexibility and cost savings).

As for the PCM applications, awareness among its applications is still insufficient. Ensuring adequate and fair treatment within the building codes at the National level and the relevant calculations of its impact on energy savings would be of most relevance for its deployment and overall awareness.

2.9 Smart grids and super grids

2.9.1 Sector description

In comparison to the conventional electricity grid, smart grids contain increasingly new elements integrating communication and ICT applications which allow for a bi-directional flow of energy and information, providing possibilities for distributed power generation especially from renewable energy resources, demand response, smart metering solutions, connecting electrical vehicles, energy storage capacities, and increasing grid reliability, quality and security through self-monitoring, remote checks and automated grid reconfiguration. Smart grids offer entirely new business opportunities for existing players in the energy supply chain such as technical and commercial aggregation services, yet provide also possibilities for value creation and capturing to existing consumers and businesses who in the end will become so-called 'prosumers'. New pricing schemes such as dynamic pricing become a potential reality, as well as possibilities for micro grids and local energy markets. Smart grids are instrumental for increasing energy efficiency, reducing GHG emissions and fostering the valorisation of renewable energy resources.

The main drivers for investments in smart grids are the need to cater for distributed energy generation due to the growth in renewable energy production, replacement of obsolete conventional infrastructure, cost reductions, potential value creation and capturing through new business models and the substantial increase in (global) electricity demand for the years to come. Also gaining knowhow and first-hand experience with prototypes and demonstration projects is an important driver for investing and developing smart grid solutions. An important group of actors in the smart grid sector are the energy companies, TSOs and DSOs. Downstream these deliver

electricity and smart grid services to customers with e.g. NZEBs, energy storage facilities from companies and households. Upstream one can distinguish electric and electronic engineering companies, and ICT companies. Large companies such as Siemens, ABB and General Electric provide a wide scope of products and services to the utility industry that wants to install smart grids. Other, more specialised companies rely on strategic partnerships to offer a comparable portfolio of solutions.

2.9.2 Barriers

Various barriers for the deployment of smart grids can be identified, yet a number of them are key to overcome in order to provide leverage to the EU smart grid deployment in the EU. One of the major barriers is adjusting the regulatory frameworks in the Member States' energy markets to allow valorising smart grid opportunities, and define the contours of the new energy markets. At EU level the supra-national dimension comes into play, building further on the internal EU energy market.

Standardisation is another important barrier to overcome, in particular standards for interoperability between various networks and systems. This is all the more important at the EU scale where interoperability provides an additional benefit for balancing idiosyncratic regional imbalances. Micro-grids definitely do have their benefits, yet the costs and benefits are local. Integrating micro-grids within the national grid systems and ultimately within the EU smart grid provides additional leverage for the smart grid sector, as well as for its client sectors such as prosumers, NZEB owners, and renewable energy producers.

Although recently quite some progress has been made in the integration of ICT solutions into the energy network, still quite a number of technological challenges remain to be solved. Experts indicate that the current state of the EU smart grid capabilities is somewhat in the middle, compared to what is needed in a mature technology phase. With the current mix of conventional and renewable energy production, grid security and balancing can still be done with conventional methods, such as importing and exporting grid load. Especially as the EU aims to increase its share of renewable energy up to 20% in 2020, a substantial growth in renewable energy production is needed, which creates the need for a large scale application of new smart grid applications which are currently only tested at individual deployment projects. Also the bi-directional nature of the grid is in most, if not all, Member States very limited, and confined to particular pilot implementation areas.

2.9.3 Levers and outcomes

One of the main policy actions to be done in the near future for providing leverage to the EU smart grid sector is optimising the regulatory framework with respect to the new smart grid functionalities. The regulation in the electricity market needs to be adapted to smaller and less complex technical units. A notable example in this respect is the minimum bid threshold of 10 MW. Although this is relatively small in terms of conventional energy production, for aggregators that use the surpluses of smaller renewable energy producers to offer flexible grid management solutions, this puts a substantial minimum entry condition in terms of network size.

Other actions with respect to regulation relate to introducing dynamic tariffs. This would provide the necessary incentives for flexible consumption and also for investing in infrastructures, goods and services enhancing the benefits of flexible consumption. This would imply a leverage effect across the entire smart grid value chain from grid management services for combining flexible demand response with distributed energy production to NZEBs and smart consumer durables and in particular electric vehicles.

The adjustment of the regulatory framework should also focus on the market regulation aspect. New technologies generate new potential business opportunities. Yet without a clear and adapted regulatory framework indicating who has to or can do what and under which minimum performance criteria, there is little incentive left for investing in more advanced smart grid solutions, let alone rolling them out on a larger scale. An obsolete regulatory framework generates a market environment with a high systemic business risk which is not conductive to investing further in smart grid solutions. Examples in this respect are the regulatory framework for open platforms, and that for aggregators.

Standards for enhancing the interoperability of smart grids between Member States but also within Member States between local so-called micro grids, even inter-regional, need to be defined and elaborated. Interoperability is not only for the TSO high-voltage energy exchange at country level. Yet it has also a clear regional and local dimension since the integration of the renewable energy is primarily at that level forming micro-grids with local prosumers, EV owners, DSOs and smart grid service providers. Beside the geographic dimension, interoperability has also a value chain dimension in the sense that devices, platforms, services all need to be able to communicate with each other ranging from renewable energy generation, storage capacity, to flexible consumption. Currently proprietary standards are used to overcome the problem but this creates a segmented market. A point of attention is that the new interoperability standards should not only focus on large and more complex units but are 'user-friendly' for the smaller units as well.

Sustained support for R&D, innovation and for the deployment of new smart grid technologies, products and services remain essential, since many of the envisaged services still are not for today and require a substantial research efforts. These can be partly covered by private investments, but public support remains essential to bridge the so-called valley of death where technology readiness is still too low for private investors to come across. A set of critical technologies have been identified that are necessary to further improve the functionality of the EU smart grid particularly when it comes to the efficient integration and use of renewable energies. These critical technologies are situated in the areas of ICT, sensing, measurement and automation, power electronics, and energy storage technologies. For these continued government funding e.g. through the EU Horizon 2020 programme, remains essential, especially given their rather fundamental research nature and since the envisaged benefits do have a societal value through improved energy efficiency and its contribution to climate mitigation, as well as knowledge creation. Also support for research focussing on solving problems concerning security, privacy and reliability is an important lever in this respect.

2.10 Rail (train, metro and tram)

2.10.1 Sector description

The European rail industry is a diverse industry, incorporating thousands of SMEs as well as major industrial champions, and a supply chain ranging from infrastructure, to rolling stock to signalling systems. The European rail industry has absolute sales of \in 47 billion, accounting for 46% of the accessible global market for rail products, and employs approximately 400.000 people all over Europe. If the workforce of the rail operators and infrastructure managers are included, the industry employs approximately 1.8 million Europeans. The rail industry is the greenest and safest mode of transport. The rail industry generates only 0.9% of energy related CO2 emissions, compared to 22% by other transport modes, while it meets 9% of the total transport demand. The industry is furthermore committed to further improve its energy efficiency through different technologies and methods, such as hybrid technologies, weight reduction, regenerative braking, energy storage, new traction technologies, optimised operational parameters or alternative green power supply solutions. The share of rail in

transport usage is still lower than it should be, and there is still a great need in increasing this share in order to meet the decarbonisation target of a 60% reduction in CO2 emissions in the transportation sector by 2050.

Traditionally, Europe still has an absolute leadership in the fields of know-how, innovation, research and technology. Innovations such as the high speed train, the ERTMS and automated metro systems have all derived from the European rail industry. However, the European rail industry is facing a pivotal moment as industrial competition from Asia and particularly China is increasing rapidly. The accessible market is expected to grow with a compound annual growth rate (CAGR) of 2.8%, with major growth markets in NAFTA (3.7%), Asia Pacific (4.2%) and Latin America (5.7%). A large part of the global market growth takes place in regions with a strong own production base and therefore a relatively low import penetration, which implies that domestic suppliers will benefit larger from this growth. In Europe the rail industry is also expected to continue growing, among other reasons due to the policy objectives set for changes in the European transport sector.

2.10.2 Barriers

One of the barriers in the European railways system relates to the many different strategic choices that have been made and the different laws, different technologies that are in place in the Member States hampering the interoperability of the rail industry in Europe. As an example of negative consequences, these differences make the authorisation of rolling stock in Europe a costly, lengthy and complicated process. Relating to these interoperability issues, is the issue of fragmentation in the production, which results in a low level of collaboration and partnership among the rail industry players, a lack of system approach, a lack of appropriate consideration of customer needs, etc.

Europe's export potential is limited by different non-tariff barriers to enter non-EU markets, especially in the major competing economies. Examples of such barriers in China are related to standardisation and technical regulations, insufficient IPR enforcement and heavy certification procedures. However, also within the EU there are still improvements to be made with respect to creating a single market in the EU for railway supply.

As identified earlier in this chapter, Europe thanks its technological leadership partly to the successful innovations being a result of the R&D investments of the industry. However, the lower gross operating rate of the industry in recent years limits the ability to raise the necessary funds for R&D activities to maintain its technological lead. Innovation costs are relatively high in the rail industry. Finally, the process of entering innovations into the market is a very complex process of acceptance and homologation, hampering innovation in the industry. Contributing to these financial barrier, is the capital intensive characteristic of the railway industry. The lifecycle for vehicles is about 40 years and the lifecycle for infrastructure is up to 100 years. As a consequence, investments cannot be made overnight, an issue which is magnified by the European complexity of making large scale cross-border investments. Furthermore, the issue of the long lifecycles is a major problem for the market entry new and innovative solutions, especially in the freight sector, where fleet renewal is extremely slow.

Another barrier relates to the competitive pressure of other transport modes on the rail sector. This competitive pressure should not be undermined, since it may create a vicious circle: higher competition could pressure profit margins, which in turn pressures investments, which in turn results in a higher exposure to competition. This problem is mainly driven by financial barriers: the high capital intensity of investments, the long lifecycle of assets, expensive product customisation. However, besides the financial barriers, flexibility issues such as the last mile issue also play a role, as well as reliability issues such as a poor customer satisfaction, and a lack of information in the freight sector.

Shortages of skilled personnel are already experienced, and these shortages are expected to increase due to an ageing population in many Member States. The lack of skilled labour is further driven by the trend towards more sophisticated railway technologies.

2.10.3 Levers and outcomes

The European rail industry is facing a pivotal moment where industrial competition from Asia, and especially China and Japan, is becoming increasingly strong. In an event, organised in 2015 by UNIFE (the European Rail Industry Association), European rail industry leaders and stakeholders and EU decision makers have gathered to discuss the competitiveness of the European rail supply industry. The need for both industry and European leaders to act quickly and take measures to strengthen the industry by fostering research and innovation in rail and improve the skills and training of the rail supply work force was highlighted, as well as the need to enhance the internal EU market for rail supplies, ensuring fair market access to European rail suppliers abroad and boosting export potential. Furthermore, it was highlighted that there is a need to improve the business environment for rail supply SMEs and demand for rail projects should be stimulated both domestically and abroad through pro-rail policies, financial instruments and funds.

With respect to creating a single market in the EU for railway supply, the European Commission is aiming to gradually increasing the harmonisation and interoperability of EU railways through the implementation of several Directives. Enhancing the functioning of the internal market is expected to spur efficiency and productivity in the European rail industry (e.g. through economies of scales, reduction of certification, testing and common standards reduce the number of variants to be produced). Besides increasing the competitiveness of EU companies within the Single Market, harmonisation efforts may contribute to a reduction of non-tariff barriers in third markets. One of the major initiatives with respect to the rail sector is the Shift2Rail initiative. Shift2rail is a joint European undertaking for rail research aiming to leverage or promote a shift to rail by accelerating the integration of new and advanced technologies into innovative rail product solutions. The Shift2Rail initiative aims to double the capacity of the European rail system and increase its reliability and service quality by 50 %, all while halving life-cycle costs. The initiative was established in 2014 under the Horizon 2020 programme, amounting a budget of at least €920 million for the period 2014-2020, of which a maximum of €450 million will be contributed from the Horizon 2020 Framework Programme. To access this funding, the rail industry had to commit to a contribution of at least €470 million. The rationale for this public-private partnership is the transnational nature of the infrastructure and technologies to be developed in support of the Single European Railway Area, and the need to achieve a sufficient mass of resources.

With respect to capital and financing, there is always a need for more public funding, more advantageous taxation, and loans or structural funds for big structural projects. A mechanism to encourage investors should be developed in order to solve these issues of rentability. There are some organisations such as the Bank of Japan that invest in vehicles, buying vehicles and renting it to other companies to provide the transport and services (like investments in real estate). It could be extremely interesting for the European railway industry to take capital outside from Europe.

With respect to maintaining sufficient supply of skilled labour, it is advised to intensify or sustain cooperation of companies with universities; to continuously adapt curricula of training and education programmes to address new technological developments and trends such as the drive towards higher energy-efficiency; to develop progressive formal career paths by companies and their associations and to improve the skills of medium qualified labour (e.g. through the introduction of apprenticeships or similar vocational schemes); and to improve labour mobility by regular monitoring of supply and demand across Europe.

A final interesting notion to mention relates to the many developments in recent years related to the 'uberisation' of society (Uber, Blablacar, etc.). The railway system has a huge potential to contribute to the objectives pursued by this movement (environmentally friendly, no car ownership, free movement). However, there remain problems in terms of reliability, accessibility, price, and regarding the so called last-mile. These problems cannot be solved by addressing the railway section alone, instead, we should address more the complementarity of the different modal transports. An idea could be to propose demand side solutions such as companies offering employees an Uber abonnement to go to the station (to solve the problem of the last mile). For instance in Belgium there are benefits for companies that stimulate their employees to come to work by metro or train, which is a way to stimulate the demand for the rail sector. Furthermore, policy cooperation between the rail and road sector should be stimulated, as there is now some sort of a policy gap. Especially regarding the freight segment it would be beneficial to combine these two modes of transport.

2.11 Thermal insulation

2.11.1 Sector description

The EU aims to have a complete energy-efficient building stock by 2050. This requires significantly growing building renovation rates and proposes additional value added and jobs in the European thermal insulation industry and related services, mainly in SMEs and on the local level. Similar developments to improve energy efficiency of buildings can be observed in other countries and world regions. This pushes the global demand for thermal insulation of buildings that prevent heat gain respective loss through the building envelope (i.e. floor, walls and roof). Estimations show that improved efficiency in buildings could cut Europe's total energy use by over 20%, reduce energy bills by \in 270 billion and CO₂ emissions by 460 million tonnes yearly. This concerns new buildings as well as improvements for existing buildings. In order to achieve the long-term EED targets, estimations come to \in 100-170 billion investments p.a. necessary for insulation and windows from 2015-2040⁸, implying 170,000 to 290,000 jobs p.a.

The total market for thermal insulation products in Europe 2014 equated to an approximate value of €11.5 billion. 59% of the market is attributed to Western Europe, 25% Eastern Europe and 16% Central Europe. Glass wool (36%) and stone wool (22%) combined represent 58% of the European thermal insulation market, the remaining market is nearly exclusively attributed to cellular plastic products. The EU has a strong technological and trade competitiveness in thermal insulation products, creating good preconditions to tackle more complex technological solutions and to participate in the forecasted growing demand inside and outside the EU. Yet, due to the local character of the superior construction industry, global competition in the thermal insulation product market is less pronounced than in other Clean Industry markets.

Regulation policies and legislative support (e.g. tax benefits or rebates) coupled with high operational costs due to increasing energy prices will be the main drivers for the overall demand for thermal insulation products. Other drivers are population growth and urbanization as well as rising disposable incomes in emerging economies in Latin America and Asia Pacific. Furthermore, the construction of new buildings, suffering a lot during the global recession, has recovered in most regions. This is particularly true for the US, but also for Europe inter alia

⁸ Boermans et al (2012).

supported by low interest rates. In Europe and North America medium-term growth in thermal insulation products will mainly be attributed to wool insulation demand, in Asia Pacific to plastic foam demand.

Sustainability is the major force behind the development of new technologies, but there is no easy answer to this issue with respect to conventional insulation materials. Hence, it is not correct to assume that natural fibers be automatically more sustainable than plastic foams. Advanced super insulation materials (SIMs), such as vacuum insulation panels or aerogel based products are expected to witness growth in the future particular in niche areas of the renovation market, such as refurbishments with weight or space limitations or to avoid thermal bridges. Further innovations in this field could slowly disrupt the conventional insulation market and might force the actors to lowering prices, increasing marketing efforts, delivering more systematic approaches or focusing on SIMs, too. With respect to new buildings, there is an increasing trend to develop factory-made durable high quality building envelope elements combining high insulation levels, high air-tightness and fast erection speed.

2.11.1 Barriers

As already mentioned in the context of Near Zero Energy Buildings (chapter 2.4) and efficient heating and cooling technologies (chapter 2.6) Europe's challenge mainly relates to the energy-efficient renovation and investments in the existing building stock, because the existing market for building renovation is still small relative to the size of the opportunities. This is mainly due to the fact that although diverse national plans and targets exist on paper, the slow implementation of the required measures and the lack of unique standards and certificates hamper the market development for thermal insulation within the EU. Thus, the barriers and levers described in this chapter are similar to those identified for the other priority sectors in the field of "Energy Efficiency in Buildings".

Important regulatory barriers particularly refer to a lack of coherence in the implementation of the Energy Efficiency Directive (EED) at national level, since the national long-term renovation strategies have not been transported in higher energy renovation rates satisfactorily. Furthermore, the implementation of Energy Performance Certificates (EPC) schemes at Member States level is still ongoing and struggles with challenges such as public acceptance and market uptake.

Furthermore, initial costs are a main barrier for deep thermal insulation. Advanced building envelope alternatives are cost-effective over a long-term investment period but require greater initial capital financing. Reducing first costs and increasing annual savings that result in a greater overall improved return on investment will enable greater market uptake of advanced building envelope designs.

Another barrier is misalignment of financial incentives, because the residential owners investing in energy efficiency measures are often not the ones receiving the direct benefits, as around 70% of the EU population lives in privately owned buildings. This manifests itself as the usual "landlord/tenant" barrier. Moreover, the long-term financial and wider benefits of improved energy efficiency (improved supply security in terms of reduced dependency on fossil fuels and energy imports, reduced carbon emissions) are often regarded as less certain, partly because of the lack of relevant and trustworthy information in the market. This is not only true for residential buildings, but also for industrial buildings and impedes particularly the market diffusion of new thermal insulation technologies, that are generally unknown to potential users, as well as to building planners and installers that recommend thermal insulation products to final consumers. This also applies to new super insulating materials (SIMs) that are superior to conventional insulation products, but have higher material costs and suffer from actor's lack of knowledge and experience.

2.11.2 Levers and outcomes

Generally, the retrofit of the building envelope to more energy-efficient solutions can be leveraged via integrated business models combining energy consulting, selling of the actual equipment, installation and maintenance. Experiences made in single Member States (Germany, Sweden, United Kingdom) show that building codes and standards play a highly significant role in promoting the development of technology and in pushing high-performance products onto the market. The analysis proves that the EPBD and voluntary standards have forced market actors to find system solutions and to establish various forms of collaboration. This is particularly important in the insulation industry, where platforms for interaction and feedback processes with potential intermediaries (such as architects, construction firms and installers) are still limited.

Since energy efficient investments in thermal insulation require high investment costs, policy actions to foster thermal insulation in buildings should focus on the fast implementation of renovation rates and mandatory building codes within the national long-term national renovations strategies combined with public funding and financial incentives for private building owners as well as specific support for social rental properties and low income households. Clear targets and building codes also provide guidance for building owners towards the required level of thermal insulation. Programs that support the broader implementation of energy managers can help to avoid split responsibilities.

Establishing targets, stricter legislation and support measures for deep energy renovations will also help to unlock the transition of new insulation technologies and materials (e.g. SIMs). To allow one type of insulation to be compared with another, it is vital to have accurate test protocols, ratings and performance declarations for the energy performance of different materials. Case studies and demonstrations can help to promote overall greater system energy efficiency and better cost-benefit-ratio of high-level thermal insulation solutions, thus supporting market distribution. Furthermore, trainings, guidelines and quality schemes shall be implemented to increase the competence level of the on-site workforce and building services in order to level the potential of advanced thermal insulation technologies.

To close information and knowledge gaps with respect to investments in thermal insulation, the long-term financial savings and co-benefits of low-energy buildings, such as comfort and health, need to be communicated in a better way to the public and to financial communities. A recent example is the German campaign "Deutschland macht's effizient", addressing all potential users (households, enterprises, communities) and serving information as well as public support measures to all sectors concerning energy-efficiency, thereby also thermal insulation in buildings. In this context, it should also be made clear, that all policy measures to improve thermal insulation will directly leverage investments, create jobs and pay back in Europe because of the local characteristic of the industry.

2.12 Traffic control systems

2.12.1 Sector description

As of today, transport is still one of the major sources of greenhouse gas emissions in the EU, due to its large dependency on fossil fuels. And total emissions from transport are expected to increase due to a combination of factors including rising vehicle numbers, higher transport volumes, longer transport distances and improved safety, speed and comfort. Traffic control systems have been identified as one of the possible means to reach the ambitious target of reducing greenhouse gas emissions from transport by 2050 by 60% on 1990 levels.

Traffic control systems can be described as a variety of applications for planning, monitoring, and controlling or influencing various modes of transport (road, rail, aviation and waterborne). Traffic control systems are aimed at providing a wide variety of applications to help realise broader transport policy goals (e.g. maximising the effectiveness of the use of existing infrastructure; ensuring reliable and safe operation of transport; addressing environmental goals; and ensuring fair allocation of infrastructure space (road space, rail slots, etc.)) including decreasing emissions from transport. A particular strength of Europe in the field of traffic control systems appears to be the cooperation between the European Commission and various transport industries in the development of coordinated initiatives for the implementation of European wide traffic control systems. Examples are the 2008 Action Plan and 2010 Directive for the implementation of Intelligent Transport Systems (ITS) for the application of traffic control systems in road transportation, the European Railway Traffic Management System (ERTMS) for the application of traffic control systems in rail transportation, and the Union Maritime Information and Exchange System (SafeSeaNet) for the application of traffic control systems in waterborne transportation.

In order to be effective, traffic control systems need to be deployed systematically throughout a given transportation system and across countries. Furthermore, since traffic control systems are supported by a wide set of technologies and services supplied by a wide variety of public and private stakeholders, there is a great need for standardisation and harmonisation in this sector.

2.12.2 Barriers

The 2008 ITS Action Plan was aimed at overcoming the slow and fragmented uptake and deployment of ITS in road transportation. ITSs had at the time already been applied across the EU, but in a fragmented manner, in mono-modal instances, in geographically isolated domains, and incompletely. The action plan listed different measures to counter different barriers contributing to this slow and fragmented uptake and deployment of traffic control systems, including: differences between national policies and rules for cooperation on data exchange, content and service provision; interoperability issues; fragmented deployment of traffic control systems; lack of easy and efficient access to knowledge about the benefits and costs of ITS applications and services, and about experiences and evaluations of ITS implementation. Besides the many successes the Action Plan has achieved in the past few years regarding the deployment of ITS's in Europe, there have also been some difficulties in the implementation of the Action Plan. Difficulties have been encountered in building consensus among Member States and stakeholders. As a consequence of the multitude and diversity of stakeholders and its various and sometimes diverging stakeholder interests, progress has been slow in some actions owing to the resistance of some players. In other cases, lack of involvement or real interest from some major stakeholders has caused delays. Finally, the wide range of very specific but quite different types of action set out in the Action Plan did not help to prioritise actions. Most of the earlier mentioned key barriers are found still to be in place. Additional barriers mentioned in specialised literature are: unbalanced deployment of ITS among EU Member States, among transport modes and among major transport players and SMEs; lack of or limited funding that would facilitate investments; reluctance from some transport operators (especially SMEs) to adopt advanced technologies (either due to financial restrictions or due to lack of specific quantified benefits); bureaucratic obstacles and a lack of legislation in certain European countries; lack of or limited cooperation between the research/academia and industrial sectors; lack of quantified/tangible benefits from the use of mature ITS applications that would prompt other transport stakeholders to invest in similar solutions; and low visibility of outstanding ITS applications.

The wide variety of barriers mentioned with respect to the uptake and deployment of traffic control systems in road transportation in the form of ITSs are a good illustration of the barriers related to traffic control systems in general. However, the main barriers mentioned with respect to traffic control systems in rail, aviation and

waterborne transportation are related to interoperability issues. Interoperability in technological and regulatory terms, is seen as a key requirement for further development of sector, and also for potential export of European products to promising regions. Traffic control systems require different components, technologies and actors to cooperate for the functioning of the system as a whole. Deploying traffic control systems requires a careful analysis of the specific institutional and regulatory frameworks that are in place with respect to the different stakeholders involved. Traffic control systems require the inter- and intra-system interoperability, within sector but also in connection with other sectors, such as the ICT sector and the energy sector. Effective deployment of traffic control systems also requires data sharing, and challenges regarding the privacy, availability and trustworthiness of data still need to be overcome. Harmonised regulation, standardisation, legislation and policy could contribute to solving the some of the problems resulting from this complexity, and the lack of harmonisation and standardisation can therefore be considered as one of the major barriers related to traffic control systems.

One of the barriers for the further development of traffic control systems in Europe is derived from a platform for stakeholders from the various EU transport sectors aimed to discuss the implementation of the 2011 White Paper on Transport. As one of the most important barrier the stakeholders identified a lack of commitment and a lack of goals and targets behind policy goals on traffic control systems. Currently, recommendations on EU policy level are too general. The different interpretations of the current policy framework on a European level represent a major barrier, which can only be overcome by multi-level and multi-actor policy coordination. Without a clear goal and purpose (e.g. to achieve a considerable increase in public transport) there is no incentive to invest in multimodal information systems and there will not be sufficient political driving power to overcome these implementation barriers.

Finally, traffic control systems require considerable investment and effort. Funding schemes are necessary to implement investments, at both regional, national and European level. As a result of the economic downturn in 2008, followed by the financial crisis in 2011, receiving funding for the deployment of traffic control systems has become an increased issue, since there is competition against traditional hard infrastructures.

2.12.3 Levers and outcomes

A review of the ITS Action Plan highlighted its major successes. Identifying the successes is important in determining further policy actions. The main foundation for the success of the Action Plan was mainstreaming the notion of ITS in the design of transport policies and highlighting the value of deployment of ITS. Furthermore, the Action Plan has increased awareness about the need to tackle bottlenecks that hinder interoperable deployment and to address other technical or legal issues hampering a broader take-up of such systems. Finally, the Action Plan has been a catalyst for a greater and more focused involvement, cooperation and collaboration of the large stakeholder community. Demonstrating the benefits of traffic control systems has turned out to be crucial in securing funding. It thus appears that increasing awareness and providing information about the benefits of traffic control systems is a policy suggestion that should be pursued among all areas of traffic control systems.

With respect to barriers related to interoperability issues there is a need for harmonisation and standardisation on a European level. European policy should support national and regional approaches by proposing specific quality measures for harmonizing services across Europe. EU Cohesion Policy can provide support for research and innovation in this area.

However, besides regulatory harmonisation and standardisation it is necessary to organise commitment, cooperation and collaboration between the many stakeholders involved in traffic control systems. Examples of relevant platforms are iMobility Forum, the European Technology Platform ERTRAC, the European Innovation

Partnership Smart Cities and Communities, the Smart Cities Stakeholder Platform, the Green Digital Charter, and the Covenant of Mayors.

With respect to capital and financial barriers involved with traffic control systems, accessibility to funding is deemed highly necessary, and European structural and investment funds in combination with other financing opportunities remain key to the further deployment of the traffic control systems industry and its deployment in Europe.

A final interesting notion regards the disruption traffic control systems might impose on traditional business models in the transport industry. Traditionally governments provide infrastructure, and the industry provides vehicles. Traffic control systems however operate in the various areas that are interconnected. The traffic control systems industry therefore may create opportunities for many players ranging from different industries and different levels of authorities. In a paper on the challenges arising from this new situation it is concluded however that no single player can bear the costs needed to fund the investments in these traffic control systems projects. As a solution, joint investment pools and new contribution-remuneration systems are suggested. Examples can be found in the sharing economy, such as a consortium built around Autolib' in Paris, a form of joint investment and sharing of public and private benefits, or a partnership between General Motors and RelayRides, a peer-to-peer company that provides a service to rent your own vehicle to another person. Another example of an industry that might provide interesting business models are telecommunications, where cooperation between public and private players have succeed in bringing technological breakthroughs (2G-3G-4G, capacitive technology) into innovative offers based on new, shared and viable business models.

3/ Barriers and levers: interrelations among Clean Industry sectors

While the previous chapter focussed on the 12 selected sectors separately, this chapter explores the interrelations between the 12 selected Clean Industry sectors in terms of barriers and levers. Since these sectors can be considered as a good representation of frontrunners in the Clean Industry in terms of clean potential, economic growth potential, technological leadership and comparative advantage, the resulting barriers and levers can be considered as essential ingredients of a policy promoting Clean Industry in the EU. Therefore this chapter will analyse the horizontal dimension across Clean Industry subsectors and aims to identify common barriers and levers, as well as the interrelations between the 12 sectors in the areas of levers and obstacles to overcome. The first section analyses the barriers, the second the levers and the last section aims to unravel the interdependencies with respect to providing an effective leverage policy.

3.1 Common barriers

The barriers impeding growth of the selected Clean Industries share a number of interesting commonalities. In order to bring these to the surface, the barriers have been classified into various groups as indicated in

Table 2 and for each sector the three most stringent barriers are indicated and scored, based on the analysis of the individual Clean Industry sectors. The bottom rows of the table provide the frequency of a particular type of barrier across sectors for a specific rank of importance. The last row provides a weighted score taking into account the degree of importance.

As can be observed a number of barriers are of critical importance to almost all sectors, notably capital and finance, regulation, market functioning and information/awareness. Below we will discuss the common patterns regarding the barriers across sectors in more detail, in order of importance. As a result of the strong interlinkages, aspects related to standards are included in the discussion of market functioning.

	Regulation	Standards	Market functioning	Capital and finance	Technology, R&D, innovation	Labour market	Information, knowledge, awareness
 Wind energy Vehicle powertrains 	1 Stable legal framework missing, no binding national targets		3	2 Changing government support, investment insecurity, high CapEx for offshore 1	3 Grid capaciy and storage technologies not yet mature 2		
			Many fragmented, isolated markets with different policies	Low operating margins, expenses on many fronts	Uncertainty about prevailing technology of the future; Possible lock-in in internal combustion engine technology; Weak position electro-mobility		2
4 NZER	Planning interferes with ownership rights	2	Difficulty to establish network solutions with many actors	High CapEx and long- back periods, smaller public funding than for energy production			Information deficit regarding waste heat potential and rising cooling demand
5 AMT	3	2 Renovation targets unclear, staged do-it- yourself	Many small actors, lack of collaboration and quality assurance	High CapEx, access to and cost of capital, unwillingness to take up loan		2	
6. Heating and cooling system	Lack of market surveillance for machine tools in EU		This relates to both the low uptake of AMT in the EU, as well as obstacles in	2	3	Lack of sufficient skilled personel is important constraint	1
				Low emphasis on life cycle costs	Renewable solutions less attractive due to missing storage		Lack of information, spontaneous purchasing decisions
7. Measuring and monitoring	2	1 Missing EU and global standards		2 CapEx and long pay back periods	1		3 Slow acceptance of new technologies, lack of information of
o. Inclinal circly surage	Regulatory framework that supports renewable energy and waste heat recovery in general,			Funding especially for larger scale and risky (underground) TES can be difficult to obtain	Development and integration of more cost-effective, both small and large scale TES is key		
9. Smart grids	1 Adjusted regulatory framework needed that triggers investment, innovation and new	3			2 Specific critical technological		
10. Rail	business models	Interoperability	2	1	challenges	3	
			Non-tariff barriers to enter non-EU markets; Potential for improving single EU market; Interoperability issues in Europe;	Low gross operating rate; high innovation costs; Capital intensive assets		Shortages of skilled personnel due to an ageing population and the trend towards more sophisticated railway technologies	
11. Thermal insulation	1 Insufficient implementation of EU renovation targets in national legislation	1	3	2 High CapEx, access to and cost of capital, misaligned financial incentives (owner/tenant 2			3 Lack of information and knowledge, particularly with respect to advanced insulation materials
and non-control systems		Interoperability in technological and regulatory terms is seen as a key requirement for further development of sector	Difficulties in building consensus among Member States and stakeholders; interoperability issues	Traffic control systems require considerable investment and effort			
Most important barrier Second barrier Third barrier	4 1 1	2 1 1	2 1 3	3 6 1	1 2 2	0 1 1	1 0 3
Score	15	9	11	22	9	3	6

Table 2:An overview of the three most important barriers by Clean Industry sector and type of barrier (1:
most important)

Source: IDEA Consult and NIW

3.1.1 Capital and finance

Difficulties to finance activities have been identified as one of the main problems across sectors. This relates to the general proposition offered by Clean Industries: higher upfront investments costs, but lower running costs. Indeed, Clean Industries generally offer solutions which are often more expensive than the traditional counterpart, but which allow savings on energy and material bills across their lifecycle. The high capital expenditure requirement, e.g. for district heating as well as for certain thermal energy storage applications or rail, is a significant barrier. In the NZEBs and heating and cooling sector, consumers have to bear the investment costs, and high upfront costs can discourage owners. In the current uncertain economic climate, both companies and consumers are less likely to invest in clean solutions which do not offer a short payback time, even if they are interesting investments in the medium to long term. Especially in some heating/cooling related applications, lifecycle benefits of the investments are often overlooked.

In all sectors that target housing, including NZEBs, thermal energy storage, heating and cooling as well as thermal insulation, the well-known owner-tenant dilemma comes into play. Often it is unclear how costs and benefits of a refurbishment project shall be shared between the owner and the tenants paying the energy bill.

Apart from the financing of buying and use of clean solutions, companies in clean industries also face financial challenges internally. Notably in the technologies to realise efficiency gains in vehicle powertrains and rail sectors, the low operating margins in combination with high product development cost (including compliance with various regulations) is a threat for maintaining the technological lead of the EU.

Additionally, also a number of sector specific barriers can be quoted. For the wind energy sector, the uncertainty about the stability and predictability of government support schemes, weakens the investment climate. Sudden and sometimes retroactive changes in legislation (i.e. Romania, Spain) make it hard for investors and developers to plan investments. Particularly the offshore segment that requires especially high capital expenditures considers reliable, continuous expansion more important in the long term than any one-off records. For some underground thermal energy storage (UTES) applications and district heating based on geothermal energy, uncertainty regarding the results of drilling (which are not 100% predictable) can impede investment. In the case of smart grids, Member States' existing regulatory frameworks for the energy market are not fully adapted for valorising potential business opportunities and therefore generate a sense of uncertainty for incumbent investors and new ones alike.

3.1.2 Market functioning

Optimal market functioning assumes several elements, including costless access of all producers to the markets and complete information for producers and user to make decisions. The issue of lack of information is discussed separately below. Yet, also other elements, notably regarding market access, are playing a role as well.

For several sectors, including the three transport related sectors (technologies to realize efficiency gains in vehicle powertrains, traffic control systems, and rail), there is still considerable difference in the legislative framework affecting these sectors. As a result, there are still rather isolated, fragmented markets, and the power of the single market is not fully exploited. For example, in the rail sector, different legislation and strategic choices in place in the Member States are hampering the interoperability of the rail industry in Europe. These differences make the authorisation of rolling stock in Europe a costly, lengthy and complicated process. In the traffic control systems market, the national markets remain rather isolated, even if the 2008 EU Action Plan resulted in progress on this point.

In the automotive sector, the EU is characterised by a lack of coordination and a less uniform market place compared to other key automotive markets, properties that negatively influence the industry. Slow decision making processes regarding standards hamper the uptake of new technologies. Also in building related markets, e.g. NZEBs and thermal insulation but also measuring and monitoring, increased coherence in legislation and developments of unique standards would support the mass deployment of more cost-effective solutions, leading to higher adoption rates.

Market functioning is often complicated by the innovative and cross cutting character of the products offered by clean industries, which results in complex multi-stakeholder processes to integrate these. For example, in underground thermal energy storage, technologies in itself are fairly well developed, but how to integrate them optimally in the energy system (heat, electricity grid) is far from straightforward. Also in the case of smart grids, several challenges relate to the coordination of (the new roles) of various actors in the electricity production and consumption, requiring novel business models to support these developments. In the traffic control system sector, a key challenge relates to the interoperability of systems and the continuity of ITS-related traffic-management and freight-management services across borders, operators, networks and different modes of transport, and the coordination efforts to realise this. In the wind energy sector, the administrative procedures for new plants involve a great number of parties and form long (expensive) processes, posing a high risk in the project development phase.

Looking beyond the borders of the EU, rapid access to (emerging) foreign markets is critical for EU clean tech companies, which already today rely significantly on exports. Yet for several sectors, there are indications that protectionist measures impede EU companies from realising their full export potential. For example, EU AMT companies experience several tariff and non-tariff barriers when exporting, such as complicated and discriminatory health and safety regulations, certification requirements, lengthy customs and administrative procedures, poor intellection property rights (IPR) protection, etc. But also for the rail, the measuring and monitoring and the wind energy sector, different non-tariff barriers to enter non-EU markets, especially in the major competing economies, are into place. Examples of such barriers in China are related to standardisation and technical regulations, insufficient IPR enforcement and heavy certification procedures.

3.1.3 Regulation

Regulation plays a key role in development of Clean Industries. Across the priority sectors, a number of regulatory obstacles were identified, which are discussed below. To put things in perspective however, it needs to be noted that regulation in the EU in general has been quite favourable towards Clean Industries, by imposing rather ambitious environmental targets considered from a global perspective. Several EU Clean Industries have gained a first mover advantage resulting from the home market created in the EU for clean products and services. For example, the EU wind energy sector, district heating and cooling sector, heating and cooling sector, thermal storage (CSP, UTES) have all grown thanks to ambitious regulations and incentives in the EU, and are nowadays also very competitive on the export markets due to the expertise they have built up. Similarly, the EU is one of the most stringent regions with respect to fuel economy and CO₂ emission standards for cars and light commercial vehicles around the world, and EU manufacturers are generally very strong in developing fuel-efficient and high performance internal combustion engines, which plays to their advantage in export markets.

At the same time, there is still significant room for improvement on the regulatory side. A general concern is the stability respective predictability of regulation in the EU, especially in the field of renewable energy support (e.g. wind energy, concentrated solar power, where the regulatory framework in several Member States has been

changed regularly over past years, making market predictions more insecure and investments consequently less attractive). Reduced predictability of regulations directly relate to increased uncertainty which often increases capital requirements threatening project development. In addition, the speed at which novel regulations are developed and implemented is an issue, and the lack of alignment of national policies impedes the creation of a full single EU market, as was discussed in more detail under 'Market functioning'.

Apart from this, a number of sector specific barriers are at work. Sometimes these reflect the incapability to adapt regulation to the new possibilities and requirements that are associated with the growth of clean industries. For example, in the area of district heating, existing regulations still tend to favour on-site rather than collective solutions. Regulation also impedes the further use of geothermal district heating since security of licenses for deployment of found resources is not given in all Member States. Also for (underground) thermal storage legislation is not always adapted to the new possibilities, e.g. in some Member States it is forbidden to inject hot water into the ground.

In other cases existing regulatory frameworks can be fit, but the problem lies in the implementation. For example, in the thermal insulation sector, a lack of coherence in the implementation of the Energy Efficiency Directive (EED) at national level is observed, since the national long-term renovation strategies have not been transposed in higher energy renovation rates satisfactorily. In the AMT sector, a lack of market surveillance impedes the enforcement of product regulations.

3.1.4 Information & awareness

A key theme across sectors is the lack of information that many potential customers have regarding existing clean solutions. Perfect market functioning assumes that all actors have complete knowledge. Besides, the issue of information and awareness directly relates to financial barriers since appreciation of lower life-cycle costs is only possible for informed actors. However in practice lacking information and awareness is a major issue in several Clean Industries, for example:

- In the heating/cooling sector, specific consumer behaviour such as last minute purchasing decisions are likely to lead to the choice of known, but less efficient technologies and thereby create severe lock-in effects for years.
- In the district heating/cooling sector, lack of information has been attested to nearly all stakeholders involved, in particular regarding potential of using of waste heat and regarding potential for cooling demands. Similar for thermal insulation: the benefits of (more expensive) advanced technologies are unknown.
- In the traffic control systems sector, a lack of easy and efficient access to knowledge about the benefits and costs of ITS applications and services, and about experiences and evaluations of ITS implementation, is recognised as a key reason for slow investment.
- In the thermal energy storage sector, one of the key challenges of PCM materials is the dissemination of the benefits amongst professionals involved in the value chain for buildings (e.g. architects or installers). Increasing its reliability and confidence towards these professionals would ease the uptake.
- As for AMT, many potential AMT users, especially SMEs, struggle to keep track of the different evolutions in available AMTs and what would be the precise costs and benefits of adopting certain novel technologies. Such costs and benefits can often only be assessed after in-depth analysis and testing with new equipment.

These examples illustrate that the information/awareness barrier is not restricted to one or few sectors, nor is it restricted to particular customer types. Indeed, the examples above include both consumers, professionals (e.g. architects), industrial companies and governments as potential clients of clean solutions. In addition, it was noted that in some cases apart from a lack of information, potential clean solution customers also do not possess the required trained employees to deploy the solution, e.g. for using 3D printing tools significant new skills are needed.

3.1.5 Technology & innovation

Technology is a critical building stone for successful development of Clean Industries. Two main types of barriers can be perceived, the first one refers to a specific technology – storage capabilities-, the second is more generic in nature but the particular barriers – needed technological solutions - differ across sectors. The main missing point in the technology mix is the ability to cost-effectively store energy (heat and electricity) at large scale. Several sectors including wind energy, district heating and cooling, efficient heating and cooling systems and smart grids strongly rely on storage capabilities as enabler for their mass deployment, as it can help to address the shortcomings of intermittent renewable energy supply.

More generically, quite a number of Clean Industry technologies still face substantial technological challenges in order to fully valorise their envisioned potential. For instance, technologies to realise efficiency gains in vehicle power trains are currently an important topic for the European automobile industry and therefore have been selected for the analysis. Yet, in the long run, the ICE technology is aimed to be replaced by cleaner power trains (electric vehicles) where the EU has a relatively weaker competitive position compared to non-EU global players. Also the uncertainty about which technology will eventually prevail in the future generates the need to have a relatively strong position in a relatively broad spectrum of technologies. In the smart grid sector specific remaining technological challenges were highlighted in the areas of (i) information and communication technologies, (ii) sensing, measurement, control and automation technologies and (iii) power electronics and energy storage technologies. The thermal energy storage sector needs further R&D and innovation for integrated cost-efficient small and large scale solutions.

3.1.6 Labour market

Clean industries face a constraint that also several other manufacturing sectors face, i.e. the lack of skilled personnel such as engineers, technicians (STEM) in general, but also with sector-specific knowledge and competencies. This was reported as being already a current challenge especially for the AMT and rail sector and is also seen at least as a future challenge for the wind energy and the measuring and monitoring sector. At the same time, it should be noted that the source of technological lead of several EU Clean Industries lies partly in the high skill-level of their employees.

3.2 Common levers

In conjunction with the classification of the barriers, the levers can be classified according to the type of barrier they seek to overcome. Table 3 provides an overview of the levers for each of the Clean Industry sectors, classified according to the type of barrier to be remedied. The levers that are addressing other than the top three barriers are presented in colour. The numbers of the levers give a broad indication of priority following the

66

importance of the barriers that they correspond with. In the following sections the common levers are presented across Clean Industry sectors, following the same order as the corresponding barriers.

	Regulation	Standards	Market functioning	Capital and finance	Technology, R&D, innovation	Labour market	knowledge, awareness
1. Wind energy	1			2	3		
Lovor: what	1) Commit to PE			2) halve average	5) Maintain P&D	6) improve interactions	8) Information charing
Level. wildt	deployment to receive			s) haive average	funding 8 improve	industry condemin	o) momation sharing
	deployment targets by			permitting time	runding & improve	industry - academia	platform (WISE)
	MS; appropriate				support for	(personnel,	
	carbon pricing; life-				demonstration	cooperations);	
	cycle counting of taxes				projects, aim for		
	and subsidies; ensure				quicker time-to-market		
	predictable regulatory				access		
	framework						
who	MS			MS, LA (Local	EU	EU, MS, companies, IA	EU, MS, Regions, LA,
				Authorities)		(Industry Associations)	Companies, IA
						· · · · · · / · · · · · · · · · · · · ·	
Lever: what	2) FIL energy market			4) Foster alternative		7) standardization of	
Level. what	integration			financing (community		vocational education 8	
	integration			rinancing (community		vocational education &	
				and cooperative		training, improving	
				runaing)		workforce mobility	
						across MS	
who	EU			MS, LA		EU, MS, companies, IA	
Lever: what						9) offshore: encourage	
						cross-sector mobility,	
						e.g. skills from oil and	
						gas industry	
who						EU, MS, companies, IA	
2. Vehicle powertrains							
			3	1	2		
Lever: what	5) Proper balance	4) Robust fuel	3) Harmonisation of		1) Sustained R&D and		
Level. what	hetween ambitious	efficiency and emission	relevant regulation		innovation support for		
	omission objectives	ethiclency and ethission	relevant regulation				
	emission objectives	stanuarus			anciary technologies		
	possibilities for EU						
	automotive industry						
who	EU, MS	EU, MS	EU		EU, MS		
Lever: what					Incentivation of		
					demand for efficient		
					vehicles		
who 3. District heating and					EU, MS		
who 3. District heating and cooling	1		1	2	EU, MS		3
who 3. District heating and cooling Lever: what	1 1) Grant DHC		1 3) DHC-friendly	2 5) DHC operaters can	EU, MS 8) Support	9) Holistic approach via	3 6) include waste heat
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special		1 3) DHC-friendly municipal heat	2 5) DHC operaters can be granted special	Venicles EU, MS 8) Support demonstration	9) Holistic approach via integrated education	3 6) include waste heat in the companies'
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special rights to extent DHC		1 3) DHC-friendly municipal heat planning	2 5) DHC operaters can be granted special rights to extend DHC	8) Support demonstration projects of DHC for	9) Holistic approach via integrated education and training of	3 6) include waste heat in the companies' energy management
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special rights to extent DHC networks		1 3) DHC-friendly municipal heat planning	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior	Venicles EU, MS 8) Support demonstration projects of DHC for NZFRs	9) Holistic approach via integrated education and training of neighboring disciplines	3 6) include waste heat in the companies' energy management system regulated by
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special rights to extent DHC networks		1 3) DHC-friendly municipal heat planning	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBs	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning	3 6) include waste heat in the companies' energy management system regulated by FN16001 standards
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special rights to extent DHC networks		1 3) DHC-friendly municipal heat planning	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling object for	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBs	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture)	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special rights to extent DHC networks		1 3) DHC-friendly municipal heat planning	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for genthermal DH) (c	Venicies EU, MS 8) Support demonstration projects of DHC for NZEBs	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture)	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special rights to extent DHC networks		1 3) DHC-friendly municipal heat planning	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s.	8) Support demonstration projects of DHC for NZEBs	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture)	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards
who 3. District heating and cooling Lever: what	1 1) Grant DHC operators special rights to extent DHC networks		1 3) DHC-friendly municipal heat planning	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning)	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture)	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards
who 3. District heating and cooling Lever: what Who	1 1) Grant DHC operators special rights to extent DHC networks		1 3) DHC-friendly municipal heat planning MS, LA	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS
who 3. District heating and cooling Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry
who 3. District heating and cooling Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise
who 3. District heating and cooling Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its
who 3. District heating and cooling Lever: what Who Lever: what	1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members
who 3. District heating and cooling Lever: what Uho Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members
who 3. District heating and cooling Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members
who 3. District heating and cooling Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members
who 3. District heating and cooling Lever: what Uvho Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members
who 3. District heating and cooling Lever: what Uho Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU		1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members
who 3. District heating and cooling Lever: what Who Lever: what Who A. NZEB	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members 1A
who 3. District heating and cooling Lever: what Who Lever: what 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1 1) Enhance Energy	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale
who 3. District heating and cooling Lever: what Uho Lever: what Who 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2) Tying refurbishment obligations to change	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign
who 3. District heating and cooling Lever: what Uho Lever: what 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by	Venicies EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS. 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilisine
who 3. District heating and cooling Lever: what Uho Lever: what 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support:
who 3. District heating and cooling Lever: what Uho Lever: what Who Lever: what UNo 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding.	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful
who 3. District heating and cooling Lever: what Uho Lever: what 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2) Tying refurbishment obligations to change in ownership	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, notentially in	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration
who 3. District heating and cooling Lever: what Lever: what 	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising incle of EPC support; promote successful demonstration projects
who 3. District heating and cooling Lever: what Who Lever: what Who 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1)	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a carbon tax	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards 2) Jet industry associations advertise waste heat selling to its members 1A 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects
who 3. District heating and cooling Lever: what Uho Lever: what Vho 4. NZEB Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2) Tying refurbishment obligations to change in ownership	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1) MS LA	2 S) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a carbon tax	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects
who 3. District heating and cooling Lever: what Uho Lever: what ever: what Uho	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership MS, LA	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1) MS, LA	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a carbon tax MS, LA	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS. 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects MS, Regions, LA
who 3. District heating and cooling Lever: what Who Lever: what 4. NZEB Lever: what Who 4. NZEB Uever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership MS, LA 3) Couple financial	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1) MS, LA	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a carbon tax MS, LA	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects MS, Regions, LA
who 3. District heating and cooling Lever: what Who Lever: what Who 4. NZEB Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership MS, LA 3) Couple financial support to ambition	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1) MS, LA	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a carbon tax MS, LA 6) Offer preferential	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects MS, Regions, LA
who 3. District heating and cooling Lever: what Who Lever: what Vho 4. NZEB Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership MS, LA 3) Couple financial support to ambition levels (to avoid	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1) MS, LA	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a carbon tax MS, LA 6) Offer preferential loans to investors in	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects MS, Regions, LA
who 3. District heating and cooling Lever: what Who Lever: what 4. NZEB Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership MS, LA 3) Couple financial support to ambition levels (to avoid windfall gains)	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1) MS, LA	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing metching public funding, potentially in contracting (EPC) by providing metching public funding, potentially in contracting the second methods of the second potentially in contracting the second methods of	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects MS, Regions, LA
who 3. District heating and cooling Lever: what Who Lever: what Who 4. NZEB Lever: what Who Lever: what	1 1) Grant DHC operators special rights to extent DHC networks LA 2) Emphasize DHC in EED cost-benefit analyses MS, EU	2 2) Tying refurbishment obligations to change in ownership MS, LA 3) Couple financial support to ambition levels (to avoid windfall gains)	1 3) DHC-friendly municipal heat planning MS, LA 4) Incentivize DHC operators to increase efficiency and to reach a high share of RE in the long run (similar to the so-called white certificates in place in some MS) MS 3 4) see also 1) MS, LA	2 5) DHC operaters can be granted special rights to extend DHC networks (e.g. prior claims on property, drilling place for geothermal DH) (s. market functioning) MS, EU 1) Enhance Energy Performance Contracting (EPC) by providing matching public funding, potentially in combination with a carbon tax MS, LA 6) Offer preferential loans to investors in combination with refurbishment to NZEB	Vehicles EU, MS 8) Support demonstration projects of DHC for NZEBS EU, MS, Regions	9) Holistic approach via integrated education and training of neighboring disciplines (e.g. urban planning, architecture) EU, MS, companies, IA	3 6) include waste heat in the companies' energy management system regulated by EN16001 standards EU, MS 7) let industry associations advertise waste heat selling to its members IA 5) Large scale information campaign highlighting stabilising role of EPC support; promote successful demonstration projects MS, Regions, LA

Table 3: An overview of levers by Clean Industry sector and by type of barrier they seek to overcome

Information

	Regulation	Standards	Market functioning	Capital and finance	Technology, R&D, innovation	Labour market	Information, knowledge, awareness
5. AMT Lever: what	4) Increase effective market surveillance measures; promote government initatives aimed at identifying and removing sector specific regulatory obstacles (e.g. Green Deals in NL)		1 1) Promote EU/ISO standards abroad, bundle efforts of national export support institutes, from which especially smaller EU countries would benefit	5) European investment bank to take leading role in: (i) increasing awareness about existing funding mechanisms (ii) expand advisory services around these (iii) develop of instruments beyond traditional debt financing	6) Promote (production chain' type of projects, involving both AMT producer and user, better cooperation between SMEs and research institutes, and better cross border cooperation	2 2) Promote a constant revision of curricula and dual learning programmes or apprenticeships (as e.g. in Germany), and through promotion of the benefits of STEM educations	3) Promote initiatives wherein SMEs can access free expert consultation about adopting novel equipment
6. Heating and cooling	IVIS		EU, MS	2	2U, MS	MS	EU, MS
systems Lever: what	4) Stronger incentives to use renewable energies instead of fossil ones for Heating or Cooling via a carbon tax as in place in Northern European countries (Finland, Denmark, and Sweden)	5) Increase efficiency standards for new equipment (in particular cooling); target passive cooling	6) Publicly subsidized (and maybe standardized) energy service contracting for low-income households, which are not reached by other measures (e.g. awareness campaigns)	2) Promote integrated business models encompassing all actors	3) (i) promote storage R&I (ii) combined systems to increase renewable heating and cooling		1) Mandatory advice could be given during the regularly inspections of heating and cooling equipment to prevent inefficient spontaneous consumer choices
Who	EU, MS	MS, EU	EU, MS	EU, MS, IA	EU, MS		MS
monitoring		1		2			3
Lever: what Who Lever: what		1) Develop EU standards EU 2) Promote use of EU/ISO standards in trade negotiations to	5) Remove market entry barriers MS, EU	 Provide financial incentives combined with regulatory targets for investors and users EU, MS 		6) Promote STEM education and interaction between companies and eduction institutions MS, EU, IA 7) Standardization of education and training to improve work force	4) increase awareness about innovative technologies and its benefits EU, MS, IA
		mitigate export barriers				mobility across MS	
Who 8. Thermal energy		EU				MS, EU, IA, companies	
Storage Lever: what Who Lever: what	2 2) Promote renewable energy and waste heat valorisation, and make sure that the value of storage is well reflected in incentive schemes EU, MS 3) Remove specific barriers such as interdiction in some MS to inject hot water in the ground. Promote best practices sharing across MS to accelerate adoption of more suitable regulatory frameworks		S), Use signaling function of government, promote showcases EU, MS	3 4) Promote insurance funds for underground TES applications, EU, MS	1 1) Increase R&I support to large scale TES, support demo projects that target innovative ways to integrate TES in the energy system EU, MS		6) Increase awareness about possibilities of PCM applications, and ensure fair of PCM treatment within national building codes EU, MS

	Regulation	Standards	Market functioning	Capital and finance	Technology, R&D,	Labour market	Information, knowledge,
					innovation	1	awareness
9. Smart grids Lever: what Who	1 1) Optimize existing regulatory framework with respect to the new smart grid functionalities MS, EU	3) Define EU-wide interoperability standards EU			2 2) Sustain R&D and innovation support for new smart grid technologies, products and services EU, MS		
10. Rail			2	1		3	
Lever: what			2) Sustain existing efforts fo enhance the functioning of the internal market	1) Assess new financing mechanisms to foster (co-)investment in new rail solutions		 Improve the skills and training of the rail supply work force 	
Who Lever: what			 EU Endeavor policy solutions to promote cross modal transport solutions in relation to 'uberisation' and rail 	<u>EU, MS</u>		<u>MS</u>	
Who			MS, EU				
11. Inermal Insulation	1			2			2
Lever: what	1) Sustained monitoring of EU renovation targets based on stringent building codes	4) Foster having accurate and comparable test protocols, ratings and performance declarations for the energy performance of different materials	5) Support broader implementation of energy managers to prevent split responsibilities	2) Integrated policies for energy efficient investments in thermal insulation including financial incentives, mandatory building codes as well as specific support for social rental properties and low-income households MS ELL	6) Case studies and demonstration projects to promote greater system energy efficiency of high level TI solutions	7) Promote and sustain trainings, guidelines and quality schemes to increase the competence levels of on-site workforce and building services for advanced thermal insulation solutions	3) Communicate in a targeted way the net benefits from NZEBs (financial community, households, SMEs)
12. Traffic control	20	20, 1915	IVIS	1013, 20	ivis, iA, companies	ivis, Eo, companies, iA	1913, 20
systems		1	3	2			
Lever: what		1) Sustain the Intelligent Transport System Action Plan	 Sustain the existing cooperation and collaboration initiatives and platforms 	 Assess new ways for fostering investment such as joint investment pools, new contribution- renumeration systems 			5) Increasse awareness and information about the (net) benefits of traffic control systems
Who Lever: what		EU 2) Increase the level of harmonized standards	EU, MS	MS, EU			MS, EU
Who		EU, MS					

Source: IDEA Consult and NIW

3.2.1 Capital and financing

In essence three common types of capital and financing barriers have been identified: 1) the dichotomy between relatively high upfront investment costs in the short-term and low running costs over a mid- to long-term payback period, 2) the sector's relatively high product development costs in combination with low operating margins and 3) investment uncertainty, the precise nature of which is rather specific for each Clean Industry sector.

Across the various sector-specific levers that have been identified to solve the above mentioned types of capital and financing barriers three routes for solutions can be identified: 1) developing alternative financing methods, 2) developing new business models of a product service systems nature, and 3) regulatory measures.

The analyses brought to the surface that the further growth of most of the identified Clean Industry sectors is reaching the limits of conventional financing methods. A clear need for developing and applying alternative financing methods is perceived. In the wind energy sector community and cooperative funding schemes are being applied. In the traffic control systems sector joint investment pools are an option. In the rail sector co-investment and new leasing formulas are potential solutions. However in other sectors such as AMT, and district heating and

cooling alternative financing methods have still to be developed and applied. Nevertheless one may conclude that overall the need for developing and applying alternative financing models remains a crucial point in the further deployment of Clean Industry solutions.

The enhanced application of Clean Industry solutions does not only require new alternative financing methods, yet new business models as well. Both are often interlinked. New business models may offer new ways of value capturing that are more targeted towards energy and resource efficiency, providing the same, if not more, value for the client. The types of new business models that have been suggested in the detailed sector studies are of a product service systems (PSS) nature where value capturing is linked to the energy efficiency, and often also resource efficiency, realised and not only to the selling of products as in conventional business models. In two Clean Industry sectors new business models have been explicitly identified as a potential way to overcome the capital and finance barrier: the NZEBs and heating and cooling system sector. In the NZEB sector Energy Performance Contracting (EnPC) is a new PSS-type of business model which has substantial potential to provide leverage to the sector. However the US example has shown that matching with local/public authority funding is an important condition to get it running. In the heating and cooling systems sector new business models that integrate energy consultations, manufacturers, planning, installation and maintenance may provide leverage to the sector and offer new ways of service delivery and value creation and capturing that are more sustainable.

Regulatory measures have been suggested as well which in various degrees, either directly or rather indirectly through providing better framework conditions, may increase the financial viability and proliferation of Clean Industry solutions in the EU. Examples of regulations and measures that directly impact capital expenditures and financial viability are regulations which make the application of financial support subject to reaching minimum energy efficiency targets and the mandatory involvement of energy managers for control and optimisation. Examples of indirect regulatory measures are wider in scope and can be found in the subsequent sections 3.2.2 to 3.2.6.

3.2.2 Standards and market functioning

Suboptimal market functioning in clean industries has been observed in several forms: 1) fragmented, isolated markets within the EU 2) difficulties in coordinating and executing new multi-stakeholder projects 3) insufficient access to foreign (emerging) markets. For each of these, we discuss potential levers.

For several sectors there is still considerable difference in the legislative framework affecting these sectors, and as a result, the EU market remains fragmented. In order to address this, harmonised regulation across Member States and the faster development and adoption of EU wide standards should be priority. A particular issue in both transport related sectors such as rail and traffic control systems as well as the smart grids sector is the interoperability between various networks and systems. Creating a stronger single market for clean products and services is considered a key element for reducing compliance costs of companies and for enabling large scale deployment of more cost-competitive standardised products.

The innovative and cross cutting character of the products offered by clean industries often results in complex multi-stakeholder processes to integrate these. Government can play an important supporting role in this area. For example, in order to improve administration procedures and social acceptance of wind power projects the EU funded WISE project has implemented an interactive platform (one-stop-shop) for information-sharing which allows stakeholders to have a say in the siting and expansion of wind projects. By providing a diverse set of best practices, it aims to foster public support for onshore wind power in order to at least halve the average permitting time for a wind farm. The project has a strong focus on alternative financing, such as community and cooperative funding of wind farms as a method to broaden local engagement. But also for other sectors, alternative financing

70
can be a very useful tool. As another example, the ITS Action Plan has been a catalyst for a greater and more focused involvement, cooperation and collaboration of the large stakeholder community in adopting advanced traffic control systems.

Apart from direct coordination activities, the government also has a very important signalling function. A clear and credible ambition put forward by government makes it more likely that various stakeholders will align their behaviour. This ambition can be expressed by 'soft' measures such as roadmaps or vision documents, but also by concrete 'hard' measures such as creating a favourable regulatory framework (e.g. imposing targets) or by increasing public R&I investments. This would e.g. be very useful for accelerating the concept of (thermal) energy storage by the energy sector.

It will be necessary to find ways to organise the new types of interactions that emerge between different players, in the energy sector and beyond. In Denmark an example exists of agreements between thermal storage parties (implemented in district heating) and the TSO and DSO's in the electricity grid, simplifying the exchange of electricity and heat and providing flexibility to the electricity grid. This kind of new forms of business models and organisation should be further explored.

The growth of emerging economies makes these increasingly large buyers of Clean Industry products. Yet, it is found that EU companies do not always have good access to these markets. A variety of measures can be used to help overcome this barrier. For example, the EU should always maximally promote the use of EU/ISO standards in the context of trade negotiations, avoiding that country specific standards with very different requirements constitute a barrier to export. At the same time, this is a double argument for the EU to promote the single market and develop EU wide standards in a timely manner, e.g. in the rail industry, such that these can also be used in an international perspective. As a second point, the EU should promote bundling of the efforts of export promoting agencies. Especially smaller countries do not have sufficient funds to guide domestic companies when exporting to all third countries, and could win from more EU coordination.

3.2.3 Regulation

Although the regulatory framework in the EU is already quite favourable for fostering Clean Industries in the sense that it provides a clear policy direction towards a sustainable economy, for a number of sectors improvements concerning regulation may provide an additional push for further growth. These Clean Industry sectors where regulation was indicated as a main barrier were: wind energy, district heating and cooling, thermal storage, smart grids and thermal insulation. The potential improvements situate in the areas of regulatory predictability, better alignment between Member States, optimisation and adaptation of the regulation to the new technological and potential business valorisation possibilities, and effective implementation.

Three common levers can be identified: 1) improving regulatory coherence, 2) optimisation and 3) implementation. Regulatory coherence implies building further on the internal single EU energy market, including the Clean Industry sectors. This includes e.g. applying appropriate carbon pricing, including life-cycle counting in determining the level of taxes and subsidies, identification and dissemination of best practices of more suitable regulatory frameworks across Member States.

Optimisation of existing regulation in order to allow valorisation of new business opportunities due to new technological capabilities is another common lever that can be observed. This is prevalent in the smart grids sector, district heating and cooling, and the technologies to realise efficiency gains in vehicle powertrains. In the smart grids sector regulation needs to be adapted to be able to allow for (better) deployment of new smart grid functionalities such as aggregation, dynamic pricing. For the district heating and cooling sector new ways need to

be investigated in order to valorise the clean and business potential, e.g. in the form of special rights to extent the networks. Technologies to realise efficiency gains in vehicle powertrains benefit from ambitious emission objectives yet in balance with the technological and business valorisation potential.

The third common lever to address regulatory obstacles concerns the effective implementation of EU Directives and Member State polices. For instance the policies to attain the renewable energy targets by the Member States for the EU wind energy sector remain without effect without effective implementation and deployment at the Member State, regional and local levels. Also the continued integration of renewable energies into the single EU energy market is of importance. In the thermal insulation section the sustained monitoring of the EU renovation targets can be highlighted as another example.

3.2.4 Increasing information, knowledge and awareness

The analysis of the barriers in Task 3.1 clearly indicates that a lack of information and awareness plays a limiting role in several clean industries. If customers would be better informed about possibilities and benefits of clean products, they would be more likely to purchase these. Interestingly, this observation applies across a variety of Clean Industries and customer types (ranging from individuals over enterprises to governments). In Chapter 2, a number of sector specific levers that can address this barrier were proposed. Below we summarise a few examples:

- For the AMT sector, dedicated initiatives can support SMEs in adopting AMT, by providing them with access to expert consultation, self-scans, access to infrastructure where they can test equipment, etc. that help to assess the possibility of adopting novel equipment. A good example of this has been implemented in Belgium in the form of the MADE DIFFERENT program, which provides free expert support for SMEs in developing novel production strategies.
- For the district heating and cooling and thermal energy storage sectors, more awareness regarding the potential of recovering waste heat would be beneficial. In this respect, it is suggested to include waste heat as a particular category in the companies' energy management system regulated by EN16001 standards in order to draw attention to the potential. Moreover, industry associations can advertise the selling of waste heat to their members and provide assistance and communication platforms thereby increasing awareness.
- In the heating and cooling sector, the barrier of spontaneous (and therefore often conservative) consumer choices could be tackled e.g. through mandatory advice to be provided during the regularly inspections of heating and cooling equipment. These advisory services could refer to suitable follow-up systems to be installed.
- In the area of traffic control systems, an Action Plan focused on promoting Intelligent Transport systems (ITS) has been successful particularly thanks to its impact on mainstreaming the notion of ITS in the design of transport policies and highlighting the value of deployment of ITS. Furthermore, the Action Plan has increased awareness about the need to tackle bottlenecks that hinder interoperable deployment and to address other technical or legal issues hampering a broader take-up of such systems.

It is clear from these examples that all measures need to be sector specific, both because of the different technical aspects and the different types of customers involved. Yet, there is also a clear commonality among them. Indeed, they all build on existing structures to reach the customers as effectively as possible. For example, the MADE DIFFERENT program is implemented by industry associations and their competence centres, such as Agoria and Sirris. Other proposals aim to make smart use existing contacts between heating customers and technicians, or from existing certification schemes, to increase awareness.

New information & awareness initiatives should ideally aim to answer to various aspects of customer needs, i.e. acting as a one-stop shop. For example, a programme targeting support to SMEs in selecting novel AMT equipment should also be able to provide the necessary training services to work with the new AMT, and provide information about potential innovation funding options, or be able to refer SMEs to organisations who could provide these services. That way, these initiatives could not only address the information and awareness challenge but also help overcome other barriers.

The development of such one-stop shops would in some sectors benefit from the promotion of new integrated business models. For example, in the efficient heating and cooling sector, integrated business models could encompass energy consultants, manufacturers, and related services such as planning, installation, and maintenance. These networks can be initialized and established via demonstration projects where cooperation and learning can take place. In case, some equipment breaks down, these contact points can be a good start to prevent lock-in effects. Moreover, they can employ their central position to explore the aggregation of several retrofitting projects (e.g. leading to development of a district heating project).

These initiatives should also strongly benefit from cross-country learning, as in some Member States awareness about/ implementation of clean products is more advanced than in others. Even more, cross country initiatives could also promote information sharing between countries, as it is found e.g. in the AMT sector that companies are very often not aware about technical solutions that are available at knowledge institutes in other countries.

3.2.5 Technology, R&D and innovation

Two main policy levers for addressing the barriers concerning technology, R&D and innovation can be distinguished: 1) R&D and innovation supply side support policies and 2) incentivising the demand for Clean Industry solutions, which is a demand side policy. The EU has already quite a well-developed R&D and innovation support policy framework, most notably with the Horizon 2020 programme, and examples of supported demonstration projects and initiatives can be found in virtually all Clean Industry sectors. Nevertheless each Clean Industry sector has (a) particular area(s) where sustained support is needed to bring laboratory findings to demonstration projects, as a precondition for further upscaling in the technology development curve. Yet before embarking on examples of individual sectors, one particular technology should be addressed, which is energy storage. It is an important component in the value creation of virtually all Clean Industry solutions, ranging from wind energy to heating and cooling systems and smart grids.

Concerning sector specific needs for sustained support of R&D and innovation one can indicate the need for R&D, demonstration and deployment projects with a faster time to market access in the wind energy, the support for ancillary technologies to the ICE to improve the efficiency in vehicle power trains, and the specific technological challenges in ICT applications, sensing, measurement, control and automation technologies and power electronics in smart grids.

Supply side support should also be targeted at developing solutions that require a combination of technologies from various Clean Industry sectors, for instance the support for combined district heating and cooling and NZEB solutions, the integration of production processes in the AMT sector, and the integrated renewable energy system solutions for heating and cooling systems.

The second type of common lever addressing the technology, R&D and innovation barriers are demand side policies promoting the uptake and use of Clean Industry solutions. This may help creating a lead market providing enough leverage to proliferate further into a more mature market environment where policy support may gradually be reduced or re-oriented towards new challenges and barriers to overcome. An example indicated in

the study is the incentives provided for the uptake of efficient vehicles. Also the incentive schemes implied across Member States for installing thermal insulation is worth mentioning.

3.2.6 Labour market

The common lever addressing the barriers related to the labour market is increasing the skills match of the labour force in order to be able to provide, deploy and advance existing Clean Industry solutions and to help valorising new solutions. Various specific methods have been indicated to increase the skills level and skills match with the needs of the Clean Industry sector. These include 1) an increased cooperation between academia and industry through e.g. dual learning programmes, apprenticeships, 2) on the job training schemes, 3) schemes promoting workforce mobility across sectors yet also across Member States, 4) harmonisation of vocational training standards and 5) promotion of education in Science, Technology, Engineering and Mathematics (STEM).

3.3 Cross-sectoral interdependencies between the 12 selected EU Clean Industries

In order to determine the cross-sectoral interdependencies we have conducted an analysis using a scoring matrix displayed in Table 4. We have ranked per sector to what extent it needs other sectors as an input for its production. From a value chain perspective a need is defined in terms of upstream inputs. A value of 0 indicates no cross-sectoral interdependency, a value of 1 indicates a low cross-sectoral interdependency, and a value of 2 indicates a high cross-sectoral interdependency. The score per column gives an indication of the dependency of the sector (say its input from other Clean Industries), while the score per row gives an indication of the driving power of the sector (say its output to other sectors). Note the demand for a column sector's services can be derived by looking at that sector's row values across columns (see driving power scores).

Table 4:Cross-sectoral interdependencies

	•													-
		1. Wind	2. Vehicle	3. District	4. NZEB	5. AMT	6. Heating	7. Measuring	8. Thermal	9. Smart	10. Rail	11. Thermal	12. Traffic	
		energy	powertrains	heating and			and cooling	and	energy	grids		insulation	control	
				cooling			systems	monitoring	storage				systems	
ğ	1. Wind energy		0	1	1	0	0	0	1	2	1	0	0	6
Ē	2. Vehicle powertrains	0		0	0	0	0	0	0	0	0	0	1	1
v	3. District heating and cooling	0	0		1	0	0	0	1	0	0	0	0	2
	4. NZEB	0	0	0		0	0	0	0	1	0	0	0	1
	5. AMT	2	2	1	0		1	1	0	1	1	1	1	11
	6. Heating and cooling systems	0	0	2	2	0		0	0	0	0	0	0	4
	7. Measuring and monitoring	2	2	2	2	2	2		1	2	2	1	2	20
	8. Thermal energy storage	2	0	2	2	0	1	0		2	0	0	0	9
	9. Smart grids	2	0	0	1	0	0	0	1		1	0	0	5
	10. Rail	0	0	0	0	0	0	0	0	0		0	1	1
	11. Thermal insulation	0	0	1	2	0	1	0	1	0	0		0	5
	12. Traffic control systems	0	0	0	0	0	0	0	0	0	2	0		2
	Dependency ->	8	4	9	11	2	5	1	5	8	7	2	5	

Output ->

From the last column in Table 4 we can see that one sector has a particular driving power: measuring and monitoring. All sectors have either a low or high crosssectoral interdependency with the measuring and monitoring sector. The smart grids sector for example needs measuring and monitoring technologies for measuring electricity flows, while the traffic control systems sector needs measuring and monitoring equipment to obtain data on traffic flows. Another sector with many cross-sectoral interdependencies, although not as prominent as the measuring and monitoring sector, yet still markedly distinguished from the others is the AMT sector. The sector related to technologies to increase energy efficiencies in vehicle powertrains for example requires AMT for further pushing the efficiency limits of internal combustion engine parts, while the wind energy sector needs AMT for the production of complex rotating parts of the turbine.

The last row of Table 4 provides another perspective on the cross-sectoral interdependencies, namely the dependency of a sector on other sectors. A particular sector that is dependent on many other sectors is the NZEB sector. NZEBs make use of products such as thermal insulation, heating and cooling systems, and measuring and monitoring technologies. Furthermore, thermal energy storage technologies such as solar heat collectors or small wind energy turbines can provide NZEBs electricity to be self-sustaining. Other sectors that also have some cross-sectoral dependencies are the wind energy sector, the district heating sector, the smart grids sector, and the rail sector. The wind energy sector for example will be dependent on developments in (thermal) energy storage and smart grids in order to properly function in the future energy system.

Identifying Levers to Unlock Clean Industry – Summary Report | IDEA Consult – NIW – WIFO | June 2016

>

In comparison to the driving power score, the dependency scores are more equally distributed with five sectors having relatively similar scores (wind energy, district heating and cooling, NZEB, smart grids, and rail) at the top of the distribution. This hypothesis is supported by calculating the variance of the dependency scores (9.5) versus the variance of the driving power scores (31). This indicates that the Clean Industries are relatively more interdependent in terms of inputs (solutions) needed from other Clean Industries, yet that the driving power comes rather more from other industries in the EU value chain, with the notable exception of measuring and monitoring and advanced manufacturing technologies. Indeed a large part of the Clean Industry solutions are made by 'conventional' industries that find a niche market for their products and solutions in the EU Clean Industry market. Furthermore it should be noted that the analysis merely covers cross-sectoral interdependencies within the 12 identified priority sectors. A weak dependency or driving power score does therefore not provide an inclusive view on the total dependency or driving power of the industry.

Focussing on the intra-Clean Industry relations, we can depict the content of Table 4 in network visualisations displayed in *Figure 2*. The thin lines represent the weak cross-sectoral interdependencies and the thick lines represent the strong cross-sectoral interdependencies. The size of the circles represents the driving power of the sectors. Both figures visualise the same content, yet the structure of the figures is different. *Figure 2* presents an organic diagram, where the sectors with a higher driving power are automatically displayed in the centre of the figure.



Figure 2: Cross-sectoral interdependencies in the intra-Clean Industry value chain ordered by driving power scores

Based on a careful interpretation of Table 4 and Figure 2 it is possible to identify some leverage effects resulting from the cross-sectoral interdependencies. The leverage effects generally work in two ways. A sector that is dependent on many other sectors could provoke a rise in demand for products and services from those other Clean Industries that serve as suppliers for the dependent sector. Stimulating a sector that has a strong driving power - that is, many sectors are dependent on the products or services from that sector - can provoke a leverage effect for improving other Clean Industries.

An example of a sector that could provoke a rise in demand for products and services from other Clean Industries is the NZEB sector. The NZEB sector has a high cross-sectoral dependency from the heating and cooling systems, measuring and monitoring, thermal energy storage, and the thermal insulation sectors, and also a relatively weaker cross-sectoral dependency from the wind energy, district heating and cooling, and smart grids sectors. When Europe is able to communicate a strong message to unlock the NZEB sector, an indirect demand boost would be generated for products and services from these other Clean Industries.

The measuring and monitoring sector for example was identified as a necessary input for all other Clean Industries. Indeed, typical application markets for the measuring and monitoring sector with respect to the Clean Industry taxonomy used in this study are Factory and Business Automation in manufacturing industries (in terms of "clean production"), Home and Buildings (e.g. automation, safety, energy management, construction), Electric Power and Grid (e.g. generation, transport, and distribution; focus renewable energy, smart grids, metering), and Clean Mobility (e.g. embedded solutions for e.g. ABS braking, air conditioning, engine control, traffic control). Unlocking and strengthening the position of the EU measuring and monitoring sector could therefore serve as a lever for unlocking the EU Clean Industry due to the enabling and driving character of that industry.





Analysing such leverage effects and turning them into prospective, concerted and targeted, but flexible policy instruments has several advantages. It combines a demand-driven and a supply-driven approach, allowing flexibility for various policy instruments. Furthermore, these policy instruments can entail coordinated levers, and they are not limited to strictly picking 'winners' due to the many cross-sectoral interdependencies. With these coordinated levers, multiple sectors can be targeted at once, creating synergetic value.

The idea of cross-sectoral interdependencies has been long recognised by European policies. In 2007 for example, an initiative on lead markets was initiated: "Based on a broad stakeholder consultation for defining a valid approach for fostering emergence of markets with high economic and societal value. This would include identifying areas where concerted action through key policy instruments and framework conditions, coherent and

coordinated policy making by relevant public authorities, as well as enhanced cooperation between key stakeholders can speed up market development, without interfering with competitive forces." (European Commission, 2007). The identification of lead markets can be compared with the dependent sectors such as the NZEBs. An example of European policy targeted at driving sectors, is EU policy regarding KETs: "KETs provide the basis for innovation in a range of products across all industrial sectors. They underpin the shift to a greener economy, are instrumental in modernising Europe's industrial base, and drive the development of entirely new industries. Their importance makes them a key element of European industrial policy." (European Commission, 2016).

From an intra Clean Industry value chain perspective one could identify four general clusters where such crosssectoral interdependencies are relatively dense, and where both demand-driven and supply-driven interdependencies are in place:

- Enabling Sectors: Measuring and monitoring and AMT
- Electric Power and Grid
- Energy Efficient Homes and Buildings
- Cleaner Transport Solutions



Figure 4: Clean Industry clusters

Enabling Sectors: Measuring and monitoring and AMT

The measuring and monitoring sector has appeared to be an enabling sector in the area of Clean Industries, since many other sectors require technologies, services or products from the measuring and monitoring sector, most notably sensors. Like the measuring and monitoring sector, the AMT sector has an enabling character due to its contribution for efficiently manufacturing products that can be applied in other Clean Industries.

Electric Power and Grid

The Electric Power and Grid cluster would be centred on the smart grid sector, and entails clean energy production, storage and distribution. Therefore, next to the smart grids sector, also the wind energy sector, and the thermal energy storage sector are involved. The above mentioned Enabling Sectors are one of the upstream supplying industries to the Electric Power and Grid group of Clean Industries.

Energy Efficient Homes and Buildings

The Energy Efficient Homes and Buildings cluster would be centred on buildings with the NZEB sector as a central component which is embedded in terms of activity and efficiency gains with the heating and cooling systems, thermal insulation and district heating and cooling. In order to become energy efficient, houses and buildings increasingly sustain their own electricity and/or heat demands which includes inputs from the wind energy sector and from the thermal energy storage sector (e.g. solar heat collectors). Because this efficiency can also be improved at a larger scope and with increased functionalities and quality, smart grid services are needed as inputs. In terms of materials and products, the Enabling Sectors provide inputs as well.

Cleaner Transport Solutions

The fourth cluster of Clean Industry sectors focuses on clean transport solutions. It contains the following sectors: technologies to realise efficiency gains in vehicle powertrains, traffic control systems and rail. Although there are clear links with the Electric Power and Grid cluster, looking at the interactions in *Figure 2* the main input relations are with the measuring and monitoring sector and with the AMT. Yet it is clear that the clean potential of the rail sector is largely codetermined by the source of electricity energy that it uses, conventional or renewable.

4/ Policy conclusions: levers for unlocking the EU Clean Industry

This chapter presents the levers to unlock the EU Clean Industry from two perspectives: first along the lines of the intra Clean Industry value chain which resulted from the analysis in previous chapter, second a number of conclusions and observations are formulated which help developing an integrated vision across sectors and Member States. The last section presents some reflections on the boundaries of this study and provides suggestions for further research.

4.1 Levers along the intra Clean Industry value chain

In the previous chapter the cross-sectoral interdependencies between the 12 priority sectors have been explored. It became clear that the priority sectors are strongly interlinked and that a clear intra Clean Industry value chain can be perceived with four main clusters of sectors. In a stylised manner one could depict the underlying intra Clean Industry value chain as displayed in Figure 5. This section presents the main barriers and levers for each of the clusters in the value chain and presents the common levers for each of the clusters.

Starting from upstream to downstream parts of the stylized Clean Industry value chain we present the common levers for each of the four constituent main building blocks displayed in Figure 5.

Figure 5: Simplified intra Clean Industry value chain



Enabling Sectors: Measuring and Monitoring and Advanced Manufacturing Technologies

The barriers in the two sectors that have been identified as enabling sectors in the Clean Industry environment do not seem to overlap at first sight. The measuring and monitoring sector indicates missing EU and global standards, a high Capex and long payback periods, and the slow acceptance of new technologies as the main barriers hindering the development of the sector. The AMT sector lists imperfect market functioning, a lack of sufficient skilled personnel, and a lack of market surveillance for machine tools as the most important barriers.

Yet, the two sectors do share a number of barriers, typically associated with their enabling role. Both sectors have in common that they would benefit from efforts that facilitate their access to client industries, either through the development of standards, proper financial incentives, or information and awareness instruments. Indeed, quite often the challenge lies with informing and convincing potential users about the benefits of the new enabler. For potential users, especially SMEs or self-employed workers (e.g. architects), it is not straightforward to be fully informed about different possibilities. Moreover, sometimes the potential users or intermediaries (e.g. electric installers) lack the skills to deploy the new enabling technologies. Tools and networks that improve user awareness about enabling technologies (e.g. through free expert consultation or trainings) can be very useful in overcoming this hurdle.

But even when awareness is complete, financial constraints (high upfront investment cots) can refrain potential users from making the purchase. The need for novel financial incentives and schemes (business models) to

A different aspect of financing relates to the growth capital for fast growing companies. In the AMT sector a stronger responsibility for the European Investment Bank, including the development of instruments beyond traditional debt financing has been suggested. Also in the measuring and monitoring sector, which encompasses fast growing SMEs as well, such a measure would be beneficial.

Both sectors refer to the need to promote Science, Technology, Engineering, and Mathematics (STEM) Education, as well as continuous interaction between companies and education institutes, for example through dual learning programmes or apprenticeships or the involvement of the industry in revising curricula.

Electric Power and Grid

stimulate investments by users have therefore been discussed.

An overarching feature of the Electric Power and Grid cluster is that it is at the heart of the transition of the EU energy system. It is an important building block in the move towards clean production systems in the EU economy. Therefore the performance of this cluster is a key co-determining factor for the competitiveness of client sectors, both of the Clean Industries itself and others in the rest of the economy.

A central barrier in this cluster is the regulatory framework. Both the smart grid sector, the wind energy sector, and the thermal energy storage sector highlight the need for an improved and adjusted regulatory framework, with respect to smart grid functionalities, energy market integration, and storage integration. Given the new technological and market developments - most notably flexible demand response and distributed energy generation - the roles and responsibilities in smart grids are not well defined anymore. This creates a situation with high systemic business risk where it is not clear who is responsible for what, and what can be expected in the foreseeable future. Evidently, this is not conductive to investing further in smart grid solutions, integrating renewable energy production, and upscaling electricity storage capacity. In this respect it is very important to note that for a proper functioning of the future smart grid, it is necessary to define EU-wide interoperability standards, and this not only for large and complex systems, but for small ones as well.

Another common barrier relates to technology, R&D and innovation. In all sectors of the Electric Power and Grid cluster sustained R&D support is mentioned as a key lever to unlock these industries. With the smart grid sector at the core of this cluster it is important to find solutions in critical technology areas such as ICT, sensing, measurement and automation, power electronics, and energy storage technologies, as well as in the areas of security, privacy preservation and grid reliability. In the wind energy sector demonstration and pilot projects with a higher time-to-market rate are desired. In the thermal energy sector support for large scale projects is needed and research on finding innovative ways to integrate thermal energy storage into the smart grid.

A final common barrier relates to capital and finance. In the wind energy sector alternative financing methods are suggested such as community and cooperative funding. The thermal energy storage sector opts for insurance funds to take away the risks of the capital intensive financing needs of the industry. In the smart grid sector new business models may bring in new ways of value creation and value capturing and therefore contribute to (co-) financing the necessary investments.

The different sectors involved in the Electric Power and Grid cluster will become increasingly interconnected. Therefore using levers that apply to all sectors in this cluster will create value added, both for society and business, for the cluster as a whole and with leverage effects further downstream the value chain in the rest of the economy. Based on previous analysis one may conclude that for the Electric Power and Grid cluster these levers are 1) an integrated and adjusted regulatory framework, 2) sustained and integrated R&D and innovation support and 3) new smart financing methods and business models.

Energy Efficient Homes and Buildings

The most important barrier within the Energy Efficient Homes and Buildings cluster relates to capital and finance issues. Ambitious energy-efficient solutions in this cluster are generally more expensive than conventional solutions, especially in the refurbishment segment of existing buildings that promises the highest carbon saving potential. Investors and building owners shy the high upfront costs without considering long-term lower running costs and other positive effects such as health. This is directly linked to the two other important common barriers, the lack of information and awareness towards innovative solutions such as DHC, renewable heating and cooling systems, advanced thermal insulation materials and – last but not least – refurbishments to NZEB standard on the one hand, and regulatory issues on the other hand. If investors and building owners face clear renovation targets in terms of ambitious energy-efficiency standards and know about and accrue the advantages of innovative, highly-efficient building solutions, they will be more willing to accept higher investment costs.

Overcoming those barriers cannot be achieved by demand side or supply side policies alone, but requires instead an integrated policy approach. This should include (i) strict and ambitious renovation targets to support the development of a mass market for innovative and highly efficient building solutions with NZEB standard combined with (ii) financial incentives for investors and building owners to cushion high upfront costs of innovative solutions with a gradual reduction over time as the market for these solutions becomes more mature. The approach should further be accompanied by specific programmes for low-income households and social buildings since those possessing the least financial means often also have the least energy-efficient technologies installed and therefore are important for significant emission reductions. A carbon tax, already used in some Northern European countries, could also be introduced in other MS to get the required public funding. Since innovative building solutions highly depend on other Clean Industries within and beyond the Buildings cluster, an increasing demand for refurbishment to NZEB standard will simultaneously pull the demand in other sectors, such as measuring and monitoring, renewable energy (e.g. from the wind sector), smart grids and storage etc.

Cleaner Transport Solutions

Applying to both the technologies to realise efficiency gains in vehicle powertrains sector and the rail sector is that a proper balance should be pursued between ambitious emission objectives and maintaining valorisation possibilities for the EU industries. In other words, the EU should strive to reach its emission reduction goals, but not to the expense of losing jobs and added value in the EU. The reason for this difficult balance is that the most important barrier in the transport cluster relates to capital and finance. The technologies to realise efficiency gains in vehicle powertrains sector and the rail sector are characterised by low operating margins which hinder further investment in increasing energy efficiency and decreasing emissions. Furthermore, the rail sector as well as the traffic control systems sector require considerable investments for further developments within the sectors. In both sectors assessing new financing mechanisms to foster (co-)investment is mentioned as a lever to sustain financing. Examples are joint investment pools, co-investment schemes and new leasing formulas. A second common area of attention in the sectors within the Cleaner Transport Solutions cluster is the need for harmonised standards. Cross-border interoperability issues hamper development of these sectors in the EU and efforts should be directed towards increasing the internal market functioning. A final lever which applies to Cleaner Transportation Solutions as a whole is mentioned in the rail sector, where it is suggested to endeavour policy solutions to promote cross modal transport solutions.

When shifting the perspective from the various transport modes towards a general Cleaner Transport Solution perspective it becomes clear that traffic control systems contribute in a general manner towards cleaner

transportation. What also becomes clear from this general Cleaner Transport Solution perspective, is that there is a certain competition between the various modes of transport, all representing a certain share of transport. This does not imply that one should choose for stimulating a certain mode of transport that contributes mostly to a cleaner future of transport; on the contrary, it could be worthwhile to enhance the cooperation between various transport modes if this contributes to cleaner transport. For example, the last mile issue in rail sector, in principle one of the cleanest modes of transport, could be solved by closer cooperation with other transport modes such as road transportation. The EU efforts towards increasing the energy efficiency and decreasing emissions from its transportation system are not unnoticed. In all transport related sectors there is a mentioning of the 2011 White Paper: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system. This is a positive example of coordinated policy making, which might be an inspiration for the other clusters identified in this study.

4.2 A cross-sectoral and cross-country perspective: towards an integrated vision

From the analysis in section 3.3, it appears clearly that Clean Industries cannot be regarded in isolation. There are very strong interdependencies between the sectors of the EU Clean Industry (as visualised in Figure 2), and shortcomings in one sector can have a major influence on other sectors. It is therefore recommended to aim for an integrated approach in promoting clean industries. Such an integrated approach could for example be based on creating parallel initiatives that mutually reinforce each other.

When a region or country aims to promote e.g. wind energy production, it may be worthwhile to consider parallel initiatives that support related Clean Industries. For example, one may also promote in parallel the construction of additional charging points for electrical vehicles, promote developments of smart grids, incentivise further renewable electric heating (e.g. through heat pumps), or support demonstration or full-scale thermal energy storage plants. Such parallel initiatives would promote the use of cheap energy that is available at peak wind moments, strengthening each other's business case.

As another example, initiatives that promote more efficient heating systems such as district heating, could be more regularly coupled to thermal energy storage investments (there are already a number of examples, e.g. in Denmark), but also the promotion of advanced insulation or information campaigns on benefits of measuring and monitoring (e.g. home automation) solutions could be run in parallel. The latter would help to reduce the required heat production capacity and support e.g. lower temperature district heating and cooling networks (4th generation type). Apart from direct (economic) synergies, such parallel initiatives also create a strong signal for stakeholders and investors in the other Clean Industry markets, particularly in the energy sector.

From the analysis in section 3.3, it emerges that especially the part related to the internal combustion engine (ICE) of the technologies to realize efficiency gains in vehicle powertrains sector bears rather few connections to the other Clean Industries. While acknowledging the improvements in the ICE over the past decades that have reduced engine fuel consumption, and the still significant potential for further improvements, it seems that in an integrated approach to clean industries the electrical vehicles would fit better given their stronger links with the other Clean Industries.

This study has also pointed to several links with 'conventional' sectors. For example, the wind energy, geothermal energy and underground thermal energy storage all can benefit from the expertise and skills built up in the oil and gas sector. Building on the work that has been done in the context of the SET plan, it is therefore recommended to explore further to what extent skills from conventional sectors (e.g. oil and gas, coal, ...) that show a declining trend can be transferred to the Clean Industries.

Another observation in this study is that Clean Industries have different states of development and operate in different policy frameworks in the different Member States. Firstly, it would therefore be good to increase regulatory coherence among Member States, in order to create a true single market in which the most efficient Clean Industry products and solutions are easily up-scaled from one country to the EU as a whole. Secondly, some Member States harbour a great deal of experience in supporting specific Clean Industries through the regulatory framework. An effective platform where Member State representatives can meet and exchange best practices could therefore be a major tool for Member States to accelerate the growth of Clean Industries.

4.3 Towards an EU Clean Industry policy roadmap

Aligning policies along the intra Clean Industry value chain may help developing a roadmap for unlocking the EU Clean Industry. Policies targeted at the Enabling Sectors can be perceived as supply side policies for the Clean Industry as a whole, even if particular measures for the sectors have a demand side nature. Similarly policies targeted at the Energy Efficient Homes and Buildings cluster and at the Clean Transport Solutions cluster can be perceived as demand stimulating policies for the Clean Industry: 1) supply side oriented, prioritising the Enabling Sectors cluster, 2) demand side oriented, prioritising the Energy Efficient Homes and Buildings cluster and Buildings cluster and the Clean Transport Solutions cluster, and 3) an overall Clean Industry approach with policies aiming at all four clusters in a coordinated manner.

Given the cross-sectoral and cross-country interlinkages depicted in previous section, an integrated policy approach for the EU Clean Industry is to be preferred, providing leverage to both the supply side of the Clean Industries and to the demand side. In other words an integrated policy would both foster market creation for Clean Industries by providing leverage for the Energy Efficient Homes and Buildings and for Clean Transport Solutions, and simultaneously helps to overcome the 'supply side' related barriers in the Enabling Sectors. This implies that the sequencing and prioritisation of policies is not so much along the intra Clean Industry value chain but rather requires a cross-sectoral set of policy actions focussing on the most important barriers and levers first.

Error! Reference source not found. provides an overview of which levers could be prioritised for each of the our clusters, based on the classification of barriers and levers in chapter 3/. The vertical axis represents the intra Clean Industry value chain and the horizontal axis represent time.





Source: IDEA Consult, NIW

According to this analysis, the way to unlock the EU Clean Industries would start by focussing simultaneously on the standards in the measuring and monitoring and AMT industries, optimising the regulatory framework conditions for smart grids, wind energy and thermal energy, and overcome the barriers with respect to capital and financing constraints in the downstream Clean Industry sectors of the Energy Efficient Homes and Buildings and Cleaner Transport Solutions. Focussing on overcoming the capital and finance problems in the downstream intra Clean Industry sectors helps creating a home market for the other Clean Industry sectors that are positioned more upstream in the value chain. Yet for the latter it is essential that the hurdles that block further growth and jobs are simultaneously solved as well since this would provide a mutually reinforcing leverage effect.

As a second order of priority, policy action could focus on promoting STEM education for the sectors in the Enabling Sectors cluster, sustained R&D, demonstration and deployment support for the Electric Power and Grid cluster and regulation in the Energy Efficient Homes and Buildings cluster and the Cleaner Transport Solutions. For the Energy Efficient Homes and Buildings cluster the regulatory actions pertain to renovation targets that are closer to NZEB standards. In the Cleaner Transport Solutions these relate to cross-border interoperability and the balance between ambitious emission objectives and maintaining valorisation potential for the EU industry, and fostering cooperation between various transport modes.

In third instance policy action could focus on information and knowledge and awareness creation for the Enabling Sectors and the Energy Efficient Homes and Buildings cluster. Although an adjusted regulatory framework is expected to provide clear business perspectives in the Electric Power and Grid cluster, remaining capital and finance problems could be targeted later on.

It is expected that sequencing and prioritising the various policy actions along the lines indicated above will create a mutual reinforcing effect across the intra Clean Industry value chain thereby unlocking the EU Clean Industry as a whole and providing further leverage to the rest of the EU economy. It has also emerged from the analyses that integrated policy actions do have a merit and may provide further stimulus to the promotion of the EU Clean Industry.

4.4 Boundaries of the study and recommendations for further research

This study has proposed the challenging task of defining Clean Industries, identifying 12 priority sectors, conducting extensive sectoral analyses with the aim of revealing specific and common barriers and levers to unlock these priority sectors. The wide scope of the study enables cross-sectoral insights, to identify levers that apply to barriers that are common across various sectors, and to take an integrated Clean Industry perspective rather than a single sector perspective. However, the downside of this wide scope is that given the time and budget constraints of the project one may not always achieve sufficient level of detail needed for further in-depth operationalisation of the policy recommendations.

Therefore in order to valorise and further build on the insights generated in this study a number of recommendations for further research might be formulated:

- More detailed in-depth studies for particular Clean Industry sectors focussing on particular levers that have been highlighted in this study.
- An evaluation or review of the existing EU policies with respect to the levers needed for fostering the EU Clean Industry or for particular Clean Industry sectors.

- Conduct studies regarding the four identified clusters. By doing so, the study still takes place in the area of the most promising Clean Industries, however, one could place greater focus on detail and the specific interdependencies in those clusters.
- The selection methodology could be applied to other sectors, since the structure and systematic was appreciated both by its results as well as its process.
- A Clean Industry Observatory could be set-up bridging the information gap across EU Member States and across Clean Industry sectors.

5/ Bibliography

BMBF (2013): Kahlenborn, W., Mewes, H., Knopf, J., Hauffe, P., Kampffmeyer, N., Fichter, K., Clausen, J., Weiß, R., Beucker, S. and Bergset, L. *Treiber und Hemmnisse für die Transformation der deutschen Wirtschaft zu einer "Green Economy*". Berlin: Bundesministerium für Bildung und Forschung.

BMU/RB (2014): *GreenTech made in Germany 4.0 – Environmental Technology Atlas for Germany*. Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and Roland Berger.<u>http://www.bmub.bund.de/service/publikationen/downloads/details/artikel/greentech-made-in-germany-40/?tx_ttnews[backPid]=2903</u>.

Boermans, T., Bettgenhäuser, K., Offermann, M., Schimscher, S. (2012): *Renovation Tracks for Europe up to 2050*. Report commissioned by the European Insulation Manufacturers Association (Eurima) to Ecofys Germany, Köln.

Brookings Institute (2011): *Sizing the U.S. Clean Economy: A National and Regional Green Job Assessment*. http://www.brookings.edu/metro/Clean_Economy.aspx

Castellazzi, L., Zangheri, P., Paci, D. (2016): *Synthesis report on the assessment of Member States' building renovation strategies*, EUR 27722 EN; doe 10.2790/052530.

Cedefop (2015): *Skill shortages and gaps in European enterprises: striking a balance between vocational education and training and the labour market*. Luxembourg: Publications Office. Cedefop reference series; No 102. <u>http://dx.doi.org/10.2801/042499</u>

Eurobserv'Er (2016): Wind Energy Barometer. http://www.eurobserv-er.org/wind-energy-barometer-2015/

European Commission (2014). *Strategic Energy Technology (SET) Plan: roadmap on Education and Training*. JRC science and policy reports.

European Commission (2016): *Review of available information accompanying the document "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU Strategy on Heating and Cooling"*, Commission Staff Working Document Part 1/2, Brussels, 16th February 2016,

https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_autre_document_travail_service_part1_v6_0.pdf

European Communities (2009): *The Environmental Goods and Services Sector – A Data Collection Handbook*, Edition 2009, Eurostat Methodologies and Working Papers, Luxembourg

European Communities (2015): A Practical Guide for the Compilation of Environmental

European Wind Energy Technology Platform (2013): *Workers Wanted: The EU wind energy sector skills gap*. <u>http://ewea.org.www.ewea.org/report/workers-wanted</u>

EWEA European Wind Energy Association (2012): *Green Growth - The impact of wind energy on jobs and the economy*. <u>http://www.ewea.org/fileadmin/files/library/publications/reports/Green_Growth.pdf</u>

Globe Advisors (2012): *The West Coast Clean Economy. Opportunities for Investments and Accelerated Job Creation*. Final Report and Methodology Document. March 2012

GWEC Global Wind Energy Council (2016): *Global Wind Report 2015 – Annual market update*. April 2016. http://www.gwec.net/wp-content/uploads/vip/GWEC-Global-Wind-2015-Report April-2016 22 04.pdf

JRC Joint Research Centre (2014): *Financing Building Energy Renovations – Current Experiences & Ways Forward.* http://iet.jrc.ec.europa.eu/energyefficiency/tags/financing-building-energy.

Kachan & Co. (2012): A new cleantech taxonomy. <u>http://www.kachan.com/about/cleaner-technology-definition-cleantech</u>.

Lacal-Arántegui, R. (2016): *Wind energy market report 2015.* Deliverable 2 of the WindValueEU project, internal European Commission report. Joint Research Centre, European Commission, February 2016.

MKULNV NRW (2015): *Umweltwitschaftsbericht Nordrhein-Westfalen 2015*. Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen. https://www.umwelt.nrw.de/mediathek/broschueren/detailseite-broschueren/?broschueren_id=5190.

6/ List of abbreviations

Abbreviation	Meaning				
3D	Three Dimensional				
АМТ	Advanced Manufacturing Technologies				
CAGR	Compound Annual Growth Rate				
СНР	Cogeneration or Combined Heat and Power				
C02	Carbon Dioxide				
CSP	Concentrated Solar Power				
DSO	Distribution System Operator				
EC	European Commission				
EED	Energy Efficiency Directive				
EIB	European Investment Bank				
EnPC	Energy Performance Contracting				
EPBD	Energy Performance of Buildings Directive				
EPC	Energy Performance Certificate				
ERTMS	European Railway Traffic Management System				
EU	European Union				
GDP	Gross Domestic Product				
GHG	Greenhouse Gas				
ICE	Internal Combustion Engine				
ICT	Information and Communications Technology				
ISIC	The International Standard Industrial Classification of All Economic Activities				
ISO	International Organization for Standardization				
ITS	Intelligent Transport Systems				
KET	Key Enabling Technologies				
LCOE	Levelized Cost Of Electricity				

MS	Member States
NACE	The Statistical Classification of Economic Activities in the European Community
NAFTA	North American Free Trade Agreement
NZEB	Nearly Zero-Energy Building
OEM	Original Equipment Manufacturer
РСМ	Phase Change Materials
PSS	Product-Service System
R&D	Research and Development
RTO	Research and Technology Organisation
SESAR	Single European Sky ATM Research
SIM	Super Insulation Materials
SME	Small-Medium Enterprise
STEM	Science, Technology, Engineering and Math
тсм	Thermochemical Materials
TRL	Technology Readiness Level
TSO	Transmission System Operator
ИК	United Kingdom
US	United States
UTES	Underground Thermal Energy Storage



1/ Annex 1: Taxonomy

[Clean Energy (production, storage and distribution) e.g. turbines, components, towers Solar (thermal, photovoltaic, concentrating solar power (CSP)) e.g. PV module technologies, inveters, mirrors Biomass e.g. combustion equipment Geothermal e.g. combustion equipment Hydropower (e.g., run-of-river and other small-scale hydro) e.g. turbines, components Wave/ocean power e.g. turbines, components Storage technologies Mechanical storage Electrochemical storage e.g. pumped hydroelectric Storage (PHES) Combined Gas and steam power plants combined heat and power units (CHP) Waste heat recovery Carbon capture and utilization (CCU) Fue cells stationary use Efficient networks Smart grids (to improve flexibility of existing regional networks), Super grids (across generation and demand diversity; requires new subsea and land routes) e.g. wall insulation, improved glazing of windows, floor insulation, improved glazing of windows, floor insulation, loft insulation Building (NZEB) Efficient lighting appliances e.g. LED Energy-efficient appliances Energy-efficient data centres (Green IT) e.g. LED Electric vehicles (PEV) Fue-cell-electric vehicles (PEV) plug-in hybrid lectric vehicles (PEV) e.g. tetan, likel-metal hybrid batteries, ilthium-ion batteries, ultra- capa	Segments	Sub-segments	Examples of technologies/products				
Renewable Energies Wind (onshore, offshore) Solar (thermal, photovoltaic, concentrating solar power (CSP)) Biomass e.g. PV module technologies, inverters, mirrors Biomass e.g. orbitation equipment Geothermal e.g. orbitation equipment Hydropower (e.g. run-of-river and other small-scale hydro) e.g. turbines, components Storage technologies Mechanical storage e.g. turbines, components Storage technologies Mechanical storage e.g. pumped Hydroelectric Storage (PHS), compressed are nergy storage (CAES) Eco-friendly energy Combined faes and steam power plants conversion combined heat and power units (CHP) Waste heat recovery Carbon capture and storage (CCS), carbon capture and utilization (CCU) stationary use Efficient networks Smart grids (to improve flexibility of existing regiona and atomato loodres to access generation and demand diversity; requires new subsea and land routes) transmission (e.g. superconductors, high- voltage control devices), demand e.g. monitoring sensors and controling and metering*, networking equipment, data analysis system) Building automation e.g. wall insulation, improved glazing of windows, floor insulation, ioft insulation e.g. nonitoring sensors and controllers*, software, data analysis and communication Efficient heating and cooling e.g. LED Nearty Zero Energy- Buildings (NZEB)	Clean Energy (production, storage and distribution)						
Storage technologies Mechanical storage e.g. pumped Hydroelectric Storage (PHS), compressed air energy storage (CAES) accumulators, capacitors Storage technologies Mechanical storage e.g. pumped Hydroelectric Storage (PHS), compressed air energy storage (CAES) accumulators, capacitors Electrochemical storage Hydrogen storage e.g. pumped-heat electricity storage (PHS), combined heat and power units (CHP) Waste heat recovery Carbon capture and storage (CCS), carbon capture and utilization (CCU) Fuel cells stationary use Efficient networks Smart grids (to improve flexibility of existing regional networks), Super grids (across regional networks), Super grids (across new subsea and land routes) District heating and cooling stationary use Energy-Efficient Buildings& Appliances e.g. wall insulation, improved glazing of windows, floor insulation, lot insulation Building automation e.g. uall insulation, improved glazing of windows, floor insulation, lot insulation Efficient heating and cooling e.g. heat pumps Energy-efficient a data centres (Green IT) e.g. LED Electro-efficient data centres (Green IT) e.g. LED Clean Mobility Electric vehicles (PHEV) Fuel-cell-celtcric vehicles (PEV) Puig-in hybrid electric vehicles (PEV) plug-in hybrid electric vehicles (PECV) Batteries Energy storage systems used in EVS lead-acid batteries,	Renewable Energies	Wind (onshore, offshore) Solar (thermal, photovoltaic, concentrating solar power (CSP)) Biomass Geothermal Hydropower (e.g. run-of-river and other small-scale hydro)	e.g. turbines, components, towers e.g. PV module technologies, inverters, mirrors e.g. combustion equipment e.g. heat pumps e.g. turbines, components				
Storage technologies Prechanical storage compresed air energy storage (CAES) accumulators, capacitors Eco-friendly energy Combined Gas and steam power plants e.g. pumped-heat electricity storage (PHES) Eco-friendly energy Combined Gas and steam power plants e.g. pumped-heat electricity storage (PHES) Waste heat recovery Carbon capture and utilization (CCU) Fuel cells stationary use Efficient networks Smart grids (to improve flexibility of existing regional networks), Super grids (across regional networks), Super grids (across regional networks), Super grids (across regional and diversity; requires new subsea and land routes) District heating and cooling e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation Building automation e.g. e.g. e.g. heat pumps communication Building automation e.g. LED e.g. LED Energy-efficient appliances Efficient lighting Energy-efficient data centres (Green IT) e.g. LED Clean Mobility Energy-efficient vehicles (PEV) plug-in hybrid electric vehicles (PEV) Fuel-cell-electric vehicles (PEV) e.g. ethanol, biodiesel, biogas	Storage technologies	Mechanical storage	e.g. turbines, components				
Thermal storage e.g. pumped-heat electricity storage (PHES) Eco-friendly energy conversion Combined Gas and steam power plants Combined heat and power units (CHP) Waste heat recovery Carbon capture and storage (CCS), carbon capture and utilization (CCU) Fuel cells stationary use Efficient networks Smart grids (to improve flexibility of existing regional networks), Super grids (across generation and demand diversity; requires new subsea and land routes) transmission (e.g. superconductors, high- voltage control devices), demand response, management (e.g. monitoring and metering*, networking equipment, data analysis system) Efficient Buildings& Appliances	Storage technologies	Electrochemical storage	compressed air energy storage (CAES) accumulators, capacitors				
Hydrogen storage Eco-friendly energy Combined Gas and steam power plants conversion Combined heat and power units (CHP) Waste heat recovery Carbon capture and storage (CCS), carbon capture and utilization (CCU) Fuel cells stationary use Efficient networks Smart grids (to improve flexibility of existing regional networks). Super grids (across generation and demand diversity; requires new subsea and land routes) transmission (e.g. superconductors, high-voltage control devices), demand response, management (e.g. monitoring and metering*, networking equipment, data analysis system) District heating and cooling e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation Building automation e.g. wall insulation, information software, data analysis and communication Efficient heating and cooling e.g. heat pumps Cooling Efficient lighting e.g. LED Nearly Zero Energy Efficient data centres (Green IT) e.g. LED Clean Mobility Electric vehicles (BEV) plug-in hybrid electric vehicles (FCEV) Batteries Energy-efficient vehicles (FCEV) lead-acid batteries, nickel-metal hybrid batteries, lickel-metal hybrid batteries, lickel-metal hybrid batteries, lickel-metal hybrid batteries, eapacitors		Thermal storage	e.g. pumped-heat electricity storage (PHES)				
Eco-friendly energy conversion Combined Gas and steam power plants Combined heat and power units (CHP) Waste heat recovery Carbon capture and utilization (CCU) Fuel cells stationary use Efficient networks Smart grids (to improve flexibility of existing regional networks), Super grids (across regions and national borders to access new subsea and land routes) transmission (e.g. superconductors, high- voltage control devices), demand and metering*, networking equipment, data analysis system) Energy-Efficient Buildings& Appliances e.g. wall insulation, improved glazing of windows, floor insulation, e.g. monitoring sensors and controllers*, software, data analysis and communication Building automation e.g. wall insulation, insul		Hydrogen storage					
Efficient networks Smart grids (to improve flexibility of existing regional networks), Super grids (across regions and national borders to access generation and demand diversity; requires new subsea and land routes) District heating and cooling transmission (e.g. superconductors, high-voltage control devices), demand response, management (e.g. monitoring and metering*, networking equipment, data analysis system) Energy-Efficient Buildings& Appliances e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation Building automation e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation Efficient heating and cooling e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation Efficient heating and cooling e.g. heat pumps Cooling e.g. heat pumps Nearly Zero Energy Efficient lighting Buildings (NZEBs) Efficient lighting Energy-efficient Efficient consumer electronics Energy-efficient data centres (Green IT) Clean Mobility Electric vehicles (PEV) Electric vehicles Battery-electric vehicles (PEEV) Fuel-cell-electric vehicles (FCEV) lead-acid batteries, nickel-metal hybrid batteries, lithium-ion batteries, ultra-capacitors Renewable fuels Conventional biofuels e.g. ethanol, biodiesel, biogas	Eco-friendly energy conversion	Combined Gas and steam power plants Combined heat and power units (CHP) Waste heat recovery Carbon capture and storage (CCS), carbon capture and utilization (CCU) Fuel cells	stationary use				
Energy-Efficient Buildings& Appliances e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation Building automation e.g. monitoring sensors and controllers*, software, data analysis and communication Efficient heating and cooling e.g. heat pumps Nearly Zero Energy Buildings (NZEBs) e.g. LED Energy-efficient appliances Efficient lighting e.g. LED Energy-efficient data centres (Green IT) e.g. LED Clean Mobility Electric vehicles (BEV) plug-in hybrid electric vehicles (PHEV) Fuel-cell-electric vehicles (FCEV) Batteries Energy storage systems used in EVs Renewable fuels Conventional biofuels	Efficient networks	Smart grids (to improve flexibility of existing regional networks), Super grids (across regions and national borders to access generation and demand diversity; requires new subsea and land routes) District heating and cooling	transmission (e.g. superconductors, high- voltage control devices), demand response, management (e.g. monitoring and metering*, networking equipment, data analysis system)				
Thermal insulation e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation Building automation e.g. monitoring sensors and controllers*, software, data analysis and communication Efficient heating and cooling e.g. heat pumps Nearly Zero Energy Buildings (NZEBs) e.g. heat pumps Energy-efficient appliances Efficient lighting e.g. LED Energy-efficient data centres (Green IT) e.g. LED Clean Mobility Electric vehicles (BEV) plug-in hybrid electric vehicles (PHEV) Fuel-cell-electric vehicles (FCEV) Batteries Energy storage systems used in EVs Renewable fuels Conventional biofuels	Energy-Efficient Buildin	ngs& Appliances					
Building automation e.g. monitoring sensors and controllers*, software, data analysis and communication Efficient heating and cooling e.g. heat pumps Nearly Zero Energy e.g. heat pumps Buildings (NZEBs) Efficient lighting Energy-efficient Efficient lighting appliances Energy-efficient consumer electronics Energy-efficient data centres (Green IT) Electric vehicles Description Battery-electric vehicles (PEV) plug-in hybrid electric vehicles (FCEV) lead-acid batteries, nickel-metal hybrid batteries, lithium-ion batteries, ultra-capacitors Renewable fuels Conventional biofuels e.g. ethanol, biodiesel, biogas	Thermal insulation		e.g. wall insulation, improved glazing of windows, floor insulation, loft insulation				
Efficient heating and cooling e.g. heat pumps Nearly Zero Energy Buildings (NZEBs) e.g. heat pumps Energy-efficient appliances Efficient lighting gods Energy-efficient consumer electronics Energy-efficient data centres (Green IT) e.g. LED Clean Mobility Eattery-electric vehicles (BEV) plug-in hybrid electric vehicles (PHEV) Fuel-cell-electric vehicles (FCEV) ead-acid batteries, nickel-metal hybrid batteries, lithium-ion batteries, ultracapacitors Renewable fuels Conventional biofuels e.g. ethanol, biodiesel, biogas	Building automation		e.g. monitoring sensors and controllers*, software, data analysis and communication				
Nearly Zero Energy Buildings (NZEBs)Efficient lighting Energy-efficient Energy-efficient white goods Energy-efficient consumer electronics Energy-efficient data centres (Green IT)e.g. LEDClean MobilityEnergy-efficient consumer electronics Energy-efficient data centres (Green IT)Image: Clean Construction of the	Efficient heating and cooling		e.g. heat pumps				
Energy-efficient appliancesEfficient lighting Energy-efficient white goods Energy-efficient consumer electronics Energy-efficient data centres (Green IT)e.g. LEDClean MobilityEnergy-efficient consumer electronics Energy-efficient data centres (Green IT)Image: Constant of the	Nearly Zero Energy Buildings (NZEBs)						
Clean Mobility Electric vehicles Battery-electric vehicles (BEV) plug-in hybrid electric vehicles (PHEV) Fuel-cell-electric vehicles (FCEV) Batteries Energy storage systems used in EVs lead-acid batteries, nickel-metal hybrid batteries, lithium-ion batteries, ultra- capacitors Renewable fuels Conventional biofuels	Energy-efficient appliances	Efficient lighting Energy-efficient white goods Energy-efficient consumer electronics Energy-efficient data centres (Green IT)	e.g. LED				
Electric vehicles Battery-electric vehicles (BEV) plug-in hybrid electric vehicles (PHEV) Fuel-cell-electric vehicles (FCEV) Batteries Energy storage systems used in EVs lead-acid batteries, nickel-metal hybrid batteries, lithium-ion batteries, ultra-capacitors Renewable fuels Conventional biofuels	Clean Mobility						
Batteries Energy storage systems used in EVs lead-acid batteries, nickel-metal hybrid batteries, lithium-ion batteries, ultra-capacitors Renewable fuels Conventional biofuels e.g. ethanol, biodiesel, biogas	Electric vehicles	Battery-electric vehicles (BEV) plug-in hybrid electric vehicles (PHEV) Fuel-cell-electric vehicles (FCEV)					
Renewable fuels Conventional biofuels e.g. ethanol, biodiesel, biogas	Batteries	Energy storage systems used in EVs	lead-acid batteries, nickel-metal hybrid batteries, lithium-ion batteries, ultra- capacitors				
	Renewable fuels	Conventional biofuels	e.g. ethanol, biodiesel, biogas				

Table 5:Taxonomy of Clean Industries

	Advanced renewable fuels	e.g. hydrogen and synthetic methane
Energy efficiency	Technologies to reduce vehicle loads by	
gains in vehicles	Lightweight materials,	
powered by internal	Aerodynamics improvements	
combustion engine	Energy-saving tires	
(ICE)	5, 5	
Rail/tram		
Other transportation	Electric bikes	
vehicles	Electric motorcycles	
Traffic control		
systems		e.g. lighting and signals
Infrastructure	Sustainable mobility concepts	e.g. car sharing
	Alternative filling station	
	Public mass transit	
	Traffic management services	
Energy and/or Materia	al-Efficient Production (Processes)/Clean Product	ion
Energy- and/or	Advanced manufacturing technologies ¹	e.g. digital printing, laser-cutting
material-efficient		techniques
production		
technologies		
Cross-application	Organic electronics	e.g. organic solar cells, organic LED
technologies		display
	Industrial biotechnology & renewable	e.g. bioplastics, enzymes to reduce the
	resources	amount of narsh chemicals used the
Moocuring and	Automation cofficiare exctance concore and	textile of pulp and paper industries
monitoring	other measurement, process efficiency	
Environmental Protect	ion	
Air pollution control	Air bandling aguipment	o a condensers vacuum numps
	All handling equipment	e.g. condensers, vacuum pumps
	systems	or perovide
	Separators precipitators	e a machinery for liquefying air/other
		dases
Water purification		54000
Noise and vibration		
abatement		
Protection and		
remediation of soil		
Waste treatment and		
management		
Sustainable forestrv.		
agriculture and		
aquaculture		

Source: IDEA Consult and NIW compilation.

Notes: ¹ following the definition used in the EU Key Enabling Technologies Observatory. <u>https://ec.europa.eu/growth/tools-databases/ketsobservatory /</u>

2/ Annex 2: Selection results

Table 6: Ranking of all subsectors with equal weights (baseline results)

Selection criteria [1 - 5] Absolute Technology prowth potential Comparative leadership Comparative Advantage 1 Wind 5 5 5 4,75 2 Efficiency tech. ICE vehicles 3 4,5 5 4,43 3 District heating 4 4 4 400 4 NZEB 3 4 5 3 4,00 5 AMT 3 4 5 4 4,00 6 Heating and cooling systems 4 3,5 4 4,00 9 Smart grids and super grids 4 4 3,67 3,51 9 Smart grids and super grids 4 2,5 5 3,50 1 Hydropower 4 2,5 3 3,25 3,44 1 Hydropower 3 3,5 4 4 3,35 1 Moropower 3 3,5 3 3,75 3,44 1 Hydropower 3 3 4 3,33 3,75 3,44 1 Biomas 3<		1		Ø ^Ø		123
Absolute growth potential Technology growth potential Comparative Leadership Owerall score 1 Wind 5 5 5 4,75 4,94 2 Efficiency tech. ICE vehicles 3 4,5 5 4 4,13 3 District heating 4 4 4 400 400 4 NZEBs 5 3 5 3 400 5 AMT 3 4 5 4 4,00 6 Heating and cooling systems 4 3,5 4 4,00 8 Internal storage 4 4 3,67 3,67 10 Rail/tram 3 3,5 4 4 3,67 11 Hydropover 4 2,5 3 3,25 3,44 13 Solar 4 3,5 3 4 3,50 13 More all storage 3 3,5 4 3,33 3,75 13 Solar 4 3,5 3 4,44 3,63 13 Solar 4 3,5			Selection cr	iteria [1 - 5]		
Determine the product of the product		Clean potential	Absolute growth potential	Technology Leadership	Comparative Advantage	
1 Wind 5 5 5 4,75 4,94 2 2 Efficiency tech. ICE vehicles 3 4,5 5 4 4,13 2 District hating 4 4 4 4 400 4 MZEBs 5 3 5 3 400 5 AMT 3 4 5 4 4,00 6 Heating and cooling systems 4 3,5 4 3,75 3,81 7 Measuring and monitoring 3 4 4 4 3,67 9 Smart grids and super grids 4 4 3,67 3,67 9 Sint grids and super grids 4 4 3,67 3,67 10 Nail/tram 3 3,5 4 4 3,67 11 Hydropower 4 2,5 3 4,53 3,50 12 Mechanical storage 2,5 3 3,25 3,44 3,33 13 Solar 4 3,75 3,44 3,33 3,33 </td <td></td> <td></td> <td>potentiai</td> <td></td> <td></td> <td>Overall score</td>			potentiai			Overall score
2 Efficiency tech. ICE vehicles 3 4,5 5 4 4,13 3 District heating 4 4 4 4,00 4 NZEB 5 3 5 3 4,00 5 AMT 3 4 5 4 4,00 6 Heating and cooling systems 4 3,5 4 4,00 7 Measuring and monitoring 3 4 4 4 3,67 9 Smart grids and super grids 4 4 3 3,67 3,67 10 Rail/tram 3 3,5,5 4 4 3,67 3,50 13 Solar 4 3,5,5 3 3,25 3,44 3,67 13 Solar 4 3,5,5 3 3,25 3,44 3,63 13 Solar 4 3,3 3,7,5 3,44 3,33 3,75 3,44 14 Biomass 4 3,3 3,25 3,44 3,33 3,325 3,44 18 Waste heat recovery 3 3 4 3,33 3,33 3,33 3,25 3,44 3,33	1 Wind	5	5	5	4.75	4.94
3 Districtheating 4 4 4 4,00 4 AZEBS 5 3 5 3 4,00 5 AMT 3 4 5 3 4,00 6 Heating and coling systems 4 3,5 4 3,75 3,81 7 Measuring and monitoring 3 4 4 4 3,67 9 Smart grids and super grids 4 4 3 3,67 3,67 10 Rail/tram 3 3,5 4 4 3,67 11 Hydropower 4 2,5 3 4,5 3,50 12 Mechanical storage 3 2,5 5 3,44 13 Solar 4 3,5 3 3,25 3,44 14 Biomass 4 3,5 3 3,25 3,44 15 Tremmal insulation 5 2,5 3 3,25 3,44 16 Traffic control systems 3 3 4 3,33 3 3,33 3 3,33 3 3,33 3 3,33 3 3,33 3 3,33 3	2 Efficiency tech. ICE vehicles	3	4.5	5	4	4.13
4 NZEBs535345 MAT34544,005 MAT34544,006 Heating and cooling systems43,543,753,8117 Measuring and monitoring34443,679 Smart grids and super grids44343,6710 Rail/tram33,5443,6311 Hydropower42,534,53,5012 Mechanical storage32,553,5013 Solar43,533,253,4416 Itomasis43,533,253,4416 Itomasis3343,333,3319 Building automation3343,3320 Biofuels3343,333,3321 Organic electronics2443,2523 Separators, precipitators13,553,53,2524 Eda-acid batteries32,544,53,2525 Plug-in Hydrid electric vehicles42,533,1726 Advanced renewable fuels32,543,0031 Arhandling equipment13533,0032 Catalytic converters, chemical recovery12,553,53,2528 Battery-electric vehicles52,522,53,0030 Acordynamics improvement to rea	3 District heating	4	4	4		4.00
5 AMT 3 4 5 4 4,00 6 Heating and cooling systems 4 3,5 4 3,75 3,81 7 Measuring and monitoring 3 4 4 4 3,67 8 Thermal storage 4 3 4 4 3,67 9 Smart grids and super grids 4 4 3 3,67 3,67 10 Rail/tram 3 3,5 4 4 3,67 12 Mechanical storage 3 2,5 5 3,50 3,50 12 Mechanical storage 3 2,5 3 3,25 3,44 14 Biomass 4 3,5 3 3,25 3,44 14 Biomass 3 3 3,25 3,44 15 Thermal insulation 5 2,5 3 3,25 3,44 18 Waste heat recovery 3 3 4 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33 3,33	4 NZEBs	5	3	5	3	4.00
6Heating and cooling systems43,543,753,817Measuring and monitoring34443,758Thermal storage43443,679Smart grids and super grids4443,679Smart grids and super grids4443,6710Rail/tram33,5443,66711Hydropower42,534,53,5012Mechanical storage32,553,5013Solar43,533,753,4414Biomass43,533,253,4415Thermal insulation52,533,253,4416Traffic control systems3343,333,3320Biofruels3343,333,3321Industrial Biotechnology and Renewabl3343,3322Industrial Biotechnology and Renewabl3343,2523Separators, precipitators13,5543,253,1925Plugin hybrid electric vehicles42,533,1724Ladadi obtateries32,543,253,1925Plugin hybrid electric vehicles42,533,1726Advanced renewable fuels32,543,253,00<	5 AMT	3	4	5	4	4.00
7 Measuring and monitoring 3 4 4 3,75 8 Thermal storage 4 3 4 3,67 9 Smart grids and super grids 4 4 3 3,67 10 Rail/train 3 3,55 4 4 3,63 10 Rail/train 3 3,55 3 4,5 3,50 12 Mechanical storage 3 2,5 5 - 3,50 12 Mechanical storage 3 2,5 3 3,25 3,44 13 Solar 4 3,5 3 3,25 3,44 14 Biomass 4 3 3 4 3,33 15 Thermal insulation 5 2,5 3 3,25 3,44 18 Waste heat recovery 3 3 4 3,33 3 4 3,33 3 3 4 3,33 3 3 3 4 3,33 3 3 3 4 3 3,33 3 3 3	6 Heating and cooling systems	4	3.5	4	3.75	3.81
a Thermal storage 4 3 4 3,67 9 Smart grids and super grids 4 4 3 3,67 10 Rail/tram 3 3,5 4 4 3,63 10 Rail/tram 3 3,5 4 4 3,63 11 Hydropower 4 2,5 3 4,5 3,50 12 Mechanical storage 3 2,5 5	7 Measuring and monitoring	3	4	4	4	3.75
9 Smart grids and super grids 4 4 3 10 Rail/Itram 3 3,5 4 4 3,67 10 Rail/Itram 3 3,5 4 4 3,63 11 Hydropower 4 2,5 5 3,50 3,50 13 Solar 4 3,5 3 3,25 3,44 14 Biomass 4 3 3 3,75 3,44 16 Traffic control systems 3 3 4 3,75 3,44 16 Traffic control systems 3 3 4 3,33 3 19 Building automation 3 3 4 3,33 3 4 3,33 3 3 3 3 3 4 3,33 <	8 Thermal storage	4	3	4		3.67
10 Rail/Train 3 3,5 4 4 11 Hydropower 4 2,5 3 4,5 3,50 12 Mechanical storage 3 2,5 5 3,50 13 Solar 4 3,5 3 3,25 3,44 14 Biomass 4 3 3 3,75 3,44 15 Thermal insulation 5 2,5 3 3,25 3,44 16 Traffic control systems 3 3 4 3,33 3 4 3,33 19 Building automation 3 3 4 3,33 3,33 3 4 3,33 20 Biofuels 3 3 4 3 3,33 3 4 3,33 21 Industrial Biotechnology and Renewabl 3 3 4 3 3,32 3,25 <td>9 Smart grids and super grids</td> <td>4</td> <td>4</td> <td>3</td> <td></td> <td>3.67</td>	9 Smart grids and super grids	4	4	3		3.67
11Hydropower42,534,53,5012Mechanical storage32,553,5013Solar43,533,253,4414Biomass4333,753,4415Thermal insulation52,533,253,4416Traffic control systems3343,33318Waste heat recovery3343,333,3319Building automation3343,333,3320Biofuels3343,333,3321Industrial Biotechnology and Renewabl3343,3322Industrial Biotechnology and Renewabl3343,3223Separators, precipitators13,544,53,2524Lead-acid batteries32,543,253,1925Plug-in hybrid electric vehicles42,533,1726Advanced renewable fuels32,543,003,0029Battery-electric vehicles52,552,53,0030Aerodynamics improvement to realize ϵ 122,673,0031Air handling equipment13512,6735Fuel-electric vehicles5222,53,2533Energy-saving tires32,5 <t< td=""><td>10 Bail/tram</td><td>3</td><td>3.5</td><td>4</td><td>4</td><td>3.63</td></t<>	10 Bail/tram	3	3.5	4	4	3.63
12,551,613Note33,5013Solar43,5314Biomass43315Thermal insulation52,5316Traffic control systems33416Traffic control systems33419Building automation3343,3319Building automation3343,3320Biofuels3343,3321Indgan denewabl3343,3322Industrial Biotechnology and Renewabl3343,3323Separators, precipitators13,553,524Lead-acid batteries32,544,525Plug-in hybrid electric vehicles42,533,1726Advanced renewable fuels32,543,203,1727Hydrogen storage22,553,003,0030Aerodynamics improvement to realize ϵ 122,53,0033Energy-saving tires22,5522,8834Geothermal3322,673,0033Energy-saving tires3322,673,0034Harbandling equipment13512,6735Fuel-cell-relectric vehicles52	11 Hydropower	4	2.5	3	4.5	3.50
13 Solar 4 3,5 3 3,25 3,44 14 Biomass 4 3 3 3,75 3,44 14 Biomass 4 3 3 3,75 3,44 15 Thermal insulation 5 2,5 3 3,25 3,44 16 Traffic control systems 3 3 4 3,33 3,325 3,44 16 Traffic control systems 3 3 4 3,33 3,35 3,35 3,25 3,35 3,25 3,5 3,5 3,5	12 Mechanical storage	3	2,5	5	1,5	3,50
1 3 3 3,75 3,44 15 Thermal insulation 5 2,5 3 3,25 3,44 15 Thermal insulation 5 2,5 3 3,25 3,44 16 Traffic control systems 3 3 4 3,75 3,44 18 Waste heat recovery 3 3 4 3,33 3 4 3,33 20 Biofuels 3 3 4 3,33 3 4 3,33 20 Diofuel sectonics 2 4 4 3,33 3 4 3,33 21 Industrial Biotechnology and Renewabl 3 3 4 3 3,25 23 Separators, precipitators 1 3,5 5 3,5 3,25 24 Lead-acid batteries 3 2,5 4 3,25 3,17 25 Pug-in hybrid electric vehicles 4 2,5 3 3,00 3,17 25 Pug-in hybrid electric vehicles 5 2,5 2,5 3,00 3,	13 Solar	4	3.5	3	3 2 5	3 44
15 Thermal insulation 5 2,5 3 3,25 3,44 16 Traffic control systems 3 3 4 3,75 3,44 18 Waste heat recovery 3 3 4 3,33 3,33 19 Building automation 3 3 4 3,33 3,33 20 Biofuels 3 3 4 3,33 3,33 21 Organic electronics 2 4 4 3,33 21 Industrial Biotechnology and Renewabl 3 3 4 3,33 22 Industrial Biotechnology and Renewabl 3 3 4 3,33 22 Industrial Biotechnology and Renewabl 3 3 4 3,33 23 Separators, precipitators 1 3,5 5 3,5 3,25 28 Gas and steam power plants 1 3,5 4 4,5 3,25 24 Lead-acid batteries 3 2,5 4 3,00 3,00 25 Plug-in hybrid electric vehicles 5	14 Biomass	4	3	3	3 75	3 4 4
12 include include in the include inclu	15 Thermal insulation	5	25	3	3 25	3.44
10 10 <td< td=""><td>16 Traffic control systems</td><td>3</td><td>2,5</td><td>4</td><td>3 75</td><td>3 4 4</td></td<>	16 Traffic control systems	3	2,5	4	3 75	3 4 4
10 10 <td< td=""><td>18 Waste heat recovery</td><td>3</td><td>3</td><td>4</td><td>5,75</td><td>3 3 3</td></td<>	18 Waste heat recovery	3	3	4	5,75	3 3 3
12 binding outwation 3 3 4 3,33 20 Biofuls 3 3 4 3,33 21 Organic electronics 2 4 4 3,33 22 Industrial Biotechnology and Renewabl 3 3 4 3 32 Separators, precipitators 1 3,5 5 3,5 3,25 23 Gas and steam power plants 1 3,5 4 4,5 3,25 24 Lead-acid batteries 3 2,5 4 4,5 3,17 26 Advanced renewable fuels 3 2,5 4 3,00 3,17 26 Advanced renewable fuels 3 2,5 4 3,00 3,00 29 Battery-electric vehicles 5 2,5 2 2,5 3,00 30 Aerodynamics improvement to realize ε 1 2 5 4 3,00 31 Air handling equipment 1 3 5 3,5 3,00 32 Catalytic converters, chemical recovery 1 2,5 5 2,88 34 Geothermal 3 2,5 3 2,67 2,88	19 Building automation	3	3	4		3,33
25 brouch 3 3 4 4,4 3,33 21 Organic electronics 2 4 4 3,33 22 Industrial Biotechnology and Renewabl 3 3 4 3 3,33 17 Combined heat and power units 3 3 4 3 3,25 23 Separators, precipitators 1 3,5 5 3,5 3,25 28 Gas and steam power plants 1 3,5 4 4,5 3,25 24 Lead-acid batteries 3 2,5 4 4,5 3,17 26 Advanced renewable fuels 3 2,5 4 3,00 3,17 25 Plug-in hybrid electric vehicles 4 2,5 3 3,00 3,00 29 Battery-electric vehicles 5 2,5 2 2,5 3,00 30 Aerodynamics improvement to realize ε 1 2 5 4 3,00 31 Air handling equipment 1 3 5 3 3,00 32 Catalytic converters, chemical recovery 1 2,55 5 2 2,88 34 Geothermal	20 Biofuels	3	3	4		3,33
21 Organic electronics 2 4 4 3 22 Industrial Biotechnology and Renewabl 3 3 4 3 3,33 17 Combined heat and power units 3 3 4 3 3,25 23 Separators, precipitators 1 3,5 5 3,5 3,25 28 Gas and steam power plants 1 3,5 4 4,5 3,25 24 Lead-acid batteries 3 2,5 4 3,25 3,19 25 Plug-in hybrid electric vehicles 4 2,5 3 3,17 26 Advanced renewable fuels 3 2,5 4 3,00 29 Battery-electric vehicles 5 2,5 2 2,5 3,00 30 Aerodynamics improvement to realize € 1 2 5 4 3,00 31 Air handling equipment 1 3 5 3 3,00 32 Catalytic converters, chemical recovery 1 2,5 5 2 2,88 34 Geothermal 3 2,5 3 2,75 2,88 34 Geothermal 3 3	21 Organic electronics	2	1	4		3,33
22 Industrial block innology and netwalsh 3 3 4 3 3,25 23 Separators, precipitators 1 3,5 5 3,5 3,25 23 Separators, precipitators 1 3,5 4 4,5 3,25 24 Lead-acid batteries 3 2,5 4 3,25 3,19 25 Plug-in hybrid electric vehicles 3 2,5 4 3,25 3,17 26 Advanced renewable fuels 3 2,5 4 3,00 3,00 29 Battery-electric vehicles 5 2,5 2 2,5 3,00 30 Aerodynamics improvement to realize ϵ 1 2 5 4 3,00 31 Air handling equipment 1 3 5 3 3,00 32 Catalytic converters, chemical recovery 1 2,5 5 2 2,88 34 Geothermal 3 2,5 3 2,75 2,81 3,67 35 Fuel-cell-electric vehicles 5 2 1	22 Industrial Biotechnology and Benewahl	2	2	4		3,33
1) Continue nation power units 1 3,5 4 1 3,5 23 Separators, precipitators 1 3,5 5 3,5 3,25 24 Lead-acid batteries 3 2,5 4 4,5 3,25 24 Lead-acid batteries 3 2,5 4 3,25 3,19 25 Plug-in hybrid electric vehicles 4 2,5 3 3,17 26 Advanced renewable fuels 3 2,5 4 3,17 26 Advanced renewable fuels 3 2,5 4 3,17 26 Advanced renewable fuels 3 2,5 4 3,00 29 Battery-electric vehicles 5 2,5 2 2,5 3,00 30 Aerodynamics improvement to realize € 1 2 5 4 3,00 31 Air handling equipment 1 3 5 3,5 3,00 32 Catalytic converters, chemical recovery 1 2,5 5 2 2,88 34 Geothermal 3 2,5 3 2,75 2,81 35 Fuel-cell-electric vehicles 3 1 4 </td <td>17 Combined best and power units</td> <td>3</td> <td>2</td> <td>4</td> <td>3</td> <td>3,33</td>	17 Combined best and power units	3	2	4	3	3,33
2.5 separators13.533.73.728 Gas and steam power plants13,544,53,2524 Lead-acid batteries32,543,253,1726 Advanced renewable fuels32,543,1726 Advanced renewable fuels32,543,0029 Battery-electric vehicles52,522,53,0030 Aerodynamics improvement to realize ε12543,0031 Air handling equipment13533,0032 Catalytic converters, chemical recovery12,55522,8834 Geothermal32,532,752,8135 Fuel-cell-electric vehicles5212,6736 Nickel-metal hybride batteries3142,6737 Wave/Ocean power13512,5038 Ultracapacitors3321,252,3139 Electrochemical storage22,522,52,2540 CCS & CCU3122,002,0041 Electric bikes1322,002,0042 Lithium-ion batteries31,511,8343 Electric motorcycles11321,75	23 Separators precipitators	5	35	4	35	3,25
28 das and stant power plants 1 3,3 4 4,3 3,13 24 Lead-acid batteries 3 2,5 4 3,25 3,19 25 Plug-in hybrid electric vehicles 4 2,5 3 1 3,17 26 Advanced renewable fuels 3 2,5 4 3,17 27 Hydrogen storage 2 2 5 3,00 29 Battery-electric vehicles 5 2,5 2 2,5 3,00 30 Aerodynamics improvement to realize € 1 2 5 4 3,00 31 Air handling equipment 1 3 5 3 3,00 32 Catalytic converters, chemical recovery 1 2,5 5 2 2,88 34 Geothermal 3 2,5 3 2,75 2,81 35 Fuel-cell-electric vehicles 5 2 1 2,67 36 Nickel-metal hybride batteries 3 1 4 2,67 38 Ultracapacitors 3 3 2 1,25 2,5 38 Ultracapacitors 3 3 2 2,5	28 Gas and stoom nower plants	1	3,5	1	3,5	3,23
24 Lead-action batteries32,345,233,1725 Plug-in hybrid electric vehicles42,533,1726 Advanced renewable fuels32,543,0029 Battery-electric vehicles52,522,530 Aerodynamics improvement to realize ϵ 125431 Air handling equipment1353,0032 Catalytic converters, chemical recovery12,552,7534 Geothermal32,532,752,8835 Fuel-cell-electric vehicles5212,6736 Nickel-metal hybride batteries3142,6737 Wave/Ocean power13512,5038 Ultracapacitors3322,552,23139 Electrochemical storage22,5522,252,2540 CCS & CCU31322,0041 Electric bikes13222,0042 Lithium-ion batteries31,5511,8343 Electric motorcycles11321,75	26 Gas and steam power plants	1	5,5	4	4,5 2.25	3,23
25 Fugern hybrid electric venicles42,5333,1726 Advanced renewable fuels32,543,1727 Hydrogen storage2253,0029 Battery-electric vehicles52,522,530 Aerodynamics improvement to realize ϵ 125431 Air handling equipment1353,0032 Catalytic converters, chemical recovery12,55234 Geothermal32,532,752,8835 Fuel-cell-electric vehicles5212,6736 Nickel-metal hybride batteries3142,6737 Wave/Ocean power13512,5038 Ultracapacitors3321,252,3139 Electrochemical storage22,522,52,2540 CCS & CCU31322,0041 Electric bikes13222,0042 Lithium-ion batteries11321,75	24 Lead-actu balleries	5	2,5	4	3,23	5,19 2 1 7
20 Advanced relevance for the solution of the	25 Plug-III hybrid electric vehicles	4	2,5	5		5,17 2,17
27 Hydrogen storage2223329 Battery-electric vehicles5 $2,5$ 2 $2,5$ $3,00$ 30 Aerodynamics improvement to realize ϵ 1254 $3,00$ 31 Air handling equipment1353 $3,00$ 32 Catalytic converters, chemical recovery1 $2,5$ 5 $3,5$ $3,00$ 32 Catalytic converters, chemical recovery1 $2,5$ 5 $2,2$ $2,88$ 34 Geothermal3 $2,5$ 3 $2,75$ $2,88$ 34 Geothermal3 $2,5$ 3 $2,75$ $2,81$ 35 Fuel-cell-electric vehicles521 $2,67$ 36 Nickel-metal hybride batteries314 $2,67$ 38 Ultracapacitors332 $1,25$ $2,31$ 39 Electrochemical storage2 $2,5$ 2 $2,5$ $2,25$ 40 CCS & CCU312 $2,00$ $2,00$ 41 Electric bikes132 $2,00$ $1,83$ 43 Electric motorcycles1132 $1,75$	20 Auvaliceu reliewable lueis	5 7	2,5	4		3,17
29 battery-electric venicies52,522,55,0030 Aerodynamics improvement to realize ϵ 12543,0031 Air handling equipment13533,0032 Catalytic converters, chemical recovery12,553,53,0033 Energy-saving tires22,5522,8834 Geothermal32,532,752,8135 Fuel-cell-electric vehicles5212,6736 Nickel-metal hybride batteries3142,6738 Ultracapacitors3321,252,3139 Electrochemical storage22,522,52,2540 CCS & CCU3122,002,0041 Electric bikes13222,0042 Lithium-ion batteries31,511,8343 Electric motorcycles11321,75	27 Hydrogen storage	2	2	5 1	25	3,00
30 Aerodynamics improvement to realize t 1 2 5 4 3,00 31 Air handling equipment 1 3 5 3 3,00 32 Catalytic converters, chemical recovery 1 2,5 5 3,5 3,00 33 Energy-saving tires 2 2,5 5 2 2,88 34 Geothermal 3 2,5 3 2,75 2,81 35 Fuel-cell-electric vehicles 5 2 1 2,67 36 Nickel-metal hybride batteries 3 1 4 2,67 37 Wave/Ocean power 1 3 5 1 2,50 38 Ultracapacitors 3 3 2 1,25 2,31 39 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2,00 2,00 41 Electric bikes 1 3 2 2,00 1,83 43 Electric motorcycles 1 1 3 2 1,75	29 Battery-electric vehicles	5	2,5	2	2,5	3,00
31 Arr haltdring equipment 1 3 5 3 3,00 32 Catalytic converters, chemical recovery 1 2,5 5 3,5 3,00 33 Energy-saving tires 2 2,5 5 2 2,88 34 Geothermal 3 2,5 3 2,75 2,81 35 Fuel-cell-electric vehicles 5 2 1 2,67 36 Nickel-metal hybride batteries 3 1 4 2,67 37 Wave/Ocean power 1 3 5 1 2,50 38 Ultracapacitors 3 3 2 1,25 2,31 39 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2,00 2,00 41 Electric bikes 1 3 2 2 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	30 Aerodynamics improvement to realize e	1	2	5	4	3,00
32 Catalytic University, Chemical recovery 1 2,3 3 5,5 3,00 33 Energy-saving tires 2 2,5 5 2 2,88 34 Geothermal 3 2,5 3 2,75 2,81 35 Fuel-cell-electric vehicles 5 2 1 2,67 36 Nickel-metal hybride batteries 3 1 4 2,67 37 Wave/Ocean power 1 3 5 1 2,50 38 Ultracapacitors 3 3 2 1,25 2,31 39 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2,00 2,00 41 Electric bikes 1 3 2 2,00 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	22 Catalutic convertors, chemical recovery	1	5	5	5 2 E	3,00
33 Ellergy-saving tries 2 2,3 3 2 2,8 34 Geothermal 3 2,5 3 2,75 2,81 35 Fuel-cell-electric vehicles 5 2 1 2,67 36 Nickel-metal hybride batteries 3 1 4 2,67 37 Wave/Ocean power 1 3 5 1 2,50 38 Ultracapacitors 3 3 2 1,25 2,31 39 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2,00 2,00 41 Electric bikes 1 3 2 2,00 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	22 Energy soving tires	1	2,5	5	5,5 N	5,00
34 Geotherman 3 2,3 3 2,73 2,61 35 Fuel-cell-electric vehicles 5 2 1 2,67 36 Nickel-metal hybride batteries 3 1 4 2,67 37 Wave/Ocean power 1 3 5 1 2,50 38 Ultracapacitors 3 3 2 1,25 2,31 39 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2,00 2,00 41 Electric bikes 1 3 2 2,00 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	33 Life gy-saving tires	2	2,5	2	2	2,00
35 Fuel-ten-fectil venicles 3 1 1 1 2,67 36 Nickel-metal hybride batteries 3 1 4 2,67 37 Wave/Ocean power 1 3 5 1 2,50 38 Ultracapacitors 3 3 2 1,25 2,31 39 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2 2,00 41 Electric bikes 1 3 2 2 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	25 Fuel cell electric vehicles	5	2,5	3	2,75	2,01
36 Nickel-netal hybride batteries3142237 Wave/Ocean power13512,5038 Ultracapacitors3321,252,3139 Electrochemical storage22,522,52,2540 CCS & CCU31222,0041 Electric bikes13222,0042 Lithium-ion batteries31,511,8343 Electric motorcycles11321,75	35 Fuel-cell-electric vehicles	2	2	1		2,07
37 wave/ocean power 1 3 3 1 2,50 38 Ultracapacitors 3 3 2 1,25 2,31 39 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2 2,00 41 Electric bikes 1 3 2 2 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	27 Mayo/Ocean nowor	5	1	4 E	1	2,07
30 bit acceptions3521,252,5139 Electrochemical storage22,522,52,2540 CCS & CCU31222,0041 Electric bikes13222,0042 Lithium-ion batteries31,511,8343 Electric motorcycles11321,75	38 Illtracapacitors	1 2	2	י ר	1 2 E	2,50
35 Electrochemical storage 2 2,5 2 2,5 2,25 40 CCS & CCU 3 1 2 2 2,00 41 Electric bikes 1 3 2 2 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	20 Electrochomical storage	с С	5 75	2	1,20	2,51
40 ccs acco 5 1 2 2 2,00 41 Electric bikes 1 3 2 2 2,00 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75		2	2,5 1	2	2,5	2,25
41 Licente bixes 1 5 2 2 2 42 Lithium-ion batteries 3 1,5 1 1,83 43 Electric motorcycles 1 1 3 2 1,75	40 CC3 & CC0 41 Electric bikes	э 1	1	2	2	2,00
42 Electric motorcycles 5 1,5 1 1 1,63 43 Electric motorcycles 1 1 3 2 1,75	41 LICUIT DIRES	1 2	5 1 5	۲ ۲	۷	2,00
43 Lieutre motor cycles 1 1 3 2 1,/5	42 Electric motorcycles	с 1	1,5 1	1 2	2	1,05
44 Fuel cells 2 2.5 1 1 1 163	44 Fuel cells	2	2.5	1	- 1	1.63

3/ Annex 3: List of interviewees

Name	Organisation	Clean Industries			
Andreas Guertler	European Industrial Insulation Foundation	Thermal Insulation			
Anna Gigantino	ERA - European Railway Agency	Rail			
Arnaud Duvielguerbigny	COGEN Europe - European association for the promotion of cogeneration	Heating and Cooling Systems District Heating and cooling			
Eric Peirano	Grid+Storage	Smart Grids Thermal Storage			
Filip Geerts	CECIMO (European Association of the Machine Tool Industries)	AMT			
Joris Koornneef	The European Association for Storage of Energy - EASE	Thermal Storage			
Luca Angelico	European Geothermal Energy Council	Thermal Storage			
Maarten de Groote	Building Performance Institute Europe	NZEB Thermal Insulation			
Marcel Bial	ESTELA (European solar thermal electricity association)	Thermal Storage			
Pal Bergan	NEST	Thermal Storage			
Paul Voss	Euroheat & Power	District Heating and Cooling			
Peter Scherm	EUROMOT	Technologies to realize efficiency gains in ICE powered vehicles			
Petr Dolejsi	European Car Manufacturers Association (ACEA)	Technologies to realize efficiency gains in ICE powered vehicles			
Rainer Bacher	ERA-Net Smart Grids Plus	Smart Grids			