Executive Summary

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Clean Air Challenge

Transport and heating solutions for better air quality

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Authors

Marta Ciszewska, *Senior Consultant*, Deloitte Advisory, Poland
Magdalena Maj, *Intern*, Deloitte Advisory, Poland
Amadeusz Marzec, *Consultant*, Deloitte Advisory, Poland
Damian Olko, *Senior Consultant*, Deloitte Advisory, Poland
Julia Patorska, *Senior Manager*, Deloitte Advisory, Poland
Irena Pichola, *Partner*, Deloitte Advisory, Poland

Coordination of the study
Marcin Lewenstein, *Innovation Officer*, InnoEnergy Central Europe

Contributing experts

Pedro Henrique Alves
Linda Baumane
Dominic Buchholz
Sanner Burkhard
Wojciech Czapla
Manish Dhungel
Ross Douglas
Armand Fopah-Lele
Oriol Gallemi
Bas Godschalk
Krushna Kaant Gupta
Alex Harter
Filip Jankun
Jacek Kalina
Magnus Karlstrom
Jerzy Kaszkowiak
Henryk Kubiczek
Discart Laurens
Łukasz Lech
Marcin Liszka
Tomasz Mania
Bradley McHugh
Geunyoung Park
Vaclav Plevka
Angela Rodriguez
Andrzej Rubczyński
Javier Sanz
Jesper Henry Skjold
Paweł Smoleń
Aleksander Śniegocki
Luigi Tischer
Jan-Willem de Vries
Alexander Walczuch
Aleksandrs Zajacs
Jakub Zawieska
Jack Zhang

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Executive summary

Objective of the Report

The report presents a thorough review of both the available technological and non-technological solutions in the fields of transport and heating, with a keen eye to those which might improve air quality. Leveraging first a dedicated survey, and then a tailored quantitative assessment, the study clusters and ranks particular solutions with the most advanced levels of technological development, as well as the highest expected market attractiveness. This analysis was conducted so as to also take into account each solution's potential impact on smog. It is believed that the resulting recommendations should help InnoEnergy scout investments which maximize profitability, environmental responsibility, and social benefit. Pursuing any of the recommended channels should also have the compound benefit of raising awareness and knowledge among key stakeholders. Hence, the report also discusses the major dilemmas, complexities and trade-offs related to environmental policies, as well as public support for innovation. Also resulting from our work are several policy recommendations, here presented in both general and cluster perspectives.

1. Introduction

A call for action: smog costs the EU around 2.9% of its GDP every year

Europe has a pressing need to sustain vigorous long-term economic growth – a challenging prospect due to demographic changes. A shrinking labour force due to aging populations will mean that more and more Europeans will have to work longer, and be more productive if they want to (at the very least), preserve their current quality of life. This being said, current levels of air pollution observed across Europe have the direct consequence of limiting the extensive increase of productivity, thus generating tangible socio-economic detriment.

According to a study conducted by the European Commission, the total external costs related to the health effects of smog in the EU-28 are estimated to reach between 243 and 775 BLN EUR by 2020.[1] This figure is a product of premature deaths, rising healthcare bills, protracted illnesses, lower on-the-job productivity, and absences.

Although the European Commission's projection notes a discernable downward trend in the economic burden of smog since 2010, the pace of improvement is predicted to level off in coming years. Hence, the BAU scenario (Business as Usual) is associated with a tacit acceptance of a persistently high cost of externalities. This is further predicted to translate into a price tag ranging between 224 and 749 BLN EUR by 2025 - only a 5-8% improvement on 2020.[2] **This means that the average value of the external costs between 2018-2025 amount to an astonishing 475 BLN EUR - around 2.9% of forecasted average annual GDP for the EU-28 in the same period (assuming the middle estimate of externalities)**.[3] Even when discussing the lower estimate, projected costs are still alarming – accounting for 1.37% of the average annual GDP.

We must thus realize that a passive acceptance of BAU is not desirable, not inevitable, and isn't even particularly viable. Fortunately, there exist alternative, more sustainable trajectories, which are largely based on an enormous volume of recent technological progress. The scenarios considered in this Report and presented below involve transparent, planned, and well-managed cooperation between the private sector and public authorities. By and large, these are directed towards boosting innovation in the transport and heating sectors. In this context, cutting-edge solutions paired with properly aligned public policies should be considered as a great opportunity - an "accelerator" for simultaneous improvements in the health, economic, social, and environmental spheres.

Potential impact of recommended solutions on the EU-28 economy: a scenario simulation

The simulation presented here is based on the survey of potential emissions impacts, as well as estimates of the external costs of air pollution, as made by the European Commission.[4] In this report, we recommend to focus on investments in 4 key clusters:

1. Electromobility
2. Smart public transport systems
3. Smart buildings
4. Distributed generation and storage

A joint impact assessment of abovementioned clusters was performed with using two scenarios regarding the pace of market growth and technological development:

1. **"Conservative 10% in 2025" Scenario** (10% of average market share in 2025)
2. **"Ambitious 25% in 2025" Scenario** (25% of average market share in 2025)

1 European Comission, http://ec.europa.eu/environment/archives/air/pdf/Impact_assessment_en.pdf
2 European Comission, http://ec.europa.eu/environment/archives/air/pdf/Impact_assessment_en.pdf
3 Forecast is in real terms, i.e. it is based on forecasted real GDP and discounted estimated cost of smog. Discount rate was set at 2% and the base year – 2018.
4 Sources: European Environmental Agency, https://www.eea.europa.eu/data-and-maps/dashboards/air-pollutant-emissions-data-viewer ; European Comission, http://ec.europa.eu/environment/archives/air/pdf/Impact_assessment_en.pdf

Both scenarios assume that market penetration for all solutions within the 4 Clusters begins at 1% in 2018. Then, this share grows at a constant pace so as to attain the respective target values – 10% or 25%.

The key inputs for these simulations were provided by a group of surveyed experts, who assessed the potential impacts on air pollution for given solutions. Hence, it was possible to estimate what could be the impact of X% resulting from the predominant market penetration of solution Y, as compared to a baseline solution.

Further assumptions for the model were derived from the abovementioned European Commission's elaboration on the external costs of air pollution. This was in turn supplemented by data on the unit cost of air pollutants, and on the sources of pollutants provided by the European Environmental Agency.[5]

Figure 1. **Forecasted potential impact on the EU-28 economy from recommended investments versus European Commission's BAU Scenario** (Net Present Value, aggregate 2018-2025, EUR BLN)

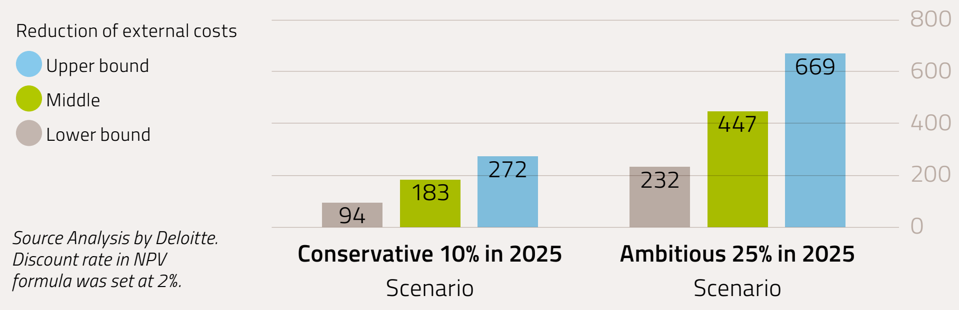
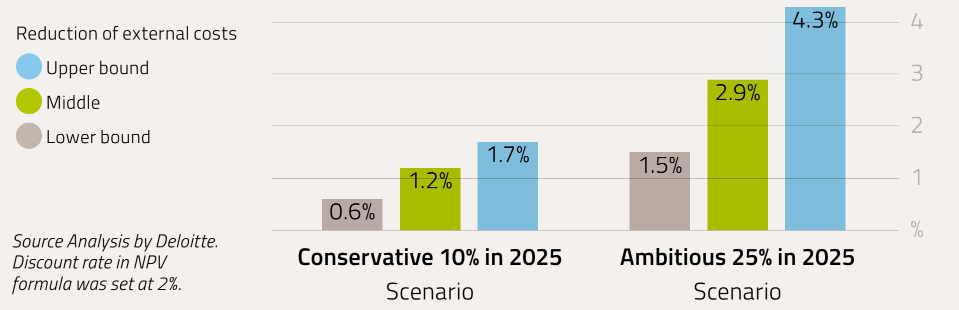


Figure 2. **Forecasted potential impact on the EU-28 economy from recommended investments versus European Commission's BAU Scenario** (Net Present Value, aggregate 2018-2025, % of GDP in 2018)



Finally, we are able to present **6 outcomes relating to the potential impact on the European economy as a result of the adoption of greener solutions. Much of the savings can be interpreted as reduced health-related expenses in relation to the total external costs of air pollution**. These 6 values come from crossing 2 Scenarios related to market and technological developments, as well as 3 estimates of the external costs (upper and lower provided by the European Commission, and one equal to their average, or "middle of the range"). The main advantage of this approach is that it enables us to capture 2 major sources of uncertainty – namely the proper estimate for external costs, as well as the forward potential for both market and technological disruptions.

According to our simulated conservative Scenario, European citizens might be able to pocket an extra 183 BLN EUR between 2018 and 2025 - the an equivalent of 1.2% of the forecasted GDP

5 European Environmental Agency, https://www.eea.europa.eu/data-and-maps/dashboards/air-pollutant-emissions-data-viewer

in the EU-28 in 2018. This result is a combination of the "Conservative 10% in 2025" scenario in terms of investments and supporting polices, as well as the middle value of estimated external costs. It should be underlined that even the lowest outcome means a non-negligible net effect – a reality which drives our call for comprehensive anti-smog action. What is more is that this course should have the added benefit of boosting both investment and innovation in the transport and heating sectors.

Smog as a pollutant – main sources and types

Air pollution is any change to the levels of air's natural constituents that has negative effect on our physical environment. As such, smog is a type of air pollution as it represents a persistent manifestation of a negative change in the atmosphere. One point which must be kept in mind though is that there are many natural sources of air pollution which remain outside of our control. Therefore, this report focuses exclusively on man-made, outdoor air pollution, with special attention given to both smog, and the main subsidiary substances affecting European cities - namely Benzo(a) pyrene, coarser particulates (PM_{10}), nitrogen oxides (NO_x), and finer particulates ($PM_{2.5}$).

In Europe, air pollution is primarily a result of the combustion of hydrocarbons in road transport and heating. A couple of things to bear in mind as we get started are that first, the Emission of NO_x, and NO_2 in particular are primarily the result of road transport. Second, emissions from household and commercial heating are known as "low-stack emissions" (when the point of origin is below 40m), and are caused largely by the use of low quality heating fuels, and old furnaces. Furthermore, low stack emissions are the primary contributor to the creation of excessive amounts of $PM_{2.5}$, PM_{10} and benzo(a)pyrene.

The main source of smog also differs by region – in Western Europe, for example, it originates primarily from transportation. By contrast, in Eastern Europe, the main source of smog is heating (and to a lesser extent, transportation). As a result, the smog problem in Europe may also be considered to be further complicated by regionalization.

Bearing all of this in mind, we must add that two types of smog have been identified. The so called "London smog" will generally intensify in the winter period as a product of an incomplete fossil fuel burn (a problem particularly onerous in the case of coal). The aforementioned type is what is known as a sulphurous smog – the result of a high concentration of SO_2, which intensifies with humidity, and higher concentrations of suspended particulate matter in the air. Even though time has seen this problem due to technological improvements, and stricter legislation, there are still places where 'classic' smog occurs (especially in Central and Eastern Europe). The other type of 'man-made' smog is created by vehicle exhaust fumes – the so called "Los Angeles smog". It is a photochemical smog, which occurs especially during summertime, and mostly in urban areas that have a large number of cars. In this case, the effect of the primary emission is greatly intensified by a high saturation of insolation, paired with windless conditions.

Socio-economic impacts

Smog may account for as many as 1 in every 10 premature deaths in the world, and over 400,000 premature deaths in Europe every year. It also affects the general quality of life on the continent by exacerbating, or even causing asthma and other respiratory problems. As with many other socio-economic issues, the elderly and the young are the most affected. With an increase of 100 units of PM_{10} comes a reduction of average life expectancy of around 2.3 years among children by age 5.

Other than health, air pollution has many other direct and indirect consequences – in fact, smog has a significant impact on regional and national economies. This is aggravated by the fact that cities are disproportionately affected by poor air quality, but also remain home to some of the most important drivers of economic growth – namely highly skilled labour, capital goods, as well as extensive technology pools.

The list of indirect effects of smog includes:

- **People's reluctance to work in cities where air quality is poor**. A consequence of this is lower economic productivity / less innovation.
- **A distorted competition dynamic, which in turn hampers "creative destruction."** As a consequence, some inefficient local firms are "protected" from external competition, which in the long-term reduces potential GDP growth.
- **A drag on human capital growth**, resulting from extensive negative health impacts. This in turn results in elevated short and long term sick leaves, as well as lower levels of education, reducing productivity and GDP.
- **Lower incomes, as well as a lower number of jobs in tourism and recreation**. Unappealing locations tend not to attract visitors or qualified professionals, limiting the potential inflow of knowledge and investment.
- **Lower value of real estate and some productive assets**, which translate into reduced income from rents or investment.

The negative socio-economic impact of smog can be long-lasting, sometimes transcending generations. For instance, during Great London smog, inhabitants were exposed to extreme levels of pollution for only 4 days, yet 60 years on, the surviving cohort (population by age) was 2% smaller than was to be expected. Moreover, those who had not died tended to suffer from persistent, premature diseases – leading to discernably reduced employment opportunities, working hours as well as skills and knowledge.

2. The Diagnosis

Why does smog continue to damage our societies, economies and ecosystems?

First of all, there is no one silver bullet when tackling the issue of air pollution. Smog is a very versatile problem, and it can have various causes as well as forms, depending on the source of emission and the local climate. Apart from geography, there are a wide range of factors, all of which can be influenced by public policy, or even changing consumer habits. Evidence shows, however, that combating smog requires a long-term commitment, which has also proven problematic due to the prevalence of "short-termism" in both private and public sectors.

Society can be unaware of the problem, or underestimate its scale, which may be the result of national and municipal authorities not providing sufficient or transparent enough information about air quality. Furthermore, public awareness has been shown to be greatly dependent on the general level of education, income, and consumer behaviour. Interestingly, it should be noted here that the latter, 'human' factors are also effected by both governmental and non-governmental organisations.

The issue of poverty has proven a serious obstacle for the adoption of clean heating and transport solutions. Simply put, many urban inhabitants cannot afford to buy cleaner cars, or use less polluting heating fuels. As a result, more affordable solutions are necessary, and as such, there is increased pressure on the public sector to bear the costs of clean heat and transport.

Bearing this situation in mind, available solutions have two defining features: they either require a scale of transformation, or require fundamental changes to habits on an individual level. With changes of scale come big investment commitments that tighten both municipal and national budgets. Along with this commitment often come conventional command and control policies such as vehicle standards or banning coal/waste use for residential heating. Such policies often hurt household finances, thus breeding resistance to change among the citizenry. This in turn means that tackling smog becomes a politically sensitive subject which, when combined with a limited public awareness, can prove unpopular, thus draining to the approval ratings of politicians attempting to effectuate positive change.

Smog in Europe in a nutshell

There is no safe level of air pollution, and with up to 98% of Europeans living in cities being exposed to unsafe levels of toxic substances like ozone, fine particulates, and benzo(a)pyrene, the current state of affairs is troubling to say the least. Despite the fact that since 1990, there have been decreases in industrial pollution and greenhouse gas emissions (primarily thanks to EU policies and investment), a significant number of Europeans – mainly in Eastern Europe – still breathe air with unacceptable concentrations of hazardous substances.

Table 1. **Smog – diversity of drivers, barriers and sources of pollution among several EU member states**

Country	Pollutant	Specific feature	Main driver	Difficulty
Bulgaria	PM_{10}	Approximately 78% of the urban population is exposed to PM_{10} levels above EU standards	Residential individual heating sector together with energy poverty	Implementation of emission regulations
Germany	NO_x	Country generates around 15% share of total EU NO_x emissions	Private transport, highest number of car passengers in EU	Large automotive industry
Italy	O_3 , PM_{10}	Up to 76% of the urban population is exposed to O_3 levels above EU standards and 59% who face excessive levels of PM_{10}	Motorization, aged vehicles	Users' transport habits
The Netherlands	NO_2	Only 2% of the urban population was exposed to NO_2 levels above EU standards but on the local level in 20 of the 393 municipalities, concentrations of PM exceeded the upper acceptable limits.	Transport	Special attention needed for urban areas
Poland	BaP	Up to 99% of urban inhabitants are exposed to hazardous BaP level.	Residential individual heating sector	Lack of awareness, limited support from public sources
Sweden	NO_2, O_3	An environmental pioneer since the 1960s, as it has actively initiated and engaged in several international collaborative projects to tackle environmental issues	Transport	Different pollutions on the regional level

Source: Analysis by Deloitte

Air quality in the European policy framework

The EU countries have made a significant progress in limiting emissions with road transport being the primary contributor to this reduction. However, the pace of reduction has slowed down in the past decade. In general, the EU has a two-pronged approach to tackling air pollution. On one hand, it regulates the problem itself – the concentration of air pollution in cities –through the Ambient Air Quality (AAQ) Directive. On the other hand, it regulates the source of the problem – the emission of air pollutants, through various policy instruments but most notably through National Emission Ceilings (NEC) Directive, which intends to regulate the source of the problem of the emission of air pollutants.

As a result of strengthening links between research and policy, the European Commission passed the Clean Air for Europe (CAFE) Programme. The aims of CAFE are: the transparent assessment of the air quality of each member state, the facilitation of providing information to the public, and the promotion of cooperation between EU members in reducing air pollution.

Significantly, the European Commission can take enforcement action against any member state which does not comply with the existing laws through CAFE. The entity responsible for collecting information on emissions (and communicating it) is the European Environment Agency. Once the findings of the EEA are articulated, the findings are passed on to the Court of Justice of the European Union to formulate a judgement. Until May 2018, infringement actions for PM10 excesses have been filed against 16 countries.

Lessons learned

Municipalities and cities have thus far been the driving forces of change. There are many measures that can be introduced on the local level that can have a significant impact on air quality in urban areas. These include: restrictions on private motor vehicles, improving the quality and accessibility of low-emission public transport, investment in low-emission heating systems, as well as more effective urban planning and management.

Following this, a strong commitment on the national level will also be required to achieve significant results on the municipal level. In particular, the provision of funds to invest in new infrastructure, and the implementation of cohesive policies are key. Even more important is a proper regulatory framework, together with environmental taxes and other economic instruments – all of which are usually introduced by legislation at the national level.

Both national and international policies have led to norms and standards that are important in setting a precedent for action, allowing priorities and values to cascade into actual projects on the ground. The sheer number of stakeholders, agents, and mechanisms (both political and economic) surrounding the problem of air quality mean that any solution will have to be multi-faceted. This being said, there are specific mechanisms which might be implemented so as to better coordinate the massive web which underpins positive action:

- **It all starts with public awareness**. Public awareness of the problem and its urgency are crucial to polities accepting the burden of policies such as congestion charges. Moreover, citizens are more likely to take action on climate change if the co-benefits are emphasized.
- **Coordination across all environmental policies is needed to achieve tangible results on all fronts**. It is important to identify the co-benefits and trade-offs in combating air pollution and other environmental issues, such as climate change, biodiversity loss, as well as to address them effectively with specific policy instruments.
- **Air quality policies should be seen within the wider socio-economic spectrum so as to ensure that the measures implemented are adequate**. Under this banner, poverty requires particular attention. National and municipal governments need to ensure that command and control type instruments such as quality standards or bans are not burdensome for households.
- **Coordination of international efforts is needed**. Air pollutants can travel over long distances – especially ozone and particulate matter. They have an international impact, and need to be managed similarly to climate change. Collaboration has to occur on the regional, national and international levels to enable the successful implementation and upholding of policies relating to pollution control.
- **It is important to bring scientists and policymakers together**. Although having strong scientific and monitoring agents involved with the issue is very important, it is not the only quintessential factor.
- These forces should also be seen as enabling policymakers to have sufficient insight so as to make informed policy decisions.
- **Effectiveness of national and municipal policies**. Government policy can help overcome market failures which contribute to the pollution problem. Modernization programmes with public support for the poor built in are good examples of the necessary cooperation between national and regional authorities.
- **Cooperation with the private sector is a key element of effective policies to address air pollution**. Public investment to boost innovative solutions can increase the overall benefit to society. Local and municipal governments can facilitate partnerships between government, research centres, and industry.

3. Solutions – how can we achieve better air quality in the most efficient way?

Feasible innovative solutions in the transport and heating sectors

The technology tree presented below summarizes the mapped innovative solutions in the areas of transport and heating. It was constructed with the help of leading industry experts, academic experts and practitioners.

Table 2. **Technology tree – key analysed groups and subgroups of solutions from transport and heating**

Level 0. Areas	Level 1. Groups of solutions	Level 2. Subgroups of solutions
Transport	Electromobility and alternative fuels	Alternative fuel vehicles
		Alternative transport solutions
		Infrastructure for alternative fuels
	Technologies supporting modal, organisational and behavioural shifts	Traffic optimisation
		Last mile solutions
		Increasing accessibility to low emission transport modes
Heating	Optimisation of combustion process	Optimisation of combustion process
	Energy efficiency	Insulation
		Efficient Energy management
	Grid, storage, and other integrating solutions	Smart Heat Grid
		Solar power efficiency
		Heat Storage
		Integrating solutions
	Heat generation	Heating from renewable energy
		Combined heat and power stations (CHPs)
		Heat pumps
		Energy recuperation
		4th and 5th generation networks
		Decentralised heat generation

Source: Analysis by Deloitte

Transport

Electromobility and alternative fuels

Improvements in the energy efficiency and the reduction-intensity of traditional internal combustion engine technologies have proven to be limited by the technology itself. Significantly though, a reduction of emissions might be achieved by implementing alternative fuel vehicles and other transport solutions, as well as through improving the infrastructure supporting alternative fuels. Alternative transport can be defined as being at least partially powered by more environmentally-friendly solutions, and in terms of road vehicles this group includes both different types of **electric vehicles** (i.e. battery-electric, hybrids, and plug-in hybrids), as well as vehicles powered by **compressed natural gas (CNG)** or **biogas**.

Making use of alternative fuels allows us to limit, or even fully eliminate the direct emission of certain air pollutants, while at the same time yielding energy savings. Even though alternative fuel

vehicles are not yet cost competitive with traditional internal combustion engines, technological improvements, as well as economies of scale are serving to drive initial costs down. For context, it would seem that the alternative fuel industry is on the same trajectory as the photovoltaic technology.

Additionally, innovative low-emission transport solutions can limit the air pollution caused by congestion resulting from traffic. Aside from the capacity to improve both the performance and efficiency of a given mode of transportation, "low" or "no" emission technologies might well change the way in which we get around altogether. In this vein, two main trends are currently on the rise – the electrification of transportation (e.g. electric vehicles, magnetic field trains, and electric waterway transport), as well as the implementation of advanced solutions adapted to traditional means of transport (e.g. high-tech buses and heavy duty vehicles).

Moving forward though, underdeveloped infrastructure supporting alternative fuels is one of the main limiting factors for their widespread adoption. Infrastructure should not only meet the increasing demand, but also serve to boost future growth in the share of alternative fuel vehicles. In response to this need, a number of projects such as **multiple car charging facilities** (e.g. charging towers – electric vehicle stack parking), and **fast chargers have emerged**. These technologies are being paired with the development of **charging corridors** (roads with recharging infrastructure being available at regular intervals), as well as **universal plugs for super chargers**.

Technologies supporting modal, organisational and behavioural shifts

Incentivising consumers to use public transport, or increasing the efficiency of traffic management, can decrease number of private vehicles on the road (and their resulting air pollution). Following in the theme of private vehicles, it is possible to minimise traffic-caused air pollution through the implementation of an enhanced transport network control system involving machine learning and big data. Another option is the implementation of systems that increase automation in the driving process, such as advanced driver assistance systems. The goal in either instance is to reduce the inefficiencies inherent to human behavioural factors, and incomplete information on a user level.

Another socio-economic and environmental challenge is that of striking a new balance between personalized products and services (need for customization), and a sustainable value chain including production, transport and consumption (need for reducing ecological footprint). One of the trends in innovation, which seeks to renegotiate how we think of, and use our physical infrastructure are **last-mile transport solutions**. These seek to both improve the consumer's traveling experience (**autonomous vehicles**), and provide incentives to use alternatives to private vehicles (**automatic guideway transit, car-sharing services**). The idea is to also increase the efficiency of delivery services, while simultaneously reducing any negative environmental impact.

Solutions that improve user experience, as well as make that troublesome commute more convenient play a significant role in embedding low emission transport in urban travel patterns. Some public authorities have already implemented policies that aim to increase the use of public transport by making it more accessible. It is hoped that by complementing such initiatives with the widespread implementation of innovative technologies (**smart ticketing, smart automated interchanges, automated cycle parking, mobile device applications**), the sum of the two prongs will allow us to sustain the ease of access on a daily basis.

Heating

The heating and cooling processes used in households and by industry currently account for 50% of the EU's annual energy consumption. Macro-solutions which also enable smart, demand-driven heat distribution will thus contribute to the decrease in fossil fuel energy dependency, and thus associated air pollution.

Optimisation of the combustion process

It is first necessary to decrease primary energy demand, and improve the efficiency of combustion-based technologies currently in use, thus limiting emissions. Any solution that allows for the reduction of airborne toxins resulting from the combustion processes will need to improve both the combustion conditions themselves (**gas adaptive systems, catalytic combustion in biomass stoves**), as well as the post-combustion stages (e.g. scrubbers, filters, catalytic destruction, precipitators).

Energy efficiency

Insulation reduces heat loss, thereby allowing us to decrease our dependency on fossil fuels without compromising the ambient comfort of buildings. Aside from increasing the energy efficiency of the building sector and lowering energy bills, insulation both enables and facilitates the integration of other low emission technologies (e.g. **PCM materials, vacuum insulation panels, aerogels, utilization of noble gases**).

Any reduction of energy consumption requires the implementation of comprehensive solutions at both the supply and demand ends – namely, a 'front to back' crackdown on systemic inefficiencies. Building **energy management systems** will complement smart energy grids, and allow for end users to both monitor and control their energy consumption based on real-time price data, as well as their personal preferences. This can be accomplished while also reducing systemic inefficiencies relating to subjective human factors and behavioural barriers, such as a lack of awareness, time, skills, etc. Efficient energy management is being made possible due to the increased availability of technologies such as **smart meters** and **home automation networks**.

Grid, storage, and other integrating solutions

Currently, stakeholders focus on the development of measures that will allow for efficient demand side management – technologies such as **smart heat meters**. Similarly, **distributed heat generation**, which is facilitated by the increasing the market share of renewable energy, is the focus of ongoing innovative activities. Both of these development strategies are endorsed by the EU Heating and Cooling Strategy.

In the process of establishing smart heating grids, a great deal of focus has been placed on the **incorporation of different heating technologies**. This is mainly due to the fact that currently, the best achievable results have come as a product of pairing the use of **renewable technologies with CHP** and **advanced heat pump technologies**. This formula has been so successful due to its ability to address the mismatch between supply and demand brought about by the intermittent nature of renewable energy sources.

Thermal energy storage (TES) technologies allow us to store excess energy for balancing the mismatch between day- and night-time, or summer- and winter-time energy demands. TES has two main advantages: first, it allows for a more comprehensive use of renewable energy sources, and secondly, through the application of TES solutions, it is possible to mitigate the peak demand, thus levelling the load. The three main types of thermal energy storage include: **sensible heat storage**, **latent heat storage**, and **thermochemical heat storage**. The latter two are still currently regarded as emerging technologies, with application of **phase changing materials** and **thermochemical energy storage**.

Heat generation

Most recent data shows that renewable energy accounted for 18.6 % of total energy use for heating and cooling in the EU in 2015.[6] However, a further increase of 8.4% (reaching 27% overall) in renewables' share in heating and cooling is needed in order meet EU energy mix targets by 2030.[7] Thus, the integration of renewable energy as part of our heat source is a field with both a great potential and need for further development.

Currently, technologies that allow for the use of bioenergy are playing the most significant role in the provision of heat from renewables. However, it is important to assess the sustainability and viability of biomass usage in the life cycle i.e. by providing local supply of good quality resources

6 Eurostat, 2017, Renewable energy statistics.
http://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics#Share_of_energy_from_renewable_sources:_heating_and_cooling

7 Euractiv, 2017, Renewable energy gap in heating 'unacceptable', EU says.
http://www.euractiv.com/section/electricity/news/renewable-energy-gap-in-heating-unacceptable-eu-says/

and implementing low emission biofuels combustion technologies. On the other hand, in coming years, solutions that enable the utilisation of **solar energy for water heating** (although available since the 1980s), are expected to experience a surge in demand. This will especially be the case once improvements such as freeze protection systems and other adjustments for colder regions are made more viable. Similarly, technologies that allow for the use of **deep geothermal energy** use have already reached market maturity, although mostly only in large-scale applications.

Supporting and supplementing market forces - economic incentives, regulations and education

Further GDP growth in Europe is unlikely to reduce air pollution "by itself"

The economic growth of developed economies today is no longer driven by basic activities such as land use, the exploitation of low-value natural resources, and leveraging of unskilled labour. In other words, currently observed progress in advanced economies is not achieved at the expense of larger energy use or air pollution per 1 unit of GDP.

While higher resource productivity is undoubtedly a positive fact, it does not mean that further GDP growth will tackle the problem of smog "by itself", without well-tailored measures on the national or local level. Our econometric study proved that GDP per capita does not directly influence prevailing smog patterns among 67 European cities. Consequently, structural, institutional and social factors can explain noticeable large differences in air pollution measures. According to our estimation, **the most important are those that increase share of renewable energy in gross final energy consumption, which in turn translates into lower concentration of PM_{10}, NO_2, PM_{10} in urban areas.**

Figure 3. **Sample of 67 European cities used for the econometric panel models and assessment of market potentiall**

Source: Deloitte's elaboration based on Esri, DeLorme Publishing Company, Inc.

Education, access to information and social awareness

Rising environmental awareness and social participation creates a set of opportunities and challenges for innovative investments. **It has been shown that there is a direct correlation between a higher level of education, and concern about the environment**.[8] Relevant to this study is that

8 E. Clery, R. Rhead, 2013, Education and attitudes towards the environment.

education also seems to directly affect both consumption and behavioural patterns vis-à-vis environmental issues. According to the OECD, there is a correlation between level of education, and individual energy / water use (as education rises, consumption decreases), as well as between education and active involvement in environmental issues.[9] [10]

Lack of awareness and the underdeveloped technological capabilities of customers can predetermine their purchasing decisions, preventing them from using renewable sources in heating or alternative fuels in transport. Awareness and increased technological understanding could play a paramount role in helping diffuse innovation.

One of the most volatile forums for societal change is social media – it at once has the ability to harness the power of whole demographics, and also to spread fear and misinformation – a phenomenon sometimes referred to as "fake news." Dangerously, this can have social and economic ramifications outside of cyberspace, with companies in the fields of nuclear, wind, biomass, biogas, and even solar energy generation seeing virtual slander lead to material loss.

Direct policies and instruments – case for public intervention

In general, the government can play a key role in creating a fertile environment for innovation, by investing in the foundations for innovation and by helping overcome barriers. These targeted policy instruments need to fit a broader enabling framework, including polices which create skilled workers, a sound business environment, and strong governance.

Rationale for public intervention should be based on a sound theory and empirical evidence based on past market failures. Even if the latter holds true, **policymakers also must be aware of government failures while planning their activities**. A reasonable case for a more active role on the part of public sector could be one of the following:

- **Capital market failures**, resulting in difficulties with financing large projects with high upfront costs, and limited access to capital which affects particularly SMEs;
- **Network effects and other positive externalities** might be an argument for government grants and subsidies to fund the development and maintenance of infrastructure, which can reduce overall cost, and thus encourage more initiative. Additionally, infrastructure enables the further diffusion of related technologies that depend on it;
- **Imperfect information, asymmetry of information and imperfect competition** are common features of the reality where innovations are being developed. For example, public transport and traffic management are under the auspices of city authorities, while the heating grid and heat generation are managed by large companies. The latter tend to be state-owned or conservatively minded, creating a barrier for developing and diffusing innovative solutions.

Besides supporting innovation, governments need to find smart ways to prevent negative environmental impacts. Studies show that environmental regulations continue to be primarily of the "command and control" type, imposing performance standards across a product or an industry.[11] While such regulations are appealing in their simplicity, they tend to discourage the application of innovative solutions by limiting the ability of companies to develop creative approaches, and by diverting funds from research and development activities. **In the environmental sector (including smog prevention), technology-driving approaches are needed, which could include the continuous updating of standards, surveillance of old technologies, or emphasis on preventive standards for new and existing sources of pollution**.

Our quantitative assessment

In this part, we present our approach to the analysis of innovative solutions for dealing with smog, as well as the data sources used.

9 W. Poorting, 2004, Environmental concern, and environmental behaviour – A Study Into Household Energy Use.
10 International Social Survey Programme 2010.
11 OECD (). Regulatory Reform and Innovation.

Methodology and data source

Our general analytical approach consists of 4 major steps:

1. First, the relevant solutions for heating and transport were mapped and grouped. The result of this is the **technology tree** presented in Table 2. Section 5.
2. Second, **a dedicated survey was conducted among a panel of experts in heating and transportation technologies**. The aim of the survey was to gather critical indicators for the potential impact of the given technologies' air pollution emissions. , and for investment attractiveness, as assessed from the market and technology readiness perspective.
3. In the next step, an urban database was constructed, covering 67 cities in 26 EU countries in order to measure **market potential using statistical methods**.
4. Lastly, **a quantitative model was created to generate a numerical assessment of the potential impact selected solutions will have on smog, and their potential market and technological attractiveness**. The model is based on our survey data and is a major tool used for giving investment recommendations.

How to interpret the results

In this investment problem we need to choose between outputs that might be "produced" by assessed solutions: market and technological attractiveness (and resulting profits) and improvement of air quality. As impact investors are interested in delivering both financial and non-financial values, in case of InnoEnergy it is desirable to present model results in a simplified, 2-dimensional space. In order to offer a more comprehensive view, our results are presented and clustered in a two-fold manner:

- **Production-possibility frontier**: the frontier shows the most promising technologies from the aspects of both total investment attractiveness and air pollution emissions reduction. The total investment attractiveness is a function of market and technological attractiveness. An optimal investment opportunity is one of the points laying on the frontier. In general, the production-possibility frontier presents maximum feasible outputs and their relative value, subject to the current state of technology and other endowments.

- **Bubble chart of market and technological attractiveness and impact on emissions**: the chart enables to split and compare the results for market and technological aspects within investment attractiveness; the bubble size indicates potential impact on emissions. Innovative solutions often experience unequal magnitude of technological and market "push" forces, thus such mapping adds to aforementioned production-possibility frontier.

Table 3. **Summary of the final indicators used in the quantitative assessment**

Final indicator	Relation to the indicators from the survey	Interpretation	Figure
Market & technological attractiveness (1)	Function of the Market attractiveness (2) and Technological attractiveness (3) specified below.	Total investment attractiveness, taking account for supply- and demand-side conditions and expectations.	Production-possibility frontier
Market attractiveness (2)	Function of an assessed dynamics of the market demand and possibility of market share increase by 2025.	Magnitude of market "pull" forces for innovative solutions	Bubble chart
Technological attractiveness (3)	Function of an assessed Technology Readiness Level and forecasted dynamics of technology development processes.	Magnitude of technological "push" forces for innovative solutions	Bubble chart
Impact on emission (4)	Function of an assessed potential impact on emission of SO_x, NO_x, PM_{10}, $PM_{2.5}$ and Benzo(a)piren, weighted by unit external cost for each pollutant.	Socio-economic value of potential reduction of smog valuated by unit external costs and structure of emission.	Production-possibility frontier; Bubble chart

Source: Analysis by Deloitte

Outcomes for Transport

According to our assessment, three solutions belonging to electromobility are characterized by an optimal combination of market and technological attractiveness as well as impact on smog. These are: interconnected charging networks; multiple car charging solutions; electric vehicles. Although fast-chargers are not defined as strictly efficient, since they do not lay on the graph on the production-possibility frontier, they are very close to the best solutions and should also be considered by prospective investors.

Table 4. **Outcomes for Transport – clusters and their business drivers and barriers**

Cluster 1 (Electromobility) factsheet

Solutions in the cluster
1. Interconnected charging networks
2. Fast-chargers
3. Multiple car charging solutions
4. Electric vehicles

Key business drivers
1. R&D activities contributing to a decrease in both the battery and energy infrastructure costs as well as vehicle weight
2. Benefits for users like fueling at home, at work, overnight etc.
3. Petrol prices tend to be volatile, while EV can make use of lower demand for electrical energy during nighttime
4. Compliance with CO_2 and air pollution regulations
5. Preferential administrative treatment for alternative fuel vehicle users and financial incentives (tax and non-tax)
6. Favourable regulations; e.g. introduction of the requirement for new buildings to establish charging infrastructure on their premises

Key business barriers
1. High upfront costs
2. Urban planning and regulatory limitations
3. Customer's negative expectations based on the limited availability of charging and refueling infrastructure
4. Limited electric grid capacity and interconnectivity
5. Policy frameworks and lack of standardization.

Cluster 2 (Smart Public Transport System) factsheet

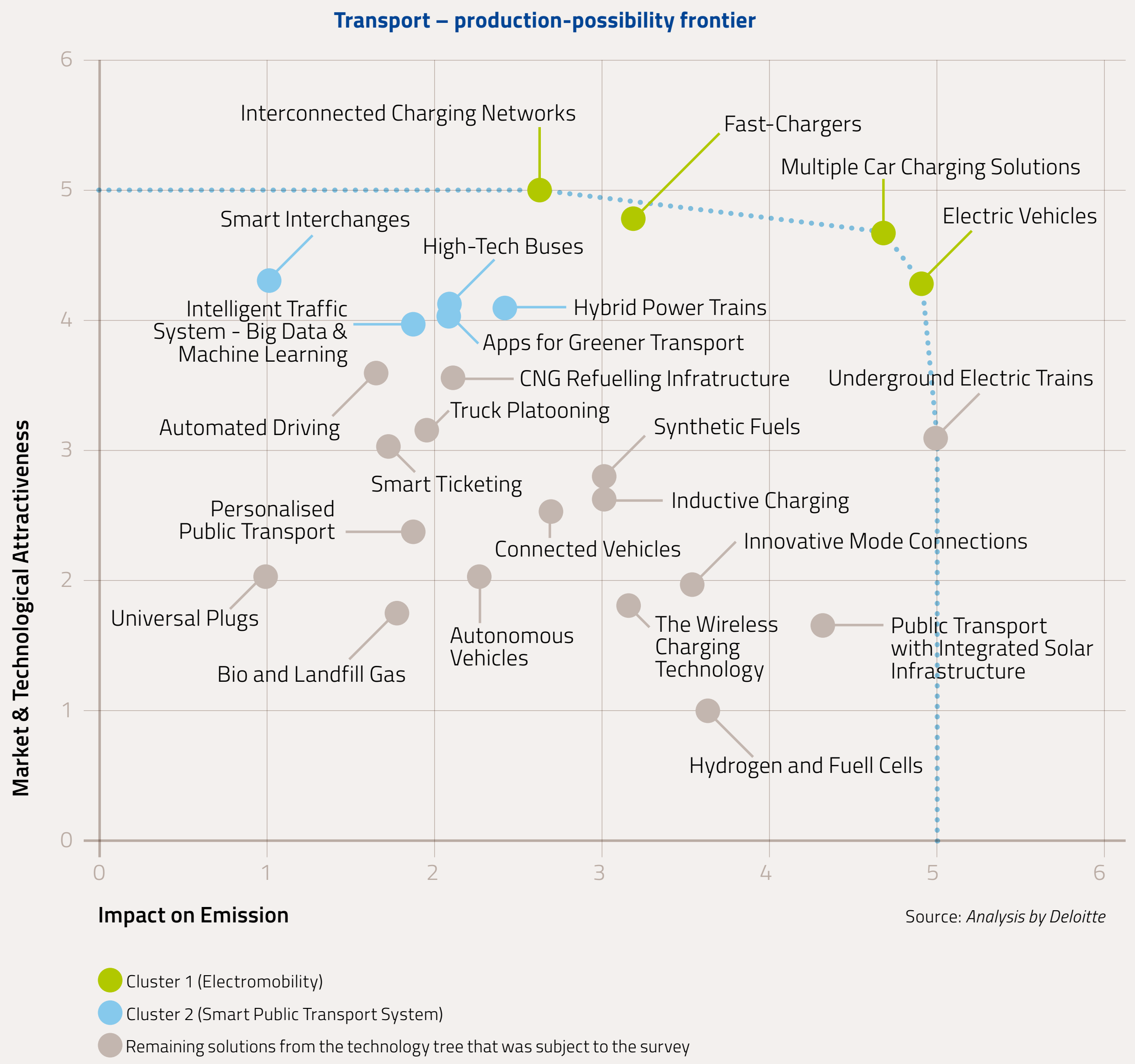
Solutions in the cluster
1. Smart interchanges
2. High-tech buses
3. Hybrid power trains
4. Intelligent traffic systems - big data & machine learning
5. Apps for greener transport

Key business drivers
1. Potential for a decrease in both the number of accidents, and as a result, insurance costs
2. Reduction of primary energy demand
3. Potential for decreased congestion and optimisation of traffic
4. Efficient asset utilisation – reduced vehicle non-use time
5. Increased consumer demand for personalised services
6. Decreased operational costs

Key business barriers
1. High infrastructure costs
2. Standardisation issues
3. Lack of consumer technological capabilities and awareness
4. Cyber-security
5. Different expectations and requirements from different stakeholder groups

Source: Analysis by Deloitte

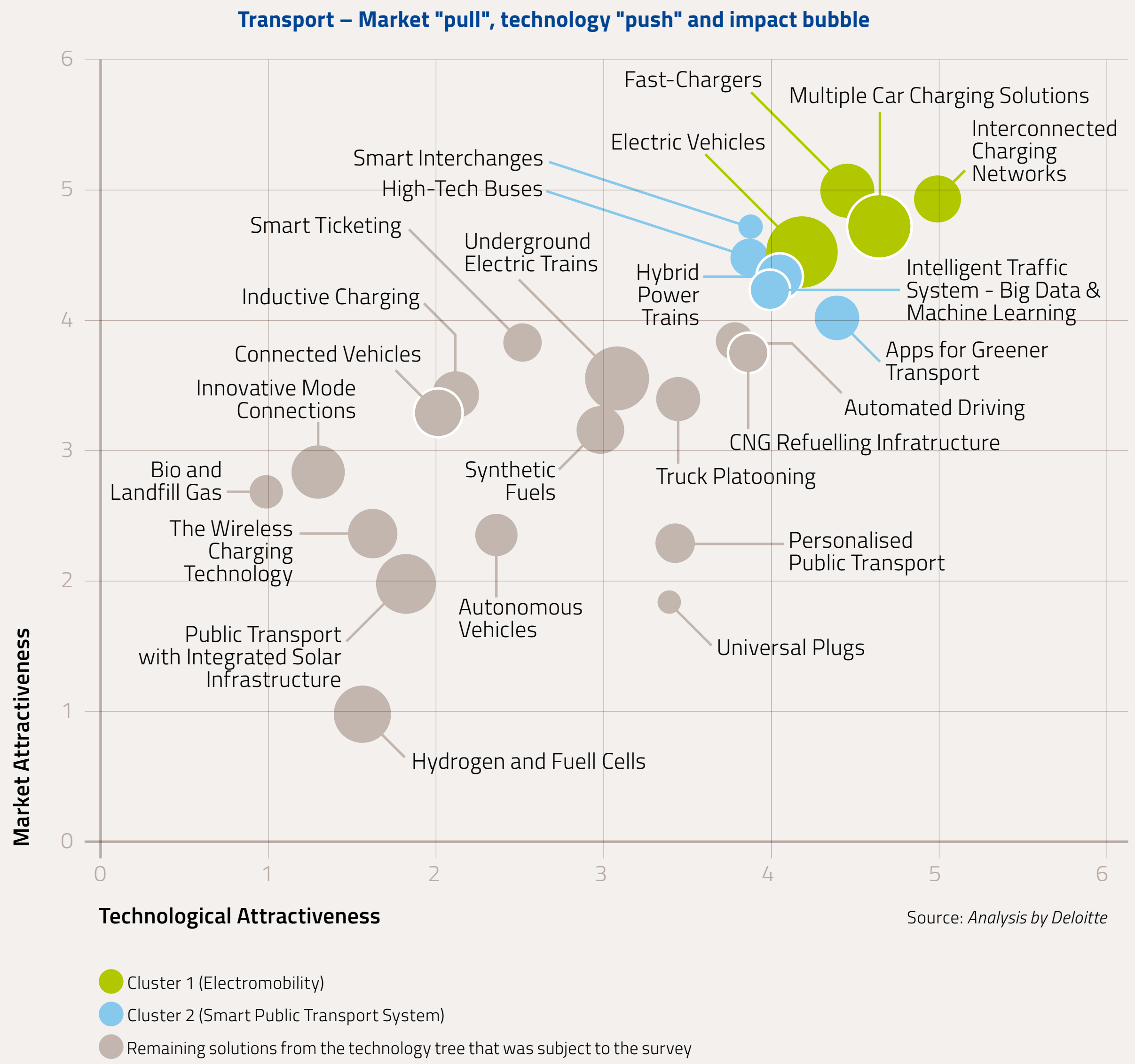
Figure 4. **Model results for Transport – production-possibility frontier, combined market and technological attractiveness (vertical axis) and impact on emission (horizontal axis)**



Source: *Analysis by Deloitte*

In terms of joint market and technological attractiveness, a group of solutions for public transport deserves some attention. Even though they seem to represent a vast range of applications and embodied technology, we can still, in fact, group them into Cluster 2 (Smart Public Transport System). Although all of them were assessed as inferior to Cluster 1 (Electromobility), they serve a very important market segment – urban transport and supporting facilities. Thus, Cluster 2 might be attractive for investors that need better portfolio diversification or have experience and specific knowledge of the public sector. **Underground electric trains** might be the best option if some investor wish to maximises impact on emission reduction, while treating market outlook with secondary importance.

Figure 5. **Model results for Transport – separate market (vertical axis) and technological attractiveness (horizontal axis) and impact on emission (bubble size)**



Source: *Analysis by Deloitte*

Outcomes for Heating

Our results indicate that there are technologies on the production-possibility frontier from each area of heating: heat generation (solar thermal energy), heat storage (underground thermal energy storage) and energy efficiency (smart building energy management systems as well as distribution management systems). Contrary to the transport sector, there is no single dominating cluster.

Relatively close to the frontier and thus included in the clusters are the following: **energy positive windows, smart meters and sensible thermal energy storage**. From an investment point of view, we can also add to the defined clusters items like: **demand-controlled and multi-zoned ventilation systems, fuel flexible CHP, low and ultra-low heating networks**. According to our survey and quantitative model, weaker performance of these selected items is related to relatively low technological readiness or average market perspective.

Table 5. **Outcomes for Transport – clusters and their business drivers and barriers**

Cluster 1 (Smart Buildings) factsheet

Solutions
1. Smart building energy management systems
2. Energy positive windows
3. Smart meters
4. Demand controlled and multi zoned ventilation systems

Key business drivers
1. Dynamic development of smart grids and green office buildings
2. Increasing demand for personalised solutions
3. Optimisation of resource use
4. Stringent building energy efficiency norms
5. Dynamic development of IoT and cloud technologies

Key business barriers
1. Multiple stakeholder engagement; lack of uniform standards
2. Lack of consumer awareness and technical capabilities
3. Potential limitations resulting from lack of flexibility in the existing built infrastructure
4. Personal data and cyber-security issues
5. Complex grid integration process

Cluster 2 (Distributed Generation and Storage Systems) factsheet

Solutions
1. Solar energy
2. Sensible thermal energy storage
3. Distribution management system
4. Low and ultra low heating networks
5. Fuel flexible CHP

Key business drivers
1. Low operation costs
2. Optimisation of resource use by utility providers
3. Ability to manage peak load more efficiently and avoid grid imbalances
4. New business models; new partnership opportunities
5. Financial incentives
6. Dynamic development of smart grids
7. Compliance with the EU regulations
8. Increasing demand for the grid to integrate intermittent energy resources

Key business barriers
1. High upfront cost
2. Lack of consumers' technological awareness
3. Multiple stakeholders; complex level of interoperability between devices is needed
4. Urban planning limitations
5. Lack of efficient price signals

Source: *Analysis by Deloitte*

Figure 6. **Model results for Heating – production-possibility frontier, combined market and technological attractiveness (vertical axis) and impact on emission (horizontal axis)**

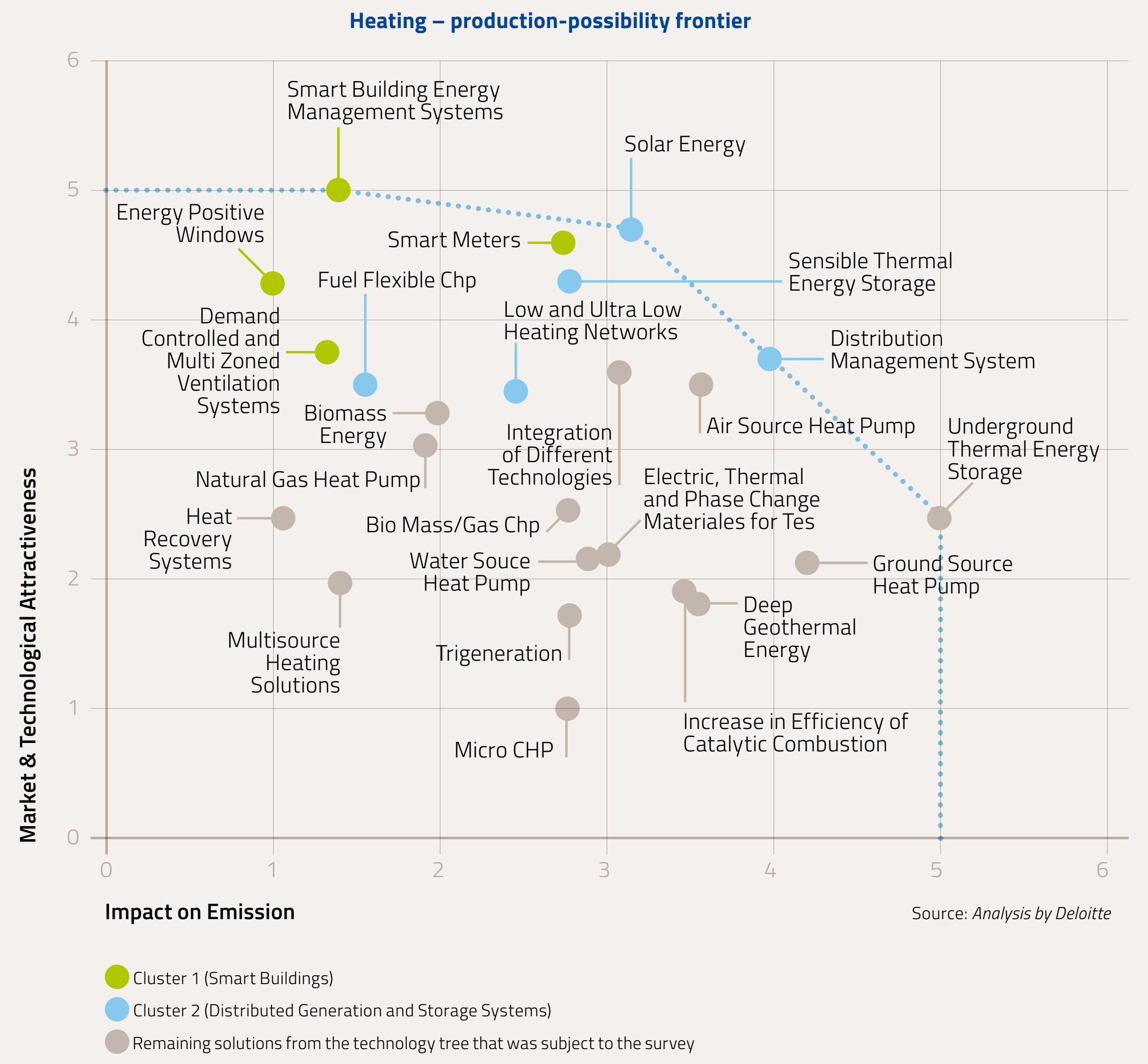
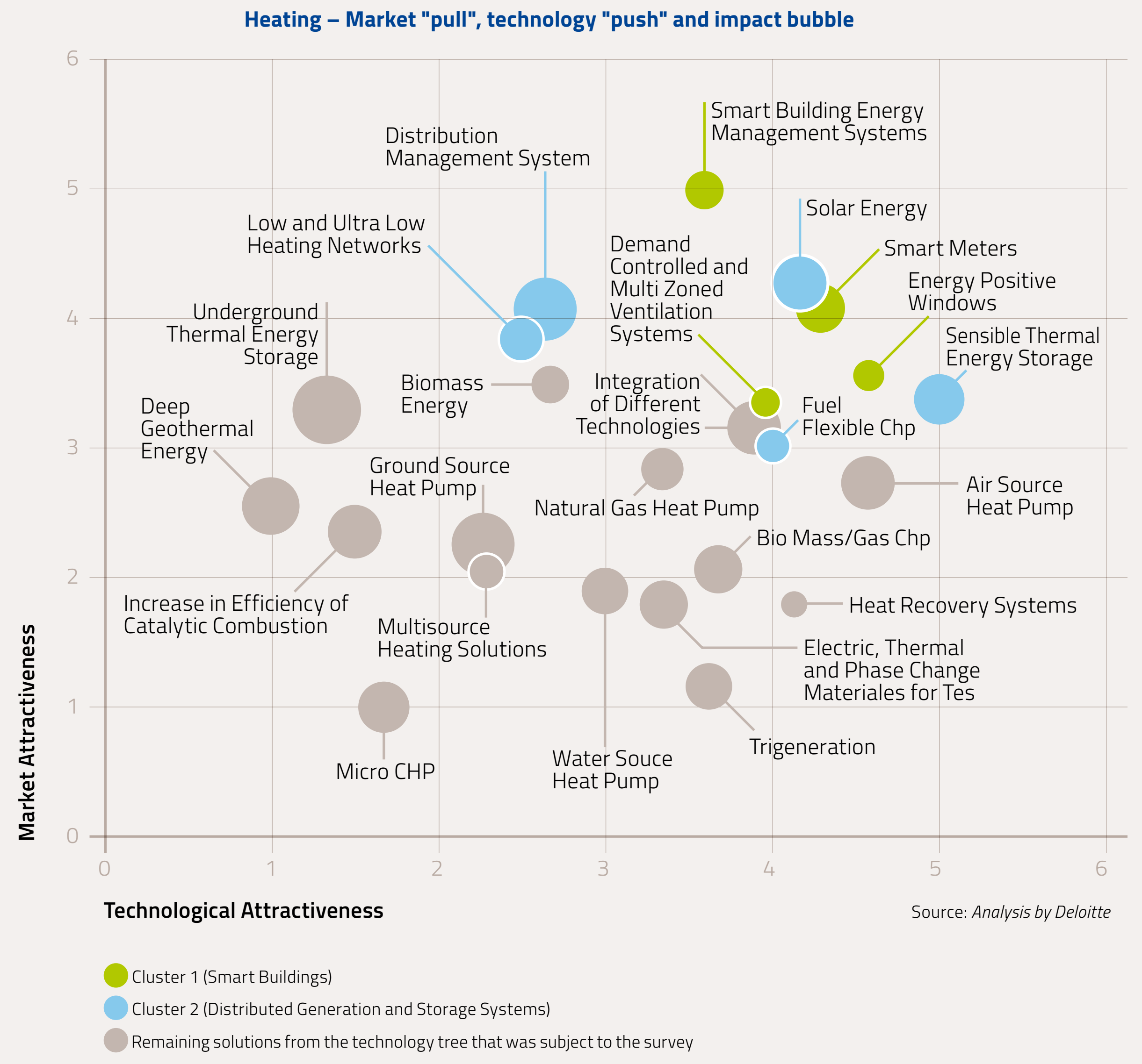


Figure 7. **Model results for Heating - separate market (vertical axis) and technological attractiveness (horizontal axis) and impact on emission (bubble size)**



4. Conclusions

- **Smog may attribute to even 1 in every 10 premature deaths in the world and over 400,000 premature deaths in Europe every year.**
- **Total external costs related to the health effects of smog are estimated to be between 243 BLN EUR and 775 BLN EUR in 2020.**[12] Such annual burden on the European economy is calculated as a function of premature deaths, rising healthcare bills, protracted illnesses, lower on-the-job productivity and absences.
- **According to our simulated conservative scenario, European citizens might gain 183 BLN EUR between 2018 and 2025, an equivalent of 1.2% of the forecasted GDP in the EU-28 in 2018**. Such a result is the combination of the "Conservative 10% in 2025" Scenario regarding investments and supporting polices as well as the middle value of estimated external costs.
- **Cooperation with the private sector is a key element of effective policies meant to address air pollution**. Public investment to boost innovative solutions can increase the overall benefit to society. Local and municipal governments can facilitate partnerships between government, research centres, and the industry.
- **Public awareness of the problem and its urgency is crucial to accept the burden of policies such as congestion charges**. In general, there is a direct correlation between higher the level of education and concern about the environment. Moreover, citizens are more likely to take action on air pollution if other direct benefits are emphasized.
- **Within the transport sector, creation of a better ecosystem for electromobility is the best investment opportunity. This holds for the market, technological, and emission reductions points of view.** The most promising investment areas include developing electromobility infrastructure (multiple car charging solutions, interconnected charging networks, fast chargers), and producing electric vehicles.
- **The Smart Public Transport System Cluster is a valuable investment portfolio supplement that allows for risk diversification and also serves very important markets**. Moreover, there are no noticeable trade-offs between market and technological attractiveness and environmental value.
- **Within the heating sector, the most promising solutions might be attributed to the Smart Buildings Cluster and Distributed Generation and Storage Systems Cluster**. Particularly attractive for investors are the following: solar thermal energy, smart building energy management systems, as well as distribution management systems. Underground thermal energy storage is the most efficient for investors that wish to maximize potential impact on smog, though the possibility of delivering it is subject to significant technological risk.

12 European Comission, http://ec.europa.eu/environment/archives/air/pdf/Impact_assessment_en.pdf

5. Recommendations

Investment recommendations

Investments are one of the most important leverages for making long-lasting impact on the society and economy. In a world of limited resources and unlimited needs, any investment decision should be backed by the best available knowledge and projections.

Ultimately, 18 selected solutions to watch from 4 recommended clusters are presented with additional insights from the survey. Investment recommendations in this report result directly from the surveys performed and a chosen analytical approach.

Table 6. **Summary of the investment recommendations by 4 clusters**

Electromobility	Smart Public Transport System	Smart Buildings	Distributed Generation and Storage System
Interconnected charging networks	Smart interchanges	Smart building energy management systems	Solar energy
Fast-chargers	High-tech buses	Energy positive windows	Distribution management system
Multiple car charging solutions	Hybrid power trains	Smart meters	Sensible thermal energy storage
Electric vehicles	Intelligent traffic system – big data & machine learning	Demand-controlled and multi-zoned ventilation systems	Low and ultra-low heating networks
	Apps for greener transport		Fuel flexible CHP

Source: *Analysis by Deloitte*

General policy recommendations

We formulate four high-level policy recommendations that summarize lessons learned from the topic and more general conclusions from economic and social research. Later on, policy recommendations for clusters aim to correspond with specific barriers and challenges to innovation adaption and new investments.

1. Green and sustainable growth as an overarching goal

Green growth should be key for both the private and public sector as it increases the quality of life for current and future generations. This requires good coordination across all environmental policies, thus linking them with the current socio-economic context.

In the overall policy context, we recommended to support green growth development, as our outcomes show that increasing the share of renewable energy translates into cleaner atmosphere. According to our econometric estimates on a sample of 67 European urban areas, sustaining or even boosting GDP growth will not lead to a cleaner air "by itself". However, a possible reverse effect should be taken into account by policymakers – i.e. smog is a hurdle for long-term economic growth, negatively impacting labor supply and human capital accumulation.

2. Sufficient room for markets with smart interventions

A smart balance of market-based instruments and a top-down approach is needed to address potential trade-offs between securing important goods like economic welfare, mobility, air quality, health, ecosystems, affordable housing, cheap energy etc.

Cooperation with the private sector is key. Hence, we underline the importance of facilitating development of sustainable finance and impact investing, a paradigm that attempts to address abovementioned issues and trade-offs. Market bottom-up forces cannot be substituted as a device for constant technological advancement, and, by the same token, the economy of scale or positive leverage that only financial sector can provide is necessary. However, modern financial markets sometimes generate externalities like boom and bust cycles that have an adverse effect on other sectors. Hence, there is a sound rationale for the state to assure that a certain level of environmental, social and governance (ESG) factors is included in investment decision-making process.

Moreover, public investments act as an important supplement to private-led investments, especially in areas where social returns might be substantially larger than private. Measures like green procurement should also "pull" innovations that have good market perspectives. In the long-term perspective, these measures will also facilitate development of sustainable finance instruments, both for institutional and individual investors.

3. Education and social awareness as a foundation for successful adoption of green innovations

Investing in education and raising social awareness should not only be one of the priorities for the public agenda, but also a responsibility of businesses and NGOs. Air quality policies should be seen and promoted within the wider socio-economic spectrum so as to ensure that the measures implemented are adequate.

Public awareness of the problem and its urgency is crucial for high levels of public acceptance for the burden of policies such as congestion charges. Awareness helps people see the overall societal benefits of such policies, and makes them more willing to accept the restriction that these policies impose. It is recommended to start from education, awareness building, and addressing specific socio-economic needs that might refrain from supporting "green" policies or adoption of innovations. In this context, poverty and exclusion require particular attention.

4. Enhanced statistical framework and new data sources to induce innovative activities

Strengthening statistical capacity is fundamental for improving the process of planning and executing private investments as well as evidence-based policies. Decentralized data sources provided by sensors, apps, and intelligent devices might largely reduce information asymmetry and, in effect, boost innovation and investments.

We recommend to support investments in expanding modern decentralized sources of data on buildings, urban infrastructure, vehicles, technologies and other important assets, as well as flows or characteristics that impact local structure of transport system and energy sector. High-quality data sources generate positive externalities, in other words – have many features of public goods. If there is a lack of strong private incentives, we recommend to provide public funds for constructing and sharing databases. As a supplement, performing broad meta-analyses and empirical assessments with on-site surveys is highly recommended.

Cluster-level policy recommendations

Policy recommendations for the 1st Cluster: Electromobility

1. **Empower the role of the private sector in urban planning**, while providing incentives for sustainable transport solutions. Assure that potential trade-offs between demand for mobility, emission, economic efficiency and social inclusion are managed in a way that is socially acceptable and, thus, sustainable.
2. **Minimize investment risk through improvement of the regulatory framework** for new investments dealing with electric grids, storage and interconnectivity. **Public policy uncertainty should be limited by a national legislation** that, on the one hand, defines boundary conditions for support schemes, and, on the other hand, leave some room for local "policy optimization" based on social preferences.
3. **Ensure right regulations, human capital and other prerequisite resources for boosting PPP projects** in the area of infrastructure, grid and storage. **Review the coherence and completeness of private property regulations** and amend any loopholes that might pose the problem of market failures, particularly externalities. For instance, good regulations should address the trade-off between full accessibility of infrastructure for alternative fuels and rights of private investors.

4. **Raise social and consumer readiness through campaigns** showing technological progress and long-term "value for money" embodied in EV and public or private infrastructure.
5. **Increase the number of police controls and consider stricter regulations concerning emission standards** that will be executed during mandatory maintenance overhaul.

Policy recommendations for the 2nd Cluster: Smart Public Transport System

1. **Analyze with an external financial auditor all the key elements of local governments' public finance that translate into ability to finance long-term transport investments**. Compare the possible supply of investment projects with the estimated local demand for sustainable and reliable transport services. In case of a large imbalance, review whole transport policy in the area, focusing on pricing, non-pecuniary factors, social preferences and habits.
2. **Check whether the public investments do not crowd out private ones. Consider privatization or PPP for some parts of infrastructure** if it might increase economic efficiency, boost investments, reduce burden for taxpayers or mitigate traffic congestion through "making users and polluters pay". Support sharing economy and similar business models based on asset renting.
3. **Eliminate bottlenecks in transport systems and distortionary solutions in regulatory frameworks that negatively affect total social costs of mobility, including environmental damages.** Check whether regulations, taxes or other non-market conditions do not discriminate greener transport modes and make them less competitive due to transferred excessive costs, supply constraints, lower reliability and accessibility etc. Introduce incentives for cycling and other forms of zero-emission mobility more attractive.
4. **Support modernization of public and private bus fleets, rolling stock** etc. by replacing old units with hybrid or electric motors, as well as alternative fuels like biogas.
5. **Facilitate innovation through creating an attractive environment for startups**. Promote cooperation between innovators that offer smart solutions and state-owned enterprises, especially infrastructure managers and carriers.
6. **Lead a transition towards smarter and greener transport in a way that does not exclude any stakeholders or communities**. Respond to specific needs and expectations raised by inhabitants, tourists, investors and other.
7. **Gain support for smart mobility solutions via education** that should start in kindergartens. Address specific needs of the less educated and elder population, which might not be accustomed nor have skills to reap benefits of innovations.

Policy recommendations for the 3rd Cluster: Smart Buildings

1. **Make an audit of existing building inventory** focusing on potential impact of installing smart technologies, thermomodernization and mapping key barriers for them.
2. **Improve or extend census data reporting systems that will create a basis for innovations as well as evidence-based policies** in the area of housing, energy and environment. Particularly, such system should be able to serve more sophisticated economic or econometric models with a spatial component, which are very useful for analyses of air pollution exposures, real estate market etc.
3. **Consider introducing more restrictive energy efficiency norms for buildings, individual heating appliances and fuel quality standards**. Assess the cost and benefits of financial incentives for making more sustainable and green modifications for roofs, walls and private gardens, as some of them might produce external benefits that are larger than private ones. Additionally, study the potential net benefit of support for prosumers.
4. **Raise social and consumer readiness through campaigns** showing possible savings and positive impact on health and environment. Invest in education showing applications of fast developing groups of solutions like Internet of Things, cloud technologies and learning algorithms. Present additional value for households – flexibility and personalization.

5. At the same time **educate and run social campaign showing the proper ways of reducing cyber-security threats, personal data breaches** etc.

Policy recommendations for the 4th Cluster: Distributed Generation and Storage Systems

1. **Review the coherence and completeness of private property regulations** and amend any loopholes that might pose a problem of market failures, particularly externalities. Land use regulations and urban or regional planning should be screened for potential undesirable impacts that might limit investments in grid or storage facilities.
2. **Promote market-based instruments as a device for establishing necessary price signals and internalizing external effects**. Monitor whether relevant public policies towards the energy sector do not distort competition nor decrease environmental effects that are expected from them. For example, consider a support scheme based on white certificates that will incentivise energy savings made by end-users.
3. **Run pilot programmes in order to establish the best practices regarding interoperability and stakeholders' role in distributed systems**. Support those programmes with a body of empirical research, new databases obtained from decentralized sources like IoT and relevant set of performance indicators.
4. **Educate key stakeholders and communities, showing possible technological and non-technological solutions and their impact**. Cooperate with business and the NGO sector and assure that regional and local authorities possess sufficient skills & knowledge to be change leaders.

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InnoEnergy
Kennispoort 6th floor
John F. Kennedylaan 2
5612 AB Eindhoven
The Netherlands
info@innoenergy.com

InnoEnergy Benelux
Kennispoort 6th floor
John F. Kennedylaan 2
5612 AB Eindhoven
The Netherlands
benelux@innoenergy.com

InnoEnergy France
Immeuble L'Alizée
32, rue des Berges
38000 Grenoble, France
france@innoenergy.com

InnoEnergy Germany
Albert-Nestler-Strasse 21
76131 Karlsruhe, Germany
germany@innoenergy.com

InnoEnergy Iberia
Edifici Nexus II Oficina 0A
Jordi Girona, 29
08034 Barcelona, Spain
iberia@innoenergy.com

InnoEnergy Central Europe
InnoEnergy Central Europe
Equal Business Park B
28 Wielicka Street
30 – 552 Kraków, Poland
central.europe@innoenergy.com

InnoEnergy Scandinavia
Valhallavägen 79
SE-114 28 Stockholm, Sweden
sweden@innoenergy.com

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www.innoenergy.com

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