

# **THE PARLIAMENTARY OFFICE FOR SCIENTIFIC AND TECHNOLOGICAL ASSESSMENT**

## **Innovation and Climate Change: The Role of Scientific and Technological Assessment**

**Green Paper presented by**

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# Introduction

This report was jointly written by the member organizations of EPTA (European Parliamentary Technology Assessment), the European structure regrouping different bodies in charge of the scientific and technological assessment for their respective Parliaments and by STOA (Science and Technology Options Assessments), the equivalent body of the European Parliament. Russian and American EPTA observing members also contributed to this report.

With the French Presidency of EPTA for the year 2015, OPECST was in charge of coordinating this report, which gathers sixteen monographs written by these different bodies.

It focuses on this year chosen theme: assessing technological contributions to tackling climate change. EPTA chose to work on this subject as it is closely related to the 21<sup>st</sup> United Nations Climate Change Conference (also known as COP21), which will be held in Paris, at Le Bourget site, from November 30 to December 11, 2015.

The aim, on the one hand, is to gather assessments regarding the three largest greenhouse gas emitting sectors: buildings, transportation and agriculture. On the other hand, in a more original approach, an overview is made on ways to induce citizens to contribute individually to climate policies, in particular when it comes to changing their habits.

Thus, this report reviews different studies carried out for several years in the relevant sectors of the EPTA organizations. Based on observations from previous evolutions, it summarizes the difficulties that have yet to be overcome. Possible and feasible solutions are presented, as well as accepted and acceptable solutions in each country, often revealed through a comparative approach.

These referenced studies aim at providing to Parliaments' members new and rigorous insight on these challenging and far-reaching questions, generally not presented by medias in proper ways for political decisions.

Therefore, it is the very purpose of the EPTA organizations to identify clearly these challenges and to be able to render their complexity through an instructive and comprehensive analysis in order to provide the necessary details for a complete understanding. Their task precisely consists of making recommendations to their Parliaments out of experts' technical analyses. These can either be compiled in publications and reports or expressed during public or private hearings.

The organizations, and consequently the cultures of the different EPTA members are very diverse, be they University departments, Parliamentary services, or even independent bodies. Even if their working methods are quite different, whether they favour written or oral procedures, they all meet the same goal: providing, with the utmost rigour, operational recommendations to members of their Parliament.



The two annual EPTA meetings are an opportunity to exchange profitable knowledge and experience. The Norwegian Presidency in 2014 took the excellent initiative of publishing a summary document to keep track of these meetings. From this inspiration, we decided to gather the contributions of our colleagues on the 2015 common theme in this report, in order to highlight the richness resulting from this coordinated work, based on different national background.

Conclusions of this collaborative work will be presented at the European Parliamentary conference, accredited by the COP21, held on the same subject by OPECT and EPTA at the French National Assembly on September 24<sup>th</sup>, 2015. This report, the conference proceedings, as well as the proposals resulting from debates will be sent to the COP21 committee.

Jean-Yves Le Déaut

Member of the Parliament for Meurthe et Moselle

OPECST President

EPTA President for the year 2015

# France

## **Innovation and Energy Efficiency of Buildings**

OPECST has studied this topic at least four times, in four different reports: a report from Mr. Birraux and Mr. Le Déaut from 2001 concerning the technological prospect of renewable energies, which already included elements related to bioclimatic architecture; a report from Mr. Birraux and Mr. Bataille from 2009 on thermal regulation modulation, which advised to add a cap on CO<sub>2</sub> emissions within construction regulations, thus complementing the requirement of an energy consumption standard; a report by Mr. Le Déaut and Mr. Sido from September 2013 on energy transition, which analyzed the costs of building renovations; and finally, a report from Mr. Le Déaut and Mr. Deneux from July 2014 on regulatory obstacles to innovation in the sector of energy efficient buildings, which proposed reforms to foster innovation, most of which have subsequently been put into law through the new July 2015 law on energy transition.

These reports analyze the situation and propose solutions.

### 1. On what analyses are based these reports?

Innovation within the building sector is key to the fight against CO<sub>2</sub> emissions, given that buildings use on average 40% of primary energy in Europe. Improved conception, building structures but also heating and air conditioning are appealing to construction as much as renovation. The goal is to minimize energy consumption, whilst retrieving as much calories as possible contained within the building's materials or in the ground, in used waters, or simply by relying on natural temperature discrepancy to allow air circulation.

In Northern Europe, where technological innovations have made the construction of so-called "passive" buildings possible, which use less than 15 kWh of heat per square meter per year, and less than 120 kWh in total per meter square per year, the primary goal is resisting against the winter's cold. But these improvements must also be geared, in the South, towards resisting against the summer's heat.

Generally, local assets must be used to profit from the use of renewable energies and have as little as possible recourse to energy produced by centrally and then distributed through national networks, which for the most part in Europe (a little under 50% on average) still stems from fossil fuels: coal, gas and petrol. On average, carbon free electricity is produced for a little under 25% from nuclear energy, for 15% by hydroelectricity and for a little over 15% by renewable energies.

## 2. What does OPECST propose?

Looking towards 2020, directive 2010/31/EC of May 19<sup>th</sup> 2010 sets the target of almost entirely energy efficient building, that is, a building which minimizes energy losses, and uses to its maximum potential local renewable energy sources.

For construction, innovations relating to phase-change materials, which strengthen the building's thermal inertia, and thus help reduce inside the effect of outside temperature changes over a longer period of time. These innovations can also cover assembling methods out of prefabricated elements, which will reduce coordination problems between the different workmen, often responsible for damage or underperformance caused by tightness issues. Indeed, when walls are drilled to make up for a preliminary mistake, the building' thermal inertia is compromised by a potential leak thus created.

For renovation, innovations cover new methods of product application which are efficient and easy to perform. Concerning insulation, reference can be made to thin multi-layer insulation, which is capable of adding tightness to the structure by its flexibility and its adaptability to imperfect volumes. Reference can also be made to an outdoors product (Parex-IT) currently being tested at the INES (located at Bourget du Lac), which is composed of an aerogel, can be applied by gun nuzzle and which achieves external thermal protection greater than polystyrene.

Innovation can also cover ventilation and air conditioning systems. For example, the University of Phoenix in Arizona, inspired by Indians customs, has come up with systems, which after digital simulation, have been perfected to function with little energy and are perfectly suited for big commercial buildings in dry desartic climates.

## **Innovation, transports and mobility**

In 2011 and 2012, Mr. Denis Baupin, MP, and Mrs. Fabienne Keller, Senator, wrote a report on behalf of OPECST concerning means of smooth and sustainable mobility and the conception of ecological vehicles.

This report mainly deals with questions relating to transportation and new types of vehicles and leads to a little over a hundred propositions.

### 1. On what analyses are based these reports?

For both rapporteurs, priority must be given to mobility itself rather than the mode of transportation, to the different uses of vehicles rather than their motorization. There is a diversity of potential technological evolutions for motors and fuels which must be recognized. The real needs of users of private and public transport must be born in mind. These differ not only according to traditional criteria (sex, age, profession) but also according to workplace and home location, and furthermore, according to individuals' behavior regarding exclusive car use only.

Growth of carpooling and car sharing requires rethinking transportation and forces public authorities, as well as car manufacturers, to contemplate the future of road use and parking. Electric vehicles, or vehicles which run on hydrogen or compressed air, also require planning new networks to charge up their batteries or new networks to insure adequate energy supply.

The rise in carbon emissions due to vehicles and transport is no longer an inevitable fate. Fine-particle emissions from diesel vehicles can be considerably reduced, thanks to technological improvements. This reduction of emissions is highly desirable but requires regular control of diesel vehicles, as well as incentives to renew the oldest vehicles, which don't have the necessary catalytic converters to respect current emissions criteria.

## 2. What does OPECST propose?

The report looks at ways to enable sustainable mobility, which reduce greenhouse gas emissions. Nine topics are covered: planning a more energy efficient, interactive, intermodal and smooth transportation; the transition of the car model to more efficiency, pleasure, modernity, friendliness, modularity and imagination; contracting with manufacturers to renew the automobile model and secure jobs; benefits given to pioneers regarding parking, fiscal policy and bonus, and influence on users to adopt more efficient, less polluting and small sized vehicles; measures to encourage car sharing; setting up partnership governance, as part of strategic State action; setting up a watch on technological and social innovations relating to mobility; promoting a European politic in favor of sober transportation.

These propositions were presented during the parliamentary debate on the latest energy transition law adopted the 22<sup>nd</sup> of July 2015. Some have been accepted. Indeed, this law gives a definition of low carbon vehicles, sets a mandatory percentage of such vehicles within the public fleet, and puts into place preferential toll prices for such vehicles. The law also plans an ID system for vehicles authorized to drive in congestion zones starting as early as 2016 and envisages a report on the possibility of reserving a highway lane to public transport, taxis and very low carbon vehicles.

Furthermore, the energy transition law sets forth a strategy for sustainable development and a 2030 objective of 7 million public and private electric recharge stations. The law also creates a cash bonus for converting from old pollutant vehicles to new or second hand low carbon vehicles. The law provides for a national strategy to reduce atmospheric pollutant emissions by 30<sup>th</sup> of June 2016, and strengthens the technical control of atmospheric pollutants and fine particles emissions.

Some of the proposals of the report were taken into account in this law. Others require prolonged action with multiple contributors. Regional entities will play a crucial role in this area. Many of them are currently starting initiatives to limit city pollution, but also to rationalize car use. Common transportation entities are now in charge of planning intermodal connections between transportation methods. This can be greatly facilitated by remodeling transport stations or building new ones which integrate from the very start the need for multimodal hubs.

Other proposals must be enacted by manufacturers. But remarkably, manufacturers themselves are gradually taking note of changes in transport users' behaviors and consequently are offering new vehicles with one, two, three or four wheels. Their range of products extends to incorporate smaller, lighter vehicles, which take up less space on public roads and parking areas. With the rapid proliferation of electronic and communication equipment within vehicles, new perspectives are now offered, among which the emergence of driverless cars, which will require public authorities to establish new sets of recommendations in the coming years.

The OPECST report, which was written on the basis of numerous hearings, was without a doubt a forerunner.

## **Innovation to feed the world with minimal greenhouse gas emissions**

OPECST has recently studied these topics through multiple public hearings: on environmental research in July 2014, on the seed sector in January 2015 and on Big Data in agriculture in July 2015. Past reports have also covered these issues. This was the case of the report by Mr. Pierre Laffitte and Mr. Claude Saunier from 2006 on scientific and technological contributions to sustainable development, the report by Mr. Gérard Miquel on water quality and sanitation, and especially of Mr. Marcel Deneux's founding report from February 2002 on the assessment of the scale of climate changes by 2025, 2050 and 2100. M. Jean-Yves Le Déaut, Member of the French Parliament, current OPECST President, has, meanwhile, chaired in 2006 a fact-finding mission for the French National Assembly, on the theme « Climate change : the major challenge », for which Mrs. Nathalie Kosciusko-Morizet, later Secretary of State and then French Minister of State for Ecology, was rapporteur.

### 1. On what analyses are based these reports?

Agricultural production techniques are subject to a global « scissors effect » between the huge demographic growth generated by the overall post-war improvement of life conditions, which further increases the number of mouths to feed for several decades, and the growing demand to produce with less greenhouse gas emissions.

Until the 1980s, increased agricultural production was based on increased farm inputs, which led whether directly or indirectly to an increase in greenhouse gas emissions. Today, agriculture must continue to increase production whilst decreasing external inputs of industrial origin. This tension will only be overcome by a number of innovations, probably groundbreaking innovations, for it is the very concept of agriculture as a production process that must be revolutionized to multiply its capacity.

This technological leap will be all the more demanding as three major transformations are now in play and will further increase the tension between food production and demand:

- rising standard of living in developed countries will lead to a demand for a better quality of diet. This will directly translate into increased consumption of meat and dairy, which require more agricultural resources;
- economic and demographic development will mechanically reduce the land available for agriculture;
- climate change will itself reduce production potential due to sea level rise and increased number of extreme weather events.

## 2. What does OPECST propose?

To solve this growing gap between food production and demand, three new approaches seem necessary:

- favoring plants, which naturally require less farm inputs, such as fertilizer or pesticides. This means that progress must be made in genetic selection and research, but also that innovations are required to improve planting combinations. Agricultural equipment will need to be adapted to new land configurations ;
- soil improvement techniques, whether by depollution or desert conquest, in order to counterbalance losses due to increased urbanization. This will inevitably happen through better water recovery and treatment, especially through desalinization techniques ;
- big Data will emerge as a key way to continuously optimize production conditions, through very precise monitoring, both temporal and spatial. This will become essential, in particular to use farm inputs in the most efficient way.

This scissor effect on agricultural production will not hit all continents the same way. Indeed, demographic pressure is unlikely to weigh heavily on western countries, whereas the Indian sub-continent will have to deal with extreme population densities, more than 500 habitants per square kilometer, by 2050. If population density doubles in Africa, huge land surfaces would still be available through desert conquest. In Egypt for example, desert makes up 96% of the country's land. Rebalancing between these different situations will occur through international transactions, which will provide leverage to adaptation requirements.

Europe will trade its surplus in production for a while, but will not indefinitely profit from this global war against hunger and global warming. Indeed, Europe is responsible, through its ecological footprint per capita, of a much greater drain on natural soil resources and water than the global average (4.9 "global" hectares for an average of 1.8). It is therefore in Europe's own interest to take an active role in this new revolution towards intensive and sober agriculture.

A distinction must then be drawn between on the one hand, technological solutions that could mature in developed countries, and then be typically broadcast around the world, and on the other, "frugal" innovations born through engineering required by the specific circumstances of developing countries, and which then go on to win the developed world.

## **Citizens' involvement in the use of smart technologies**

Citizens' involvement was an essential dimension in many topics, long-standing subject for OPECST, dealt in its first report on managing nuclear waste by Mr. Christian Bataille, MP in 1990, or on bioethics by Mr. Frank Serusclat, Senator in 1992. More recently, in 2012, it was an important part of the report by Mrs. Geneviève Fioraso's, MP, on challenges of synthetic biology, or in 2014, of the report by Mrs. Maud Olivier, MP, and Mr. Jean-Pierre Leleux, Senator, on the dissemination of scientific, technical and industrial culture.

Nevertheless, the necessary involvement as part of the fight against the greenhouse effect must not only be an acceptance in principle, but also a personal and tangible mobilisation.

### 1. How can we analyze citizen involvement in relation to innovation in favor of climate change?

The control of CO<sub>2</sub> emissions related to energy demand depends crucially on the behaviors of economic agents. The latter must appropriate innovations in energy consumption, and must favor energy savings and the use of renewable energies.

Such appropriation requires coming up with new ways of mobilizing people, besides fiscal policy and regulation.

In this regard, it appears that all big economic agents, that is, public administration, companies and households, have very different behaviors.

In fact, administrations can only modulate according to hierarchical instructions, on the condition that they are given the financial means to do so in the first place. Companies comply more easily, and some even become proactive, as they seek to adapt their image and communication technique to today's trends. In any case, they have a direct interest in investing in energy savings.

Behavior of households is oftentimes most problematic.

There is no doubt people have taken note of the reality of climate change, in France as in all other developed countries, but actions translating this reality will only follow as long as they are free and occasional. Following recycling guidelines, using one's bike or walking by foot when the weather is nice is a form of progress. But there is a large gap with a behavior where one chooses to systematically change one's investments and consumptions bearing in mind the goal of sustainable development.

Even the wealthiest households, that is, those that have the means to be role models to individual behavior change, still react essentially according to traditional criteria. Typically, buyers of high power cars continue to value an image of power and prestige associated with their purchase, and the vehicle's technological improvements are only a bonus in that decision process. It would be better to be able to count on these wealthy customers to put their purchasing power at the service of deployment, without subsidies, of new eco-friendly engines.

## 2. What could OPECST propose?

To the extent that the trending effects and imitation of the upper classes will have little of a role to play, the middle classes too will only change their consumption and investments in the fight against greenhouse effect, if they are encouraged financially or forced to do so. Thus, it is not surprising that part of the French national debate on energy transition in 2013 focused on the one hand, on the relative merits of increasing grants, and the on other, on establishing new duties.

In fact, in terms of economic flows, both devices appear quite similar. Indeed, it must be considered that all forms of aid are financed by levies. On the one hand, a system of obligations forces households to allocate part of their income to an expenditure that is not in their priorities; on the other, a system of aid confiscates the same amount through taxation, to then restore it to households when they act as desired. In both cases, the result for households is forced allocation of resources.

Yet, any forced allocation functions to the detriment of other sectors of the economy because it drains purchasing power. With these politics based on aid or duties, it is feared that too violent a drain, that is to say, very strong in too short a time, may have counterproductive effects.

In this regard, the report by Mr. Jean-Yves Le Déaut and Mr. Bruno Sido of September 2013 on energy transition recalled the extents of financial masses to mobilize in France to reduce CO2 emissions by a factor 4 by 2050: nearly one trillion euros over three or four decades. These are significant amounts, perfectly in line with those announced in Germany for the success of the *Energiewende*.

It therefore seems reasonable to dedicate aids for the less advantaged households, and also to spread the effort required of middle-class households by relaxing the schedule, so that the latter extends to the second half of the century.

Furthermore, it is essential to improve the field of incitement by adherence: "understand to act", and thus limit forced allocation of resources. This requires education and some form of participation to the decision process. The problem is that all activities are not suitable for this approach due to the complexity of the subject and scattering of those most concerned.

For example, how can we make the general population adhere to building renovation? The field is complex. For example, just looking at thermal regulation, these are not based on directly measurable consumption (heating, hot water, ventilation, air conditioning, lighting) through bills, but on conventional consumptions, melted in the mass of real consumptions and therefore difficult to grasp.

As for the participation in the decision process, this becomes difficult due to centralization of policy drafting. Hence, how can one feel personally and directly concerned if participation is limited to the involvement of representatives of associations in the decision making process? Real participation requires extreme decentralization, reaching every citizen.



# Austria

## Innovation for energy efficiency of buildings

Austria certainly is one of the leading countries in Europe regarding the development of energy efficient buildings. There are large research and dissemination programmes, funding schemes to support energy efficient technologies, active industry networks, a wide range of competent technology providers, as well as a high level of acceptance for energy efficiency in the population. In the last 15 years sustainable innovation in the Austrian building sector has taken place in an astonishing comprehensive and effective way.

Early experiences with energy efficient building technologies date back to the 1970s when privately organized groups started to develop alternative co-housing projects (Rohracher and Ornetzeder 2002). In the 1980s active and passive solar technologies became more popular and a first Passive House was constructed in 1996. Since then the market for ultra low energy buildings has rapidly increased. Statistics show that there were more than 10,000 buildings meeting passive house standard at the end of 2010 (Lang 2010, 33). Per capita, this was more than in any other country of the world. Most of these buildings are newly constructed private single-family houses. Although the passive house standard has mainly been adopted in this sector, other types of buildings such as large residential and office buildings, schools, kindergartens and other public buildings as well as even large industrial buildings have been realised in the last decade (innovative gebäude 2015). Based on these developments, ultra-low energy standards are even met in renovation projects today.

In 1999 the Austrian Ministry of Transport, Innovation and Technology (BMVIT) launched a new research and demonstration programme called “Building of Tomorrow” ([www.hausderzukunft.at](http://www.hausderzukunft.at)). This programme soon became the main innovation driver within the Austrian building sector. It substantially supported the improvement of already known architectural concepts (i.e. the active solar low-energy approach and the Passive House standard) and allowed the development of a broad range of novel building technologies, including facade integrated solar systems, super-insulated windows, ecological building insulation materials, energy efficient ventilation systems or solar cooling systems. Until today, more than 60 demonstration buildings have been supported and evaluated within the framework of “Building of Tomorrow” (BMVITa 2012). In addition to technology-oriented research, the programme also supported the development of social and organizational solutions (e.g. planning procedures and guidelines, business models for energy efficient solutions, models to better integrate users in innovation) and funded social research projects (e.g. post-occupancy research as well as STS and TA studies).

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NB: For precise references, please, contact ITA.

In 2004 the Ministry of the Environment launched the Austrian Climate Initiative (klimaaktiv), which also put much emphasis on energy efficiency and the use of renewable energy sources in the building sector ([www.klimaaktiv.at](http://www.klimaaktiv.at)). Finally, with the establishment of the Climate and Energy Fund in 2007, the conditions for the development and dissemination of energy efficient building technology were once more improved significantly ([www.kimafonds.at](http://www.kimafonds.at)).

Monitoring research shows, that demonstration buildings in the residential sector in most cases are able to meet the projected low energy standards and post-occupancy research report on a high level of user satisfaction (Lechner et al. 2015; Suschek-Berger et al. 2014). To a certain extent the technological achievements in the building sector are reflected in statistical data, too. Final energy consumption for space heating of private households decreased by 21.7 per cent per square meter in the period from 1995 to 2012. Similar reductions could be achieved in office buildings as well as in the public sector (BMFWF 2014, 90ff).

User participation is of major importance in large renovation projects. Several studies have addressed this topic and came up with a number of recommendations to improve the participation of occupants in practice (Tappeiner et al. 2005; Hüttler et al. 2006; Suschek-Berger and Ornetzeder 2006). Empirical research shows that large housing associations in Austria call on many years of experiences regarding renovation projects including well-established forms of communication and participation (Suschek-Berger and Ornetzeder 2010). Basic rights to be involved are even guaranteed by law. However, research also revealed that there is a need to improve and expand existing practices when low-energy standards have to be achieved successfully in the future.

Developments in the last years show that the innovation focus in the building sector has shifted from the building level to the district or settlement level. An indication of this shift is the increasing importance of smart city concepts. Today, large research as well as implementation programmes and projects usually focus on sustainable urban developments (BMVITa 2012). As larger urban developments basically are of political nature, models of citizen participation will play an even more important role in the future.

## **Innovation for transportation and mobility**

Austria is an important location of the automotive supply industry. Manufacturers are concentrated in three regions (Graz, Vienna, Upper Austria) and employ a total of more than 170,000 employees. Main industrial consumer for Austrian products and services is the German automotive industry. Due to a highly skilled workforce the Austrian automotive industry specializes in research and development, including engine and powertrain development, advanced combustion systems, e-drives, hybrid solutions, fuel cells, hydrogen production, etc. In addition, some companies focus also on simulation and testing of new engines and powertrains (Austrian Business Agency 2008).

To better support innovation in the area of advanced propulsion systems and energy carriers the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) founded the Austrian Association for Advanced Propulsion Systems (A3PS) in 2006 ([www.a3ps.at](http://www.a3ps.at)). The same Ministry funds the development of sustainable vehicle technologies (with a focus on alternative propulsion systems, alternative fuels, advanced electronics systems, and lightweight construction) within the framework of a large national mobility research programme (BMVITb 2012). In addition, the Austrian Climate and Energy Fund supports the introduction of e-mobility. Currently, there are seven model regions for e-mobility covering about 1,500 electric vehicles and more than 1,000 charging stations (Klima- und Energiefonds 2015).

However, vehicles with alternative propulsion systems (fuel cell, hybrid or fully electrical vehicles) are still very rare in Austria. Market shares of such vehicles amounted to 1.2% in 2013 respectively to 1.5% in 2014 of newly registered cars (Statistik Austria 2014). However, the domestic market for e-bicycles and e-mopeds is booming. With about 40,000 imported e-bikes in 2012 and high growth rates in the last years is Austria among the most dynamic markets in Europe (Eurostat). Car sharing is quite popular in larger cities. According to data from 2009 Austria is among the leading countries in Europe (Bundesverband Carsharing). It remains to be seen whether these offers actually reduce traffic and car ownership or whether car sharers have additional private cars or have been using public transport before.

The Austrian Academy of Sciences has a special commission on sustainable mobility, which recently issued a discussion paper on the socio-economic aspects of the transition to sustainable mobility systems (Chaloupka et al. 2015). The paper points to a number of barriers that make changes to more sustainable mobility behaviours difficult. Among them the paper highlights inadequate land use regulation that favours urban sprawl and prolongs daily routes; lacking cost transparency and mechanisms to internalise external costs of conventional transport systems; discrimination of bicycles, pedestrians, and public transport in road traffic regulations; etc. To influence mobility behaviour effectively the expert group recommends strategies like target specific awareness raising activities via public relations or mobility counselling. In addition an index for sustainable mobility development and a clearinghouse for mobility data management, participatory planning procedures, and interdisciplinary research to promote social innovations is needed.

The Academy paper argues that also in a sustainable mobility future there will be a mix of various transport means, including public and semi-public transport, individual motor car traffic, non-motorised vehicles, car-sharing in various forms, pedestrians, etc. From a sustainability perspective, motorcar traffic is not per se bad; it all depends on the circumstances, the technologies, and usage modes. While an urban area may need only 10-20 % car traffic (e.g. for ambulances, taxis) and go along with other forms of transportation, this is much different in rural areas, where a share of 55 % seems to be the optimum (currently it is of 90 % in the countryside). Therefore, it is argued that a future optimal transportation mix is a difficult construct. E-mobility will play a role, as well as alternative mobility concepts (car-sharing, etc.), and modern ICT will part of the solution.

Although Austria is among the leading countries regarding the use of public transport (Eurostat 2015), experts say that the full potential has not been reached so far; and this is even more true for riding bicycle and walking. In cities like Vienna a mix of 20 % bicycling, 30 % walking, 40 % public transport, and 10 % cars may be desirable as well as feasible in the future (Magistrat der Stadt Wien 2009).

## **Innovation to feed the world with minimal greenhouse gas emissions**

Austria is well known for its leading role in organic farming. While in Europe on average only 2.5 per cent of the farmland is organic with a share of nearly 20 per cent Austria is on second place behind Liechtenstein (Willer and Lernoud 2015, 23). This development is a consequence of early pioneering work of individual farmers, highly committed supermarket chains that started with organic product lines already in the 1990, and an ambitious organic action programme of the responsible Ministry, which promotes the greening of the small-scale farming in Austria since 2001 (Eder 2006).

However, a high share of organic farming does not mean lower greenhouse gas emissions in any case but according to a recently published meta-analysis organic farming practices have positive impacts on the environment in general (Tuomisto et al. 2012). In addition, recent research suggests that organic farming even could play an important role in saving world hunger (Ponisio et al. 2014). According to this study organic production may easily reach conventional productivity levels by using certain diversification methods (i.e. multi-cropping and crop rotations).

Drawing on this kind of knowledge and expertise most research activities in Austria focus on the potential of organic farming to combat hunger and climate change. One of the main players in this field is the Centre for Development Research (CDR) at the University for Natural Resources and Life Sciences (BOKU) in Vienna. Research at CDR typically is carried out within international networks; aiming at scientific and practical outcomes at the same time. Current projects at CDR include topics like carbon storage and soil biodiversity, food security and climate adaptation through soil and water conservation, resilient and profitable rural livelihood systems in Africa or adaptive small scale farming systems in in Bangladesh, India and Nepal. Participation of local people in target countries is a constitutive part in almost all of these research activities.

Innovation regarding food chain efficiency is another important topic in this area. Based on a report for STOA, the ITA recently issued a policy brief discussing options for reducing food waste in Austria (Gudowsky and Torgersen 2015) – which would be a contribution to reduce production and hence related greenhouse gas emissions. Roughly one third of all food produced for human consumption is wasted within the Austrian food chain. Farmers, manufacturers, retailers, and food service operators (e.g. hotels, restaurants, hospitals) all contribute to the extent of waste in Austria: more than 260 kg per capita and year. At least half of this waste could be avoided. Avoidable causes include overproduction, improper packaging and storage, or misleading expiry date labelling. In Europe, each ton of wasted

food generates almost two tons of greenhouse gas emissions. Here, there are several promising options for social, regulatory and technological innovations that would reduce food waste, save resources and therefore lower agricultural greenhouse gas emissions.

Reviewing current food safety regulations could identify provisions that are not mandatory with regard to protecting human health, but would otherwise cause a lot of waste. Another measure is to amend marketing standards focussing on external appearance towards consumption quality: taste, natural purity, nutritional value, and growing conditions. Furthermore, facilitating alternative marketing channels for fruit and vegetables not meeting marketing standards would reduce waste as well as shorten transport distances, e.g. farmers' markets, producer co-operatives, solidarity purchasing groups or community-supported agriculture. Also, improving food date labelling could help to reduce confusion between 'best before' and 'use by'. 'Best before' should reflect the true shelf life of products. Abolishing expiration dates for stable products is another option.

On the technological side, measures are mostly aimed at increasing efficiency, e.g. intelligent ordering systems or RFID technology, which is used to, amongst other things, collect temperature data during transport. Other 'intelligent' technologies promise to reduce food waste at different levels of the food chain, i.e. packaging labels, refrigerators, supermarket trolleys, or waste bins. Nevertheless, they are currently only being developed. It is uncertain as to how much they can contribute to solving the problem and whether they cause any side or rebound effects.

## **Citizens' involvement in the use of smart technologies**

Involvement of citizens in research and demonstration projects on smart technologies became quite popular in recent years. A status-report from 2010 on smart grid research in Austria listed eleven projects that explicitly aimed to involve end-users in their research activities (Schauer 2010). While in those early projects users usually had been involved in a selected way using classical forms of participation (i.e. focus groups, interviews, workshops) more recently citizens play an even more important role. Examples are large smart meter field trials (Seebauer et al. 2013) or integrated smart grid model villages (Salzburg AG 2013).

In one of the smart meter field trials it was investigated to what extent, and by which measures, smart meters would allow for a cut in electricity consumption in private households. 250 Austrian households were able to gain experience with smart meters in a year-long field trial. On average, these households reduced their electricity consumption by around five per cent. Consequently, the results are similar to comparable international field trials, which identified savings between 3 and 10 per cent. Smart metering, however, only led to a reduction in energy consumption when combined with comprehensive information and visualization (Ornetzeder 2014).

In the small village of Köstendorf the local energy provider (Salzburg AG) runs a demonstration project to learn more about the interplay of PV systems, electric cars and

household consumption dynamics and how to control the low-voltage grid under real world conditions. PV systems on 40 buildings and 36 electric vehicles are involved in this field test (Salzburg AG 2013). A similar project has been launched in Upper Austria, involving 37 privately owned PV systems (Abart 2012). However, results from these projects are not available yet.

Another line of research focuses on smart devices as means of participation in collective awareness raising and behaviour change initiatives to fight climate change. As stated in a recent national report, the problem pressure and need for action in Austria is especially high: “The achievement of the 2050 targets only appears likely with a paradigm shift in the prevailing consumption and behaviour patterns and in the traditional short-term oriented policies and decision-making processes (...).” (APCC 2014, 53). The international research project “*e2democracy*” studied a set of seven largely identically organised (e-)participation processes at local level in Austria, Germany and Spain (Aichholzer et al. 2013). Unique features were the long-term monitoring of a combination of several intervention approaches (informational, collaborative, learning- and community-based) and the coverage of direct as well as indirect emissions at individual and collective level. Citizen panels were collaborating with local governments over up to two years (in the period 2010 to 2012) aiming to reduce CO<sub>2</sub> emissions by at least 2 % per year. Participants used a CO<sub>2</sub> calculator for bi-monthly individual consumption monitoring and feedback of CO<sub>2</sub> footprints with free choice of participation mode, via traditional means or via e-participation. The study showed that local community based participation approaches in combination with individual eco-feedback can foster sustainable behaviour and local climate protection. The majority of participants reduced their CO<sub>2</sub> emissions by at least 2% per year. However, to provide appropriate choice options at individual level, it is crucial to create framework conditions that enable and facilitate alternative courses of action in various areas of life – from climate-friendly transport options to pro-climate choices in energy supply and nutrition. The e-participation option clearly increases participation readiness (around two thirds of the participants are “onliners”). Hence, the most important effect of the e-participation opportunity is to extend the participation rate. E-participation is not a panacea as on-liners do not differ from off-liners in terms of the effects achieved. However, in view of the high problem pressure and need for action to reduce greenhouse gas emissions in Austria integrated approaches building on the support of smart technologies are indispensable.

# Catalonia

## **Introduction: Catalan climate policy**

Catalonia is aware that the Mediterranean area is one of the regions of the European Union where the most significant impacts of climate change are expected. The 2012-2020 Plan for Energy and Climate Change is the roadmap that the Government of Catalonia has designed to respond to these challenges and to meet the EU objectives on energy and climate change. The aim is to achieve an economy and society of low energy intensity and low carbon emissions that is innovative, competitive and sustainable in the medium and long term. This is the first time that Catalonia has addressed energy and climate policies together and in a coordinated fashion. The plan establishes the lines of work and the priorities for reducing energy consumption by 20%, increasing the proportion of renewable energy to 20% and reducing CO2 emissions of the energy cycle by 25%, in line with the EU's 20-20-20 target.

## **Innovation for energy efficiency of buildings**

Buildings are points of intensive energy consumption through their use of heating, air conditioning and lighting. In Catalonia, only 7% of the building stock was built after the entry into force of the sectoral regulations on energy saving and efficiency and over 60% was built before 1980. Taken together, these factors indicate that building construction is a field with great potential for energy saving and efficiency, and that much of the effort should focus on energy rehabilitation of existing buildings.

New buildings must include energy optimization criteria in the design and choice of materials. In the rehabilitation of existing buildings, on the other hand, improvements in energy efficiency can be achieved by introducing integrated management systems through new information technologies, by working on the building envelope to improve its thermal behaviour, or by using soft measures such as replacement. The Government of Catalonia offers a line of grants for rehabilitating and controlling buildings: grants for rehabilitating empty buildings, Technical Inspection of Buildings (ITE) to obtain the Certificate of Building Fitness, grants for rehabilitating residential buildings, grants for renovation work inside dwellings for senior citizens, and grants for improving accessibility in public housing neighborhoods.

Renewable energies will be an essential element for increasing self-production of electricity by consumers towards the so-called "net balance": users generate the electricity they consume and use the network as a warehouse for storing surplus power and retrieving it when they need it, until they reach a balance at the end of a long period. In fact, estimates suggest that in a few years the price of generating one's own energy will be the same as the price of energy from the grid (a point known as "grid parity").

This scenario requires the widespread installation of small renewable energy systems in the home (mainly photovoltaic panels but also small wind turbines, etc.). The Government of Catalonia has already begun work towards the establishment of a legal framework in the Spanish State to regulate this electricity supply model, because under current regulations self-consumption is not compatible with supplying the grid. In addition to the net balance, there are other ways of bringing renewable energy to the domestic sphere. Biomass is a renewable and independent source of heating and hot water with a payback period of less than five years if a fuel oil or gas boiler is replaced after 10 years. Solar thermal energy is another renewable source of hot water and heating but it usually requires the support of a conventional boiler. Though all these technologies have applications for both single- and multi-family dwellings, the payback period is shorter in the latter because of the scale of the installations. The goal is for the buildings in Catalonia to move towards energy self-sufficiency in the long term, with the electricity and gas grids as a fall-back system

The Construction Technology Institute of Catalonia (ITeC), which forms part of the European Organisation for Technical Assessment in the area of construction products (EOTA), is an agency of the Government of Catalonia authorized to evaluate products without standards and innovative products as a Technical Assessment Body in the framework of EU Regulation 305/2011.

## **Innovation for transportation and mobility**

The transport sector is the main end consumer of energy in Catalonia because it absorbs nearly 40% of the total. In addition, 97% of the energy consumed by this sector comes from oil or its derivatives, involving a high level of polluting emissions. It is therefore a priority area for implementing savings and efficiency measures.

There are several lines of energy saving in the transport sector. One of them is to diversify the energy used by promoting the transition from conventional internal combustion engines to more efficient vehicles, such as electric ones, and by promoting more efficient or renewable fuels such as LPG and biofuel.

Progress must also be made in rationalizing the demand for mobility and transport: making as few journeys as possible, using the most appropriate means, and exploiting intermodality between different modes of transport. Another area with a wide margin for improvement is the efficiency of the current fleet of vehicles. Fleet management systems can be used to optimize routes, and efficient driving techniques can save up to 20% of fuel.

Biofuels are the main way to introduce renewable energy in the transport sector. In addition to the biofuels that are currently used, the Energy Plan mentions the need for research into second generation biofuels, i.e. those made from non-food raw materials. These new biofuels would avoid undesired effects such as environmental sustainability issues, competition with food uses and higher food prices. The aim is that these biofuels will be used by 2020. In



Catalonia, the Catalan Institute for Energy Research (IREC) has a group undertaking research in this field at its laboratory in Tarragona.

## **Innovation to feed the world with minimal greenhouse gas emissions**

The productivity of the crops cultivated in the Mediterranean is limited by the environmental conditions. However, it is improved by agronomic methods and systems based on genetic and ecophysiological knowledge of the species cultivated and the places where they grow (soil, climate, social structure, etc.). Climate change and an annual increase in the variability of the agricultural sector will lead to an increase in problems and risks. It is interesting to note that the sector contributed 8.1% of the total emission of greenhouse gases in Catalonia, a similar percentage to that of industry.

The following measures have been proposed to adapt crops to the current phase of climate change and allow them to act as carbon sinks: (a) adapting plant material to the intended destination and use, taking into account its ecophysiological characteristics (resistance to drought, extreme temperatures, salinity, pollution, relations with other organisms, etc.); (b) increasing agricultural biodiversity; (c) improving water storage and soil fertility; (d) increasing the efficiency of water use through methods and systems that integrate our needs as users with the availability of plant material and water, such as sensors to aid agronomic decision making (precision agriculture) and the use of reclaimed water; (e) valuing agricultural practices as a component of the landscape, and therefore accepting that all actions taken from inside and outside affect trophic networks positively or negatively; (f) considering that agricultural demands will be at the regional level, but they will be greatly affected by globalization and increasing population. These problems must be solved politically, through the development of social norms (insurance, subsidies, guaranteed prices for production, water and energy, etc.) and the rational regulation of the prices and ownership of land and water. Incentives must be provided for the management of crops as major water regulators and carbon sinks.

In June 2015 the Parliament of Catalonia approved a resolution urging the Government of Catalonia to “Promote and fund organic farming to reduce the growing emissions from the agricultural sector and have a positive impact to mitigate them”.

## **Citizens’ involvement in the use of smart technologies**

Catalonia is drafting a law on climate change and has called on public participation through an online survey.

In addition to this experience, civil society shows a high level of involvement in relation to climate change. Catalonia has many municipalities that form part of the European Covenant

of Mayors and more than 180 Catalan municipalities (7% of the European total) are already carrying out energy efficiency plans.

The Catalan Office for Climate Change promotes and supports the establishment of voluntary agreements with Catalan organizations, entities and groups for the reduction of greenhouse gas emissions. More than 60 organizations have joined the voluntary agreements programme in just over a year and a half. Most of the measures undertaken by these organizations involve the reduction of energy consumption. They include a wide range of activities such as improving lighting, heating and air conditioning, replacing cars with more efficient ones, purchasing hybrid vehicles (which in some cases now account for 17% of the fleet), organizing efficient driving courses, car sharing among employees, and innovative measures for reducing mobility by implementing telework and rationalizing working hours. The participating organizations are clear evidence that a good standard of living is compatible with reducing energy consumption.

Finally, it should also be noted that in June 2015 the Parliament of Catalonia approved a resolution urging the Government of Catalonia to “Continue implementing education on climate change in schools and among the public and to implement an effective information campaign on climate change, its causes and consequences, the scientific basis and measures to be taken to mitigate it”.

## **Conclusion**

Saving and energy efficiency policies will be key to ensuring the achievement of a sustainable energy system.

Renewable energies are a strategic option for the present and future.

It is possible to decouple GDP from energy consumption, as long as energy is used intelligently and sensibly.

The R&D effort in new energy technologies must be increased.

The energy sector must be strengthened as an opportunity to grow economically and create skilled labour. Electric mobility and construction are two of the main areas that can lead to the creation of new business initiatives.

It is necessary to involve civil society in the construction of the new energy model of Catalonia through training, participation and the inclusion of economically disadvantaged social sectors.

# Denmark

Before the first energy crisis in the 1970'es Denmark had a very inefficient energy system, and innovation - in buildings, transportation, food production or in anything connected to energy production and consumption for that matter - did not at all focus on the energy dimension. The two energy crises in the 1970's changed that dramatically. For Denmark the first crisis was a real shock. Denmark was nearly totally dependent upon import of energy, not the least for heating in the wintertime as a temperate climate zone country. The population, industry and commerce were therefore hard struck by the restrictions during the crisis. This ended up in strong policymaking in order to avoid the repetition of the shock.

The policies in the years after the crisis touched upon all elements covered by this green book, plus some extra important features of which the following were very important:

- Denmark invested in a gas infrastructure over time covering all towns in Denmark. The infrastructure includes 19.000 km gas distribution tubes<sup>1</sup>
- The gas came from the North Sea, and Denmark became a net exporter of gas and oil
- The energy production was changed into gas fired combined power and heat production, including small scale combined installations for small communities
- A distribution system for district heat was established covering all major cities
- Incentives for insulating houses were made resulting in a huge wave of energy renovation to increased standards
- Voluntary agreements were made with producers and resellers of household appliances resulting in a labelling system for energy efficiency
- Green taxation of gasoline, cars and other consumer goods with large energy footprints was increased/introduced, resulting in high price levels as compared to other European countries
- Incentives for innovation in the energy system were made, including subsidies for wind power

These policies resulted in Denmark “un-coupling” the relation between economic growth and energy consumption growth. The energy consumption became stabile even under times of large economic growth. This has resulted in an estimated net income from the energy policy of 50 billion DKK/year – 1.300 Euro/capita/year – or, as Henrik Lund, energy economist at Aalborg University has put it “this has paid for the Danish education system”.

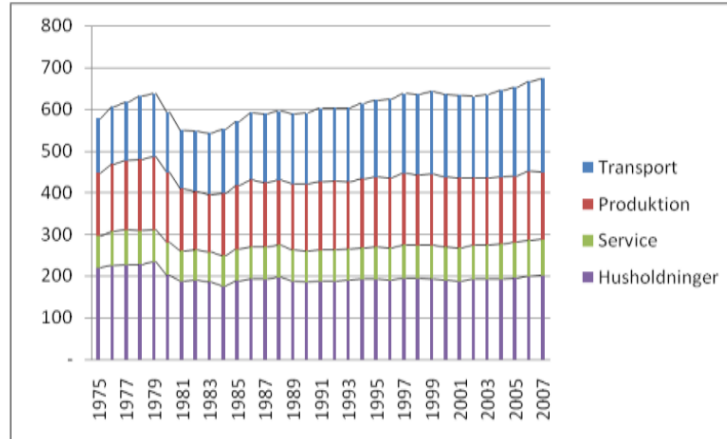
The figure above<sup>2</sup> shows the final energy consumption (that is, excluding losses in the energy production industry) from 1975 to 2007. It shows a stable consumption in all sectors except

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<sup>1</sup> [http://www.naturgasfakta.dk/copy\\_of\\_miljoekrav-til-energianlaeg/naturgasnettet-i-danmark](http://www.naturgasfakta.dk/copy_of_miljoekrav-til-energianlaeg/naturgasnettet-i-danmark)

for the transport sector in which there was some growth in the consumption. The reduction in 1979 is due to political decisions after the second oil crisis 1979. Despite a doubling of the GNP in the shown period the energy consumption has largely been stable.

Figur 2.2: Endeligt energiforbrug fordelt på sektorer i DK.(PJ)



Kilde: /6/

The energy policy in Denmark has steadily followed up upon the policies established after the first and second energy crisis. Denmark has a 35% sustainable energy target for 2020 and a 50% target for wind power alone and these will be reached. The CO2 target for 2020 is a 40% reduction, and a 100% reduction for 2050. If these targets will be fully fulfilled is being intensely debated these years, though.

The fossil energy production in the North Sea has peaked and the income of gas/oil export is decreasing. Danish energy policy is therefore focussed on avoiding net import of energy, lowering the carbon-footprint and continuing the Danish industrial success in the energy sector and in energy efficiency in other industrial sectors.

## Innovation for energy efficiency of buildings

As part of the un-coupling policies Denmark has made several very important steps towards energy efficiency in buildings. Incentives were made in the 70'es for energy renovation, which resulted in a large wave of activity, resulting in a generally high standard of energy efficiency in Danish buildings. These policies also helped innovation in the sector. These were the times when companies like Velux (flexible, highly insulated roof-top windows), Rockwool (stone-based insulation materials), Grundfoss (high-tech energy efficient pumps) and Danfoss (house heating control solutions) had their highest growth and established themselves as important global companies, based on highly innovative solutions.

<sup>2</sup> EA Energianalyse A/S, Evaluering af samtlige danske energispareaktiviteter, December 2008

Although Danish buildings had a very good standard when looking a decade back the standard is not good enough when we look thirty years ahead, at which time we are to reach a 100% CO<sub>2</sub> reduction target. Energy efficiency of buildings is therefore still an important policy aim.

New buildings are being built with the needed standards. The concepts for making “zero energy houses” are in place and the total economy of such investments is positive. The development in this area in Denmark is much comparable to the ones described in the chapter from Austria, though the incentives have been weaker and later than in Austria. There is a positive development in the amount of new zero-energy buildings being built. But new buildings only represent a minor part of the mass of buildings, so in the long term this is a needed development but with a 20-30 years view this will not make the needed change in the total energy standard of Danish buildings.

The challenge is, thus, to increase the efficiency in the old buildings. And this challenge is huge. Calculations have been made showing that large parts of the Danish building mass will lose value, so that they will be un-sellable if they are not energy renovated. This represents a problem for the house owners, but not only, since the Danish financing of houses are based on a bond-emission system, which means that the Danish economy can be drawn down by large losses of value in the building sector.

The means to reach a higher standard in the old buildings are manifold and of very different character. All involve innovation – but mostly social and political innovation – not so much technical innovation.

For very old buildings, many of them protected by conservation acts, it is not possible to make use of energy renovation, since that would reduce the historic value of the buildings, which would not be allowed. These buildings will be more and more expensive to heat up, which will reduce the attractiveness for buyers, and they will become an increasingly large problem for the energy conservation policies. The energy labelling of such houses reflects this problem and innovations that could be made are much about increasing the energy labelling without making change to the physical house. Solutions may be found in connecting local/private investments in sustainable energy production to the registration number of the house, so that the net energy consumption of the number is being reduced. In other words, owners of such houses could voluntarily attach a duty to privately fund a certain amount of sustainable energy production to the house number, which compares to the energy consumption of the house, resulting in a net zero energy consumption from the total investment in the house. This would demand new legislation in Denmark, which would favour private energy production against the large scale commercial energy production, since the privately consumed energy under this regime would not be taxed (because it would need to get status as energy conservation rather than energy production). This is probably the reason that such an innovation has not been implemented yet.

For individual buildings 30-50 years old – that is, buildings made during or after the energy crises – the problem often is that they have a much too low energy insulation standard, but it often costs more to make the needed energy renovation than to tear down the house and build

a new one – except for a fraction of these houses, which have a high architectural value. This represents a problem in many ways. One of the biggest may be that houses, which lose value, are being bought by people with low income, resulting in very large areas – and sometimes whole suburbs or towns – lose social status and to some extent develops into ghettos. Being proactive and avoid the loss of status is therefore very important, and that has something to do with energy/building policies, but not only.

One case of such a development has been the town near Copenhagen, Stenlille. Stenlille was expanded heavily during the 70-80'es and the standard of the houses energy-wise, but also in architectural terms, do not live up to the demands of today. Stenlille lost social status and social life was suffering, youth gangs were beginning to be formed, and the resourceful inhabitants to move away. The municipality therefore in 2012 initiated a process to increase the value of Stenlille, which included investments in public participation activities, social life, refurbishing the elderly care services and a general remake of the public space in the town. The results were positive, since Stenlille now is becoming more attractive, meaning that resourceful people move in, who have the economy to energy renovate the houses or build new houses. Stenlille is an example of the problems that many municipalities are struggling with, which demand mainly social/political innovation, but have a very large impact on the future energy consumption.

For the very large mass of buildings in the larger towns/cities in Denmark classical energy renovation is possible and often can be made so that it increases the visual and usability qualities of the houses. Such renovation often includes a new highly insulated roof, new windows, exterior insulation of the walls and updating the heating system equipment. For most houses this can increase the standards to what will be needed long-term. The problems to be faced in that process are connected to a) economic incentives, which is a political problem, and b) to the re-education of engineers, architects, building workers and investors and house owners. In technical terms it is recognised that the techniques to make effective energy renovation are at hand. Not to say that they cannot be improved, but the need for other measures is much higher.

In 2008 Teknologirådet, The Danish Board of Technology, gathered actors in the building sector to evaluate the Danish policies and suggest actions to improve the energy-efficiency of buildings<sup>3</sup>. The report states that a yearly replacement of 1% of the buildings with new buildings, total energy renovation of 2% of the buildings and moderate renovation of 1% in total would result in 80% reduction of the energy consumption from buildings after 25 years. This would give a net energy saving of 50 billion DKK/year (~8.000 DKK/capita ~1.000 euro/capita/year) and 10 million ton CO<sub>2</sub> (or, yet another “pay for the Danish education system”). But even more important it would keep or increase the value of the buildings. The sector pointed at incentives, education, high standards in the building directives, and the public buildings being in the front of the development as the main needed initiatives.

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<sup>3</sup> <http://www.tekno.dk/wp-content/uploads/2015/01/nummer255.pdf> (in Danish only)

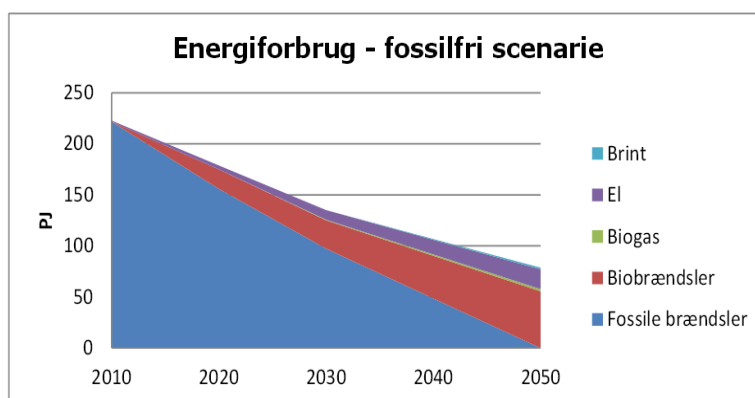
## Innovation for transportation and mobility

Although Denmark has a relatively large industrial B2B production of parts and components for the automobile industry this chapter will focus on the innovation areas in which Denmark has a leading position and a clear industrial role to play (expecting that the automobile industry will be covered by the car-producing countries).

There is no doubt that the transport sector will be important – and probably even the most important – sector to make innovation in if the national and global targets for CO<sub>2</sub> reduction are to be met. The reason is that the technologies for turning most other sectors into sustainable electricity consumption instead of fossil fuel consumption are available. That is not yet true for most of the transport sector.

The main possibility for Denmark to contribute to and make industrial development on top of innovation is in the development of biofuel producing technology<sup>4</sup>. Danish industrial production of enzymes is at the front edge technically and Danish research in this field is in the absolute global elite.

In 2012 The Danish Board of Technology published a report on scenarios for transformation of the transport system into zero-emission of CO<sub>2</sub><sup>5</sup>. The study clearly showed that biofuels will be important because they must be regarded as the primary non-fossil fuel for air, ship and long distance lorry transportation. All other forms of transportation must be expected to use electric drive 25 years ahead, which can be accommodated by the development into a 100% sustainable energy production system.



Figur 27 Transportdrivmidler 2010-2050, Fossilfrit scenarie

The availability of biomass is the limiting factor, though. It is generally accepted among experts that Danish harvest of biomass could be doubled to 200 PJ over the next 20 years. If the need for biomass in the transport sector is to be covered (air, ships, lorries only) this would take up roughly 75 PJ, which leaves only little biomass for other energy purposes left, since the rest is used by the agricultural sector itself. Therefore, innovation for effective

<sup>4</sup> Analysis of the potential for commerce of green transition of the transport sector (in Danish) : Analyse af erhvervsmæssige potentialer ved grøn omstilling af transportsektoren; udarbejdet for Energistyrelsen, DAMVAD 2014.

<sup>5</sup> Danish transport without coal and oil (in Danish), Teknologirådet 2012. [http://www.tekno.dk/wp-content/uploads/2014/12/p12\\_Dansk\\_transport\\_uden\\_kul\\_og\\_olie\\_hvordan.pdf](http://www.tekno.dk/wp-content/uploads/2014/12/p12_Dansk_transport_uden_kul_og_olie_hvordan.pdf)

production and transformation of biomass will be crucial. The figure, from the report, to the left shows the composition of energy sources in a 100% sustainable energy transport system. Although most of the transport will be using electricity (purple) the effectiveness of electric motors results in relatively low energy consumption from this part of the transport. Biofuels (red), on the contrary, are rather ineffective fuels because of the loss in the transformation of biomass to biofuels and because of the ineffective combustion motor. Biofuels must, accordingly, be seen as a highly important innovation field in order to increase the effectivity “from yield to wheel”.

Danish biomass for biofuel production is for now only consisting of straw from cereal production. This is not optimal because the availability is dictated by the factors determining the production of cereals, and because cereals have a short growth season. One major step forward is regarded to be a shift from straw to a combination of grass and nitrogen-capturing plants<sup>6</sup>. These are plants that grow all year round, so-called “green fields”, can be harvested multiple time per year, can create their own main fertilizers and can be used for multiple industrial purposes before they end in the biofuel refinery – and even after.

A report by the Danish Board of Technology, made for the Ministry of Commerce in 2009 on biofuel production in Denmark<sup>7</sup>, showed that the economy of biofuels would be dependent upon the business cases for high-value side productions, such as valuable fibres, enzymes, chemicals and nutrients, because the production price of the biofuel alone could not be expected to be able to compete with electricity or, on a free market, fossil fuels. The future will, thus, not bring us biofuel refineries, but rather multi-purpose biorefineries, which must be said to fit well into the visions of a future bioeconomy.

Some other areas which have been pointed out as innovation fields in which Denmark plays and could play an important role in increasing the energy efficiency of the transport sector are<sup>8</sup>:

- Friction reducing paint for ships: Denmark has a strong actor in Hempel ship painting.
- Logistics: Danish shipping industry is among the worlds’ largest and highly innovative.
- Friction reducing asphalt: Denmark has been in front in this area
- Smart traffic systems: Highly innovative ICT sector and relatively strong traffic research.

Other innovation areas, mentioned in the DBT report are:

- Avoiding traffic work by innovation in ICT collaboration systems and video-conferencing

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<sup>6</sup> Prof. Lene Lange, Aalborg University. Personal communication.

<sup>7</sup> White book on perspectives fo biofuels in Denmark (in Danish): Hvidbog om perspektiver for biobrændstoffer i Danmark, Teknologirådet 2009.

<sup>8</sup> Reference 4

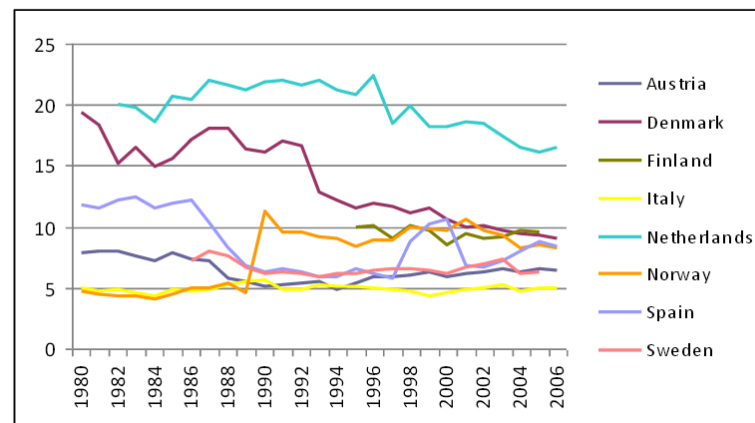


- Smart town planning to make mobility streams “move in both directions” at peak hours, thereby making better use of public transportation capacity
- Increased innovation in 2- and 3-wheeled electric vehicles to reduce the use of heavier vehicles

## Innovation to feed the world with minimal greenhouse gas emissions

Danish agriculture is highly intensive, based on strong agricultural research, but also very energy consuming. So, Denmark can hardly lead the way for other countries with regard to low CO<sub>2</sub> emission from agriculture. The following figure shows the development in energy intensity in agriculture of eight European countries 1980 to 2006. Except for Netherland, which has much greenhouse production, Denmark is the highest energy consumer per euro produced in agriculture<sup>9</sup>.

Figur 3.22: Energiintensitet, landbrug, (MJ/euro, 2000-priser).



This, on the other hand, leaves a lot to do on improvement. The Danish Ministry for Climate, Environment and Foods in 2009 published a report on 15 measures for reduction of CO<sub>2</sub> from agricultural production<sup>10</sup>. The four most effective measures, which covered 75% of the effect from the total of the measures, were:

- Manure being used for biogas
- Production of wood chips of willow on marginal/poor soils
- Straw for combined heat and power
- Closing agriculture production on wet farmland

<sup>9</sup> Reference 2

<sup>10</sup> Agriculture and Climate (In Danish) : Landbrug og klima, 2009 : <http://mfvm.dk/foedevare/indsatsomraader/klima/rapport-om-landbrug-og-klima/>

Many of the 15 measures could be subjects to innovation. Biogas is not yet a perfect technology; Yields of energy crops are not overwhelming; Straw for combined heat and power is a very low-value use of a material, which may be used for high-value biorefinery production before it ends in the boiler; and invention of low-impact production systems on wetlands could help not only Danish farmers but farmers in many parts of the world.

The report on a 100% sustainable transport system also touched upon the energy consumption in agricultural machines. Around 10% of the total Danish energy for transport is used by agriculture and the potential for innovation in energy efficiency of the machines and for less mechanical treatment of the soil is big.

Organic agriculture has traditionally been seen as having smaller environmental footprint than industrial agriculture. This picture is not necessarily true when it comes to greenhouse gas production because of the dependency on animals for fertiliser production. Methane from animals has a large greenhouse effect, whereas industrial fertilizers in principle can be produced from sustainable energy sources. The innovation potential in organic agriculture is still large and one of the obvious areas for innovation, as seen from a carbon footprint point of view, is sustainable fertilizer production.

The Danish landscape is under pressure from many sides. There are many policies for land-use in Denmark, and put together they use the Danish square-kilometres 140%<sup>11</sup>. Main sources of this over-expectation of what Danish land can be used for are the plans of establishing forest; climate adaptation strategies; loss of land because of climate change; and the continuous expansion of the cities. This development has called for new and innovative ways of using land, including agroforestry, city-farms, and moving animal farms into industrial areas – all fields of practice, which are being researched and innovated on in all corners of the world. Danish agricultural research has not yet taken this challenge up but could probably play an important role if it did so.

## **Citizens' involvement in the use of smart technologies**

The Danish tradition for citizen involvement in innovation is quite strong. Since the upcoming development of the internet a huge multitude of ICT development projects have used different technologies and methods for evaluation of consumer reactions, usability, user behaviour etc. It seems however, that this tradition has not really been rooted in the development and implementation of the energy transition.

It is a well-known fact among energy specialists in Denmark that the needed energy transition is possible with the technologies we have today and the development rates we see in them – transportation maybe being the exception from the rule. The challenge for innovation and

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<sup>11</sup> Analysis of existing policies for Danish land-use : <http://www.tekno.dk/article/baggrund-og-forloeb-i-danmarks-areal-i-fremtiden/>

implementation is therefore not to be found in the lack of technologies, but rather in the uptake of the technologies.

The important questions for research and innovation seem therefore to be of the kind like:

- What can make consumers buy the energy-effective consumer goods?
- How can consumers be nudged to eat less meat?
- Which incentives can make private house-owners invest in decentral sustainable energy production?
- How can a large part of the population be brought to a high competence level with regard to energy consumption behaviour, energy conservation investments, etc?

The answers to this kind of questions are ‘smart’ in another sense of the word than ‘technologically smart’. They can only be made through deep involvement of the citizens, so that policy-makers can be sure of the positive effects if the solutions will be implemented.

The case of Stenlille described above is another example of the importance of involving the citizens in the process of transformation of the built environment towards better energy standards. Many towns in Europe are struggling with depression resulting in little investments in the houses and their energy performance. Local empowerment and education seems to be central means – if not the only means – for solving such questions. The social innovations needed to make that happen in large scale have not really been made yet or experimented with in large scale, but would certainly have a large impact if they were.

In the transport sector we witness another problem, which only can be met by deep interaction with the citizens. We all know that increasing the private transport instead of the public transport will result in increased CO<sub>2</sub> emissions, but that does not change our behaviour – neither as consumers, voters nor as decision-makers. The innovations that could truly make a difference in the transport sector are probably social/political innovations, which will make it easy and comfortable to change behaviour. One example of such innovations could be a common payment system for private car taxes and public transportation, so that the extra price of using public transportation when you already have paid for your car is reduced. However, without knowing quite surely how the citizens will react on such measures, decision-makers will hardly take steps towards implementing them. Public participation is certainly a way forward for getting knowledge about how different policy measures will be received.

In general there is another consensus among energy specialists, that the participation of citizens in the energy transition is not enough to meet the challenges – but the challenges cannot be met without the participation of the citizens.

# Finland

## Innovation for energy efficiency of buildings

There are various policies to increase energy efficiency in buildings in Finland. They include the building code for both new and existing buildings; energy labelling; financial support for housing companies and households; R&D&D; information and training; and energy taxes. The measures also facilitate innovation through increasing demand; e.g. tightening the building code has forced construction companies to find commercially attractive ways to build passive houses.

There have been various R&D&D programmes on low-carbon buildings. Examples from recent years include

- FInZEB: building a national consensus with stakeholders on near zero energy houses to implement the EPBD in the Finnish context ([finzeb.fi](http://finzeb.fi)) ;
- GUGLE: increasing the energy performance of an aging neighbourhood near the city centre in Tampere ([eu-gugle.eu/fi/pilot-cities-4/tampere](http://eu-gugle.eu/fi/pilot-cities-4/tampere)) ;
- SubUrbanLab: engaging with residents to cut energy use in rental apartment buildings ([suburbanlab.eu/living-labs](http://suburbanlab.eu/living-labs)) ;
- Renzero: piloting the energy renovation of an old single-family house ([renzero.fi](http://renzero.fi))
- MECOREN: developing methods and concepts for sustainable renovation ([vtt.fi/sites/mecoren/en](http://vtt.fi/sites/mecoren/en)) ;
- FRAME: ensuring moisture control in energy efficient construction ([tut.fi/en/about-tut/departments/civil-engineering/research/structural-engineering/building-physics/frame/index.htm](http://tut.fi/en/about-tut/departments/civil-engineering/research/structural-engineering/building-physics/frame/index.htm)) ;

The most prominent forum for showcasing innovation has been the annual housing fair ([asutomessut.fi/en/english-home](http://asutomessut.fi/en/english-home)) drawing thousands of visitors and getting widespread media attention. Innovative solutions demonstrated at fairs have included

- zero energy houses ;
- block houses constructed of wood ;
- waste heat recovery from wood stoves ;
- recycled construction materials ;
- automated waste collection systems ;
- heat recovery from lake bed sediments ;
- CHP from biogas with fuel cells ;

- intelligent systems to monitor and manage energy use.

The Committee for the Future has advocated introducing net metering. With net metering distributed small-scale renewable power production would be compensated better which would make it more attractive to move to zero and even plus energy houses.

A key focus on reducing the carbon footprint of construction has been on increasing the use of wood. A national programme has promoted wood construction and a standard has been developed for wood elements (RunkoPES). Some Finnish examples of wood construction can be found at [woodarchitecture.fi](http://woodarchitecture.fi).

Rudus ([rudus.fi](http://rudus.fi)) has developed green concrete that the company claims can cut carbon footprint by 20–50%. An interesting innovation is a robot for sorting construction waste by Zen Robotics ([zenrobotics.com](http://zenrobotics.com)).

There is of course a of innovation activity in related fields, especially energy. For example, an Aalto University research group has made the world record in the efficiency of black silicon solar cells.

## **Innovation for transportation and mobilities**

As Finland has never been a major car industry hub, innovation has focused on areas other than engine technology. Strengths include e.g. advanced biofuels and intelligent transport systems (ITS).

Finland is home to the world's largest producer of biodiesel from waste and residues, majority state-owned Neste ([neste.com](http://neste.com)). Company's NEXBTL is advanced drop-in biodiesel that can be used up to 100% in normal diesel cars without modifications. Neste also produces renewable aviation fuel that has been demonstrated on commercial passenger flights.

For its biofuels Neste uses various feedstocks, including waste fats and oils. There has been considerable controversy on the use of palm oil and related by-products which contribute to tropical forest loss through indirect land use change (ILUC). Neste is exploring new feedstocks such as algae and microbes, but these remain at pre-commercial phases.

Various Finnish companies are involved in developing biofuels out of waste, industry by-products or solid biomass. For example, UPM ([upmbiofuels.com](http://upmbiofuels.com)) produces biodiesel out of crude tall oil, a by-product of the pulp industry. St1 ([st1biofuels.com](http://st1biofuels.com)) uses various waste streams, including bakery waste and saw dust, to produce bioethanol.

There have been numerous R&D programmes on low-carbon transport, biofuels and ITS, including:

- Transeco: developing, demonstrating and commercialising technology for improved energy efficiency and reduced emissions in road transport ([transeco.fi/en](http://transeco.fi/en))
- Liikennelabra: “Transport Lab”, demonstrating ITS solutions ([liikennelabra.fi](http://liikennelabra.fi))

- EVE: creating an EV community and developing test environments ([tekes.fi/en/programmes-and-services/tekes-programmes/eve](https://tekes.fi/en/programmes-and-services/tekes-programmes/eve))

The ITS field is convened by ITS Finland ([its-finland.fi/index.php/en](https://its-finland.fi/index.php/en)). The Committee has suggested setting up regional ITS test platforms and using taxation to support ITS solutions.

The most internationally renowned pilot is KutsuPlus ([kutsuplus.fi/home](https://kutsuplus.fi/home)), a hybrid between public transport and taxis. Registered users can hail a KutsuPlus mini bus online paying a fee of 3.5€ per trip + 0.45€ per kilometre. The bus picks passengers from any of the designated stops and delivers them to any of the same stops using algorithms to combine the routes of different passengers.

A third field of activity revolves around electric vehicles. Keliber ([keliber.fi/lang/en](https://keliber.fi/lang/en)) is planning to open the largest lithium mine in Europe and European Batteries ([europeanbatteries.com](https://europeanbatteries.com)), if it can recover from filing for bankruptcy, manufacture lithium batteries. Various companies are involved in building smart charging systems (see e.g. Ensto, [ensto.com](https://ensto.com), and Liikennevirta, [virta.fi](https://virta.fi)). The committee has called using tax reductions to speed up the introduction of EVs.

The role of different fuels in low-carbon pathways has been addressed by e.g. a Ministry working group on alternative propulsion and the Government Foresight Report on Long-Term Climate and Energy Policy ([bit.ly/1NGMuvs](https://bit.ly/1NGMuvs)). One take-home lesson from the latter is that deep decarbonisation pathways are likely to require the electrification of the car fleet. Technically cars could be powered by biofuels, but as sustainable biomass resources are limited, they need to be reserved for uses where no viable alternatives exist – in particular air traffic, shipping and heavy road transport.

Some weak signals suggest that Finland, too, may be reaching peak car, i.e. a peak in the use of private cars. However, there is insufficient data to substantiate claims. Furthermore possible underlying trends are clouded by the deep and long recession in the Finnish economy.

## **Innovation to feed the world with minimal greenhouse gas emissions**

Various studies suggest that reducing emissions in agriculture can prove challenging and possibly costly. Most promising and cost-effective measures include preserving organic soils; converting animal and vegetable waste into biogas; improving manure management; plant breeding; reducing the use of nitrogen fertilisers; increasing energy efficiency; replacing fossil fuels with renewables; cutting food waste; and moving to more vegetable-based diets. The climate programme for agriculture, co-ordinated by the Ministry of Agriculture, lists 76 measures to mitigate climate change or adapt to it.

There is a lot of R&D work going on developing commercially viable ways to produce fertilisers out of manure in a relatively sparsely inhabited country like Finland. For example,

Palopuro Agroecological Symbiosis project ([blogs.helsinki.fi/palopuronsymbioosi/english](https://blogs.helsinki.fi/palopuronsymbioosi/english)), aims at energy and nutrient self-sufficient production. Sybimar ([sybimar.fi/en](https://sybimar.fi/en)) uses industrial ecology to combine aquaculture, greenhouse, biofuels and wind power, achieving closed loops. The Committee has called for the government to set a target to make Finland the leading country in recycling nutrients.

There is some work going on in developing new ways to increase the carbon content of agricultural soils. Humuspehtoori ([humuspehtoori.fi](https://humuspehtoori.fi)) sells a product containing wood fibre from paper industry. There are also trials of using wood carbon in agricultural soils, for example at the Knehtilä farm.

As the low-hanging fruits are unlikely to suffice to reach low-carbon pathways in the medium- and long-term, more innovative and radical solutions need to be explored. These may include exploring alternative food sources, structural changes such as replacing animal products with vegetable-based options in production and consumption as well as modifying plants and animals.

There is both academic and industrial research going on searching for ways to substitute soy in animal feed with locally produced proteins. The use of blue lupin and faba bean are studied at the University of Helsinki. A Finnish dairy product company Valio ([valio.com](https://valio.com)) is developing a process for producing protein-rich liquid feed from silage.

Several companies are working on locally produced vegetable-based alternatives to meat and dairy products. For example, Bioferme ([bioferme.fi/en](https://bioferme.fi/en)) uses oats to produce alternatives to dairy products (e.g. yoghurt) and Raisio ([raisio.com/en/en](https://raisio.com/en/en)) manufactures oats-based drinks. Oy Soya Ab ([jalotofu.fi](https://jalotofu.fi)) uses hemp to substitute soy in tofu, Verso Food ([versofood.fi/en](https://versofood.fi/en)) produces protein-rich products based on faba beans and Palkuainen ([tempe.fi](https://tempe.fi)) is developing tempeh made from peas and lupin. Entocube ([entocube.com](https://entocube.com)) is working on commercialising crickets as a low-carbon protein source.

There is a relatively long research tradition in Finland looking at carbon footprints of food, led by what is now called Natural Resources Institute Finland ([luke.fi/en](https://luke.fi/en)). Projects have included research on the carbon footprint of different foodstuffs and lunch options as well as carbon footprint labelling. The aforementioned Raisio has introduced carbon footprint labels on some of its products.

Social innovations on reducing food waste like inviting senior citizens to eat what is left from school lunches for a marginal price are spreading from one municipality to several others ([sitra.fi/en/blog/industrial-symbiosis/sidestreams-food-money](https://sitra.fi/en/blog/industrial-symbiosis/sidestreams-food-money)). Also social media tools are being used for sharing food.

Specifically on the issue of converting excess renewable power to fuels, a sizeable research programme is looking at the feasibility of turning electricity into methane ([neocarbonenergy.fi](https://neocarbonenergy.fi)).

## **Citizens' involvement in the use of smart technologies**

In most cases the role of information and education in changing people's behaviour is likely to be limited and temporary. This is all the more so if other factors run counter to the goals. For example, it is of limited use to run a campaign to get people to shift from private cars to public transport if public transport services are limited, of poor quality or expensive.

“Soft” measures can be more effective if they are combined with other measures and designed carefully. Demos Helsinki ([demoshelsinki.fi/en](http://demoshelsinki.fi/en)), a Finnish think tank, has worked on the gatekeepers of low-carbon solutions, i.e. key people that can influence whether consumers choose low-carbon options. Addressing these gatekeepers – e.g. appliance sales people regarding energy efficiency – can be more effective than campaigns directed at the general public.

Based on research we know that communication by peers and role models tends to have a significantly larger impact. Information can also play a larger role if it involves a social element. For instance, being the first one in a neighbourhood to install a solar panel can have a multiplication factor as other people can see the solution with their own eyes.

Some of the work providing information on low-carbon choices is publicly funded. Motiva ([motiva.fi/en](http://motiva.fi/en)), a state-owned company, serves as a national information clearinghouse. Regional energy offices provide information and training locally in some regions, with different focuses. However, funding tends to be scarce and project-based, reducing the efficiency and long-term impact of activities.

There are various ways to involve communities and citizens in low-carbon solutions. Lumituuli ([lumituuli.fi](http://lumituuli.fi)) is the first citizen-owned wind power company in Finland. Joukon Voima ([joukonvoima.fi](http://joukonvoima.fi)) explores using crowdfunding to finance renewables projects. Also new business models can make low-carbon change easier, e.g. financing that allows the customer to pay for the investment incrementally from the savings generated.

The previous Committee for the Future worked on two general tools that can be applied also to addressing climate change. The Committee commissioned a report ([www.eduskunta.fi/FI/tietoeduskunnasta/julkaisut/Documents/tuvj\\_1+2012.pdf](http://www.eduskunta.fi/FI/tietoeduskunnasta/julkaisut/Documents/tuvj_1+2012.pdf)) and carried out a pilot project on crowdsourcing. The lessons were mostly promising, suggesting that crowdsourcing can work in involving citizens and provide multiple benefits. The Committee advocates setting clear and enabling rules to make crowdfunding attractive.

The Committee also commissioned a report ([https://www.eduskunta.fi/FI/tietoeduskunnasta/julkaisut/Documents/tuvj\\_10+2014.pdf](https://www.eduskunta.fi/FI/tietoeduskunnasta/julkaisut/Documents/tuvj_10+2014.pdf)) on what is called “kokeiluyhteiskunta” in Finnish. The term, sometimes translated as “enabling” or “experimenting” state means a society open to and actively promoting pilot and demonstration projects as a way to test ideas and learn from them quickly.

Both crowdsourcing and greater use of piloting can play a role engaging citizens in addressing climate change in general and promoting low-carbon innovation in particular. For example, crowdsourcing can be used to provide input to and increase the acceptability of certain



climate policy measures. Likewise, piloting can be a tool to test new low-carbon technologies or climate policies and gain experience for developing them before scaling them up.

# Germany

## Innovation and Energy Efficiency of Buildings

The improvement of the energy efficiency of buildings is one of the key pillars of Germany's strategy to achieve a sustainable energy consumption. Almost 40 % of the primary energy consumption in Germany is in the building sector. The official goal is to reduce the demand for heat by 20 % in 2020 and the non-renewable primary energy consumption by 80 % in 2050 (both relative to 2008 levels) (BMW<sub>i</sub> 2010, p. 22). This implies that the building stock has to become almost climate-neutral by 2050!

On the one hand there are huge potentials for energy savings in buildings, many of them are even profitable in economic terms. But on the other hand there are numerous obstacles to activate these potentials. To name just two important ones: the pay-back times for energy efficiency measures are typically rather long and there is the well-known investor-user dilemma meaning that the investment requirements on the one hand and the benefits generated by the investments in terms of lower energy costs on the other hand do not coincide with the same actor.

A number of measures have been implemented already by the German government to achieve the stated goals. To name just two of them: the efficiency standards for new and existing buildings have been raised continuously (e.g. via the latest amendment of the Energy Savings Directive (EnEV) in 2013), and the government-owned development bank KfW (Kreditanstalt für Wiederaufbau) runs a programme to finance building refurbishments with a financial volume of 1,8 Mrd. Euro each year.

However the assessment of the expert commission which evaluates the progress of the "Energiewende" (energy transition) is somewhat sobering. In order to achieve the goals, there is an urgent need for additional measures. Action has to be taken soon, taking the long capital lockup into account: "First, the German government must decide soon on the design of financial support measures for building modernisation, ensuring they are compatible with the targets and second, a stricter Energy Savings Ordinance is required – also for new buildings. At the same time, it should be examined whether the efficiency requirements for existing buildings have to be increased as well" (Löschel et al. 2014, S. 11).

Research and innovation play a key role in achieving the goals, therefore Germany has implemented a comprehensive research programme "Buildings of the Future", which aims at developing energy optimized buildings ranging from small incremental improvements e.g. by providing quality assurance for windows and glazing to innovative concepts like "energy-plus

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NB: For precise references, please, contact TAB.

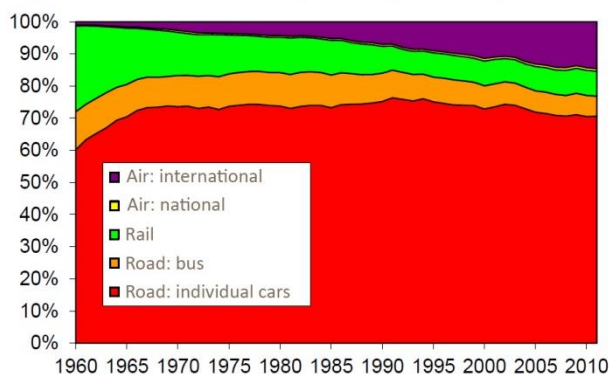
buildings" that have a positive annual energy balance i.e. they produce more energy than is consumed.

From a TA perspective the building sector is a somewhat neglected area. There are much less TA studies available for this area than for example for the electricity sector. The last TAB-project that touched this area dates back to 1999 and dealt with the use of renewable raw materials in the construction of buildings (TAB 1999). Here is certainly room for improvement.

## Innovation for Transportation and Mobility

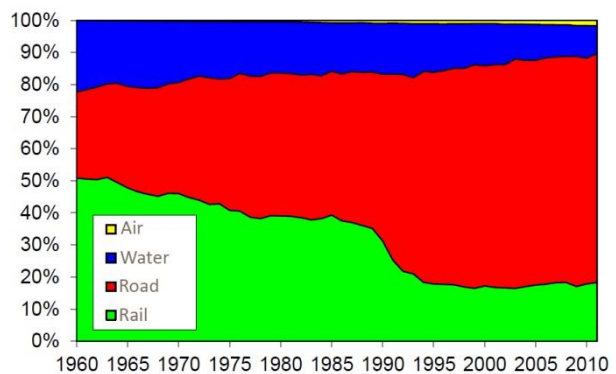
The transportation sector is one of the major sources of CO<sub>2</sub>. Its importance has even increased over the recent years, its share of Germanys CO<sub>2</sub>-emissions increased from 11 % in 1990 to around 17 % today. After a steep increase of CO<sub>2</sub>-emissions caused by the transportation sector (taking account also of the emissions from the production of the fuels) from around 1960 till 2000 the emissions have flattened out and just recently begun to decrease - however slowly - by about 2 % in the last decade. This is in contrast to most other sectors (households, industry, energy industry) where CO<sub>2</sub>-reduction amounts to 20-35% compared to 1990 levels. The main reason for the recent decrease of CO<sub>2</sub>-emissions in the transportation sector was the introduction of biofuels. In a "trend scenario", which takes into account the official forecast of transportation volume and expected trends and political decisions taken, these emissions will stay rather constant till 2030.

Fig. 1a: Traffic volume passenger transport



(IFEU 2012, p.16)

Fig. 1b: Traffic volume cargo transport



(IFEU 2012, p.17)

On the other hand the official goal is to reduce the endenergy consumption in the mobility sector by 40 % till 2050 (from 2005 levels), which would at the same time reduce the greenhouse gas emissions substantially. To achieve this goal the government has published in 2013 a comprehensive "Mobility and Fuels Strategy", which highlights that: "The key prerequisites for achieving the targets are the diversification of the energy sources for transport through alternative fuels, in conjunction with innovative drive technologies, further improvements in the energy efficiency of combustion engines and the optimisation of transport processes" (BMVBS 2013, p.6).

There are huge challenges ahead in order to implement this. Here is just one example: There is a wide agreement, that reductions of CO<sub>2</sub>-emissions can very effectively be initiated by a change in modal split towards more environment friendly means of transportation (eg. public transportation for passengers and rail for cargo). However the current trends point in the opposite direction both for passenger and for cargo transport. In the case of passengers, air transport is expanding substantially (see Fig. 1a) and in the case of cargo, road transportation has gained immensely at the expense of both rail and waterway transport (see Fig. 1b).

In terms of technological innovation in road transport, electric vehicles draw a lot of attention in the recent years. TAB has published a comprehensive report on this issue in 2012: "Electric mobility concepts and their significance for the economy, society and the environment" (TAB 2012a).

The official objective set in agreement with industry is to have at least 1 million electric vehicles in Germany by 2020 and over 5 million by 2030 (Federal Government 2009). The term »electric vehicle« here refers to four-wheeled vehicles with a battery which can be charged externally by connecting it to the mains. These are purely battery-electric vehicles (BEV) and hybrid vehicles with a mains connection, so called plug-in hybrids (PHEV). Environmental concerns on the one hand and on the other hand keeping Germany's automobile industry competitive in the future are both important factors for supporting the development and diffusion of electric vehicles.

There is still a long way to go in order to reach these targets: As of January 2014 there were 21.324 BEV, 1.374 PHEV and 161 Fuel-Cell Vehicles on the road in Germany.

From an industry point of view, the battery has the biggest share of the value added in electric vehicles. This market is currently dominated by Asian companies, Germany hardly plays any role here internationally. Therefore, it seems much more promising to invest in the next generations of batteries than in the lithium-ion technology used today. Only second to the battery, power electronics systems are of a great importance. This technology is important not only for electric vehicles, but also for other future technologies, e.g. in the fields of energy efficiency and renewable energies as well as for the control of electricity grids. It is essential to safeguard the strong competitive position Germany holds in this area today.

Electric vehicles can play an important role in changing mobility patterns, therefore the use of electric vehicles in car sharing, commercial car fleets and multimodal mobility services is highly attractive. In this way, electric mobility can be a cornerstone of a sustainable transport system.

Transportation and mobility was an important thematic focus of TABs work in recent years: already ten years before the already mentioned report on electric mobility (TAB 2012a), we published a report which developed a set of political instruments and measures to steer the energy supply in the mobility sector towards more sustainability (TAB 2002). In 2006 another extensive technology assessment report was published, which gives an overview of technological innovations in powertrain technologies and systems and their potential to reduce energy consumption and emissions. All of this was analysed in a comprehensive "well-to-wheel" perspective (TAB 2006).

## **Innovation for Agriculture, Food and Environment**

Agriculture is one of the major causes of man-made greenhouse gas emissions worldwide. Apart from CO<sub>2</sub> also large emissions of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) are produced through agriculture. In Germany, agriculture is responsible for about 7 % of all greenhouse gas emissions. Because of the very different causes and diverse sources of the emissions, it is rather difficult to tackle these emissions. At the same time, there are numerous additional obstacles and challenges to overcome in order to reduce them. For example, it is not at all easy to convince farmers to give up on traditional agricultural practices, which are sometimes proven for centuries, only because other practices promise to have a lower greenhouse gas footprint.

Also there are a number of conflicts regarding land-use: if, for example, a less greenhouse gas intensive agriculture produces lower yields, a greater area needs to be used to produce the same amount as before. Arable farm land however is a scarce resource and there are a lot of conflicting uses of land area (housing, infrastructure, nature reserves, leisure and recreation...). The biomass that is produced on a given area is also subject to use conflicts: food and feed, energy/fuels, industrial raw materials (wood, raw materials for chemical and pharmaceutical processes etc.).

On the issue of use conflicts there were three TAB reports published recently: the first (TAB 2005a) critically appraises a number of instruments and measures that had the intention of reducing land use in Germany. The second report (TAB 2010) provided a systematic analysis of "Opportunities and challenges facing new energy crops". It covered an overview on the technical and agricultural potentials of energy crops and dealt in detail with possible problems of competition for acreage on a national and a global level, with options for improving the environment-friendly production, and with the prospects of sustainability certification measures. Taking into consideration the many interdependencies between research, economics and policy, four different fundamental directions of political action on growth targets and funding policy with regard to energy crop utilization were formulated. The third report addressed quite a concrete question: is the available land better used in terms of Germany's targets for sustainable development if it is converted to organic farming or if energy crops are grown on it? Various strategic options are discussed in this report (TAB 2012b).

In this very complex field, easy answers are hard to find. Over the years TAB has undertaken a number of relevant projects: in 2005 the report on "*Precision Agriculture*" was published (TAB 2005b). Precision agriculture is an innovative (digital) information controlled management concept of crop production, based upon on various new or advanced technologies. These include in particular satellite-supported positioning systems, sensor technologies for data collection and geo-information systems. This promises to enhance the productivity of the land and at the same time reduce the environmental burden, especially since pesticides and fertilisers can be applied more precisely tailored to the specific need of the individual plants. All in all precision agriculture holds promise for a more sustainable agriculture in the future.

And finally a TAB-report from 2011 concludes that research definitely has a word to say when it comes to combat undernourishment and malnutrition that prevail on a global scale. Especially participatory user-oriented research strategies promise a potential to overcome the hurdle of transferring positive research results into the daily land management practices.

Technological options to reduce atmospheric CO<sub>2</sub> by active management of the CO<sub>2</sub>-cycle connected to land use practices have been assessed in two recent TAB reports (TAB 2012c, TAB 2014b). The cultivation of microalgae to produce energy carriers as well as chemical feedstock for the food, feed and pharmaceutical industry seems to have good prospects for large-scale application in the medium term (after 2020). Another interesting option is to convert biomass into coal-like substances ("biochar" e.g. with a process called hydrothermal carbonization). This material can either be used as a source of energy, or it can be pulverized and utilized as a soil conditioner. Under favourable conditions this can both fix atmospheric CO<sub>2</sub> and improve the harvest yield of poor soils.

## **Innovation and Citizens' Involvement**

The high hopes that information and education can quickly and thoroughly change peoples' behaviour towards a more sustainable life-style that were prominent in the 1970s and 1980s are pretty much shattered. Many more factors play a role in peoples' behavior than just their knowledge about certain issues.

One example from the electricity sector is: if you provide people with "smart meters" that measure their electricity consumption and display that information in an easily accessible fashion (displays, on their smart phones ...) they will change their consumption pattern and use less electricity. However this change is large initially and tends to decrease again over time when the old routines start kicking in again. The amount of energy that can be saved this way is around 5 % of the households electricity consumption (TAB 2015). This display of information can be called a "nudge" that softly pushes people towards a more sustainable consumption without taking away their autonomy to decide for themselves. This concept has gained a lot of attendance recently and some researchers believe that this could be a means to achieve a positive change beyond legislation and regulation (Thaler/Sunstein 2009).

On the other hand it is clear that people in Germany and other western democracies want to participate in the decision making process about issues that have impacts on their daily lives and are not willing to simply accept decisions taken by authorities. Infrastructure projects decided at the German federal level, which have to be implemented at the local level (rural districts and municipalities), therefore very often give rise to partly very committed or emotional debates and various conflicting interests. Particularly local elected political representatives are confronted with this situation. Currently, this is especially virulent for the expansion of electricity grids that is planned because of Germany's plans to switch electricity generation to renewable energies ("Energiewende"). There are indications, that well-designed public participation processes can increase acceptance of the planning process and can lead to

better overall solutions. But there are no easy recipes, a productive discussion culture and trust can only be earned after hard debates. This was the topic of a recent TAB report (2015).

A recent trend in Germany with a profound impact on the energy landscape is the abundant spawning of energy cooperatives. This is a very hands-on approach of citizens' participation. Citizens join together to build and operate power plants, mostly based on PV- or windpower, to produce their own electricity. Commonly this type of engagement is seized by people who want to contribute actively to an energy system that is decentralized, environmental friendly and based on renewable sources.

# Greece

## **Innovation for energy efficiency of buildings**

### 1. "Energy saving at home" program

This program provides financial incentives for the implementation of energy-saving interventions in the residential building sector. The program covers old, authorized buildings, which were not built under the Thermal Insulation Regulation, are located in areas with a specific zone price and are used as primary or secondary residence. Moreover, the owners must meet certain income criteria.

### 2. "Exoikonomo (Save)" program

The purpose of this program is the implementation of actions and proven best practices in order to reduce energy consumption in the urban environment giving emphasis on the building sector (municipal buildings) and the upgrade of public spaces, on one hand, and in the area of municipal and private transport and energy intensive municipal facilities, on the other, through the implementation of technical interventions and actions to raise awareness and mobilize citizens, the local government, businesses and bodies.

### 3. "Exoikonomo II (Save II)" program

This measure constitutes the continuation of “Exoikonomo” program and foresees the upgrade of municipal buildings and infrastructure and installation of electronic and “intelligent” metering of electricity. This measure aims at the utilization of electronic metering in order to measure on an hourly basis the electricity consumption giving the opportunity to collect effectively all the necessary information regarding the consumption of industrial, commercial and residential consumers and to facilitate the promotion of financial or other incentives to promote rational organization of consumption behavior.

## **Innovation for transportation and mobilities**

Reducing the energy footprint of the demand sector can be achieved by focusing on the transport sector. Examples include promoting use of LNG on sea going vessels, trains and trucks, utilizing the geographically strategic position of the existing LNG terminal at the island of Revithoussa. Strategic initiatives of the EU such as the Blue Corridor would contribute in promoting the above initiatives of Greece. We also support the effective promotion of electric and gas-powered cars and buses, the electrification of the railway and public transport network, the use of smart meters and the implementation of “smart grids”.



The replacement of old passenger vehicles aims at the replacement of EURO III passenger vehicles with new EURO V vehicles through the partial or complete exemption from the special registration passenger vehicles tax.

The extension of the Athens Metro and the development of the Thessaloniki metro has as an objective the increased utilization of fixed rail transport in the city of Thessaloniki, which will lead to the significant reduction of private car use and will result in the achievement of energy savings.

## **Innovation to feed the world with minimal greenhouse gas emissions**

The attracting of well-established international companies can ensure the safe exploration and extraction of hydrocarbons in conjunction with the close cooperation with Greek companies and will maximize the benefits from the exploitation of domestic natural resources. The most effective way to achieve this – in the fierce competition currently prevailing in the international hydrocarbon market – is to establish a stable and favorable regulatory framework that would minimize the risk of doing business in Greece. Furthermore, it requires organizing a well-targeted and dynamic informational campaign for international companies, as well as a parallel initiative informing the Greek society with regards to a realistic timetable and the real possibilities of our country in this field.

## **Citizens' involvement in the use of smart technologies**

The participation of citizens in the decisions of the Administration concerning the protection of the environment finds legitimizing basis to: (a) effectively achieved the content of Democracy (b) the existence of the social rights of the individual, the environment and therefore for protection and (c) is a growing conscious need for a balanced sharing of the arrangement and to address the social needs between public power and civil society as a whole dynamic with buffering capacity and (d) article 24 , paragraphs 1 and 2 and article 25 paragraph 1 in the 1975 Constitution. However, up to the moment, no particular measures concerning citizens' involvement have been taken.

## **Conclusion**

Greece needs a modern regulatory framework for the operation of Energy Service Companies (ESCOs) and development of energy saving and energy efficiency projects. Targeted regulatory interventions can immediately tackle hurdles such as: the absence of a framework for heat trading and active management of renewable energy sources; the lack of incentives for the energy upgrades of facilities in the private sector and the absence of a load balancing

market in gas and electricity. The issuing of financial tools such as green bonds by the local authorities (based on the American PACE model) could be very helpful in this respect as well as the provision of guarantees from European bodies.

This objective ought to be considered as one of Greece's highest priorities. At present, Greece's energy market ails from a significant amount of state intervention and distinctly lacks the necessary conditions conducive to the development of a competitive environment. The Hellenic government can promote structural reforms in the national energy market. As an example, we refer to the widening in scope of the term "choosing customer" for natural gas, the amending of terms for calls for tenders for natural gas undertaken by the Hellenic National Gas Company (DEPA), establishing rules to allow for the possibility of commercially trading LNG quantities in tanks, the liberalization of bilateral contracts for the supply of electricity, third party access to lignite deposits, and the ability to use trade optimization infrastructure for renewable energy sources.

The Hellenic regulatory framework for renewables should be harmonized in line with EU 2030 targets, and specifically make use of the cooperation mechanisms outlined in directive 2009/29/EU for the promotion of the use of renewable energy sources and cross border energy trade. In particular, the Government can promote a new competitive model based on market mechanisms driven by carefully set targets based on technology and geographic location. The Direkt Vermarktung (direct marketing) model which is being applied in Germany could serve as an indication. Such a model would drastically reduce the associated financial burdens on our national economy.

# The Netherlands

## Introduction

Climate change generates chances for innovation and opens windows for new business. Entrepreneurs are looking for new techniques to live, to consume and to transport people in a way that is less detrimental to climate than the conventional ways. Innovations can contribute to either mitigate or to adapt the consequences of climate change. Innovations focusing on mitigation reduces the magnitude of climate change itself (such as geoengineering or measures to directly reduce carbon dioxide emissions). Innovations focusing on adaptation limits society's vulnerability to climate change impacts and makes society robust against climate change (such as sustainable living and protection against floods).

## Policy initiatives and societal trends

Sustainable energy evidently is one of the domains in which innovations related to climate change take place. Those innovations mostly lead to mitigation, as these aim to less carbon dioxide emissions. Figures generated by the so-called top sector Energy, one of the sectors in which the Netherlands excels globally and which receive high government priority, show that the largest part of the sector's available financial resources was invested in biobased economy (ECN, 2014). Next to that, the number of patents in sustainable energy related technologies, has been significantly increased, especially patents for solar energy, biomass and wind energy. Public expenditures for innovation in energy-related technologies in general has nonetheless been reduced since 2010.

Water, agri-food and logistics are examples of other domains in which innovations take place with regard to adaptation and mitigation of the climate change consequences. Innovation in water management, for instance, mostly leads to adaptation. The Dutch Delta program is one of the most globally known examples; it aims to protect against floods and to secure fresh water supplies. Together with the program Knowledge for Climate, which is established to foster co-creation between universities, research institutes and government in making the Netherlands more robust to climate change, it works to a 'climate proof' country (Kennis voor Klimaat, 2014)<sup>12</sup>.

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<sup>12</sup> In 2013, the Rathenau Instituut published a report (<http://www.rathenau.nl/publicaties/publicatie/kenniscopproductie-voor-de-grote-maatschappelijke-vraagstukken.html>) about co-creation of knowledge of societal challenges. The program Knowledge for Climate is regarded as a good example of co-creation, in which both society and science work together to define future research agendas (Boon and Horlings, 2013).

## Challenges

In 2013, the Dutch Ministry of Infrastructure and the Environment published its climate agenda (Ministry of Infrastructure and the Environment, 2013), which sketches an approach that combines climate adaptation and climate mitigation. The climate agenda emphasizes the importance to further stimulate the innovation chances by creating necessary conditions for innovation and by eliminating non-financial obstacles.

Challenges for the Dutch government with regard to adaptation and mitigation are: realizing robust vital sectors (such as nature, energy, ict, transportation and public health); broadening the measures to realize mitigation (such as strengthening the European emission trade system and carbon dioxide norms); facilitating renewable energy and energy saving (such as transportation and storage of energy); stimulating sustainable mobility (such as expanding the introduction of carbon neutral cars); further developing of a circular economy and of a sustainable use of raw materials); and, stimulating sustainable agri-innovations (Ministry of Infrastructure and Environment, 2013).

## Current TA projects

The Rathenau Instituut conducts research on the societal and political effects of new technologies. Concerning technologies that contribute to the adaptation or mitigation of climate change consequences, the Rathenau Instituut currently conducts the following projects:

### 1. Innovation for energy efficiency of buildings

Building houses efficiently, by sustainable use of resources or by building houses in a way that living requires less energy, is an example of innovation that contributes to a lower demand of energy. Smart grids, for instance, enables smart energy supply to houses and enhances sustainable living. An example of such an initiative in the Netherlands is the project Stroomversnelling, an initiative of Platform 31 (a platform for spatial and urban planning). The project Stroomversnelling aims to build in total 111.000 carbon neutral houses, while the housing expenditures of its occupants stay unaffected. Four construction agencies and six housing corporations have agreed to build the first 11.000 houses during the next few years.

Next to constructing energy efficient houses and buildings, the use of sustainable materials and the recycling of household waste also contribute to a sustainable way of living. Stimulating and facilitating a circular economy and the use of sustainable materials (not only at consumption level, but merely at geopolitical and national level), are topics that are addressed in the Rathenau report Resource Hunger (<http://www.rathenau.nl/publicaties/publicatie/sustainable-alleviation-of-resource-hunger-management-summary.html>) (Krom & Van Waes, 2014). The Rathenau Instituut analyzed what (geopolitical) strategies are open to the Netherlands and the European Union for securing critical resources in a sustainable way. A transition to the circular economy can play

an important role in this, provided that the recycling of critical materials is made economically viable, and that resources that will still need to be imported as input for the circular economy at least meet minimum sustainability requirements (Krom & Van Waes, 2014).

## 2. Innovation for transportation and mobilities

In September 2013, more than 40 organizations, such as governments (both national and regional), employers, labor unions, ngo's and financial organizations, committed themselves to the national Energy Agreement for Sustainable Growth ('Energieakkoord') (SER, 2013). Essence of this agreement is that the concerning actions have to lead to a sustainable and affordable energy supply, to employment and to innovation in sustainability related technologies. Smart mobility and smart transportation is one of the focus points.

One project of the Rathenau Instituut in 2015 focused on smart mobility and autonomous cars (<http://www.rathenau.nl/publicaties/publicatie/converging-roads.html>) (Timmer et al. 2015). Self-driving cars are considered by the Dutch government as an important way to reduce congestion and improve traffic flow, to reduce fuel consumption and improve road safety. The Netherlands wants to be actively involved in the development of autonomous cars (Parliamentary Documents II, 2013/14, 31305, No. 210), for example by allowing tests and experimenting with more flexible regulations. Dutch companies play an important role as suppliers of systems and components for the automotive industry, and the country is also strong in communication technology and intelligent traffic management systems. Besides reducing environmental and congestion costs, developing self-driving cars can give an important economic boost to the mobility industry in both the Netherlands and the European Union.

The Dutch focus has been on improving communication between cars and between cars and road infrastructure. The ultimate goal is a self-driving car that smoothly connects to a platoon of cars on the motorway and that responds to warnings transmitted by smart infrastructure, for example about icy conditions, mist, or unexpected obstacles. This approach depends heavily on public-private cooperation and investments.

But now self-driving cars are also being developed in Silicon Valley. These innovative vehicles have sparked interest in the Netherlands as well. But the Rathenau project found that their rapid advance is threatening to interfere with the Dutch approach. These autonomous robot cars have onboard sensors that enable it to guide itself safely. But the cars do not communicate with other cars or with the road infrastructure, and are therefore not equipped for platooning. And precisely platooning brings the most benefits for efficient driving, i.e. saving energy and reducing congestion.

The robot cars are interesting for the automotive industry because it can function independently of other cars and a particular road infrastructure. There is a risk that private parties will focus on the development of the autonomous robot car at the expense of cooperative systems such as those being developed by the Netherlands.

In the view of the Rathenau Instituut, efficient development of the self-driving car requires convergence of the two approaches – autonomous and cooperative. In order to benefit from the technical advantages from both approaches, and to achieve public goals as regards road safety, traffic flow and the environment, it is important that the robot car is compatible with cooperative systems. This means that it must be able to connect to other cars and to traffic management systems. The Dutch government can play a role in this by imposing requirements for vehicle communication and by influencing international standards.

Another current project of the Rathenau Instituut focuses on the governance of smart cities. Not only mobility and transportation, but also digital platforms, smart ict solutions, robots and the internet of things pose challenges for the governance of cities.

One of the new projects of the Rathenau Instituut (2015-2016) will focus on the governance of smart cities. Worldwide citizens and companies are involved in setting-up digital platforms for sharing goods and services. Well-known examples are Airbnb (housing) and Ueber (mobility). These platforms have a huge potential for changing the way in which the use of goods and the delivery of services are *organized*, involving a new dynamic between policy-makers, citizens and companies. In a similar vein cities worldwide have formulated ambitions to become ‘smart’ cities, wanting to harvest the full potential of the Internet of things, in which everything is connected to everything and everyone. Potential applications include both the organization of the government itself as well as employing smart technology to govern the city and for the *organization* of delivering public services. Here too, the use of smart ICT applications have the potential to radically change the way that our institutions are organized. This raises the question, for instance, whether (local) governments are willing and able to let citizens and companies take over parts of what previously was considered a government task.

Central to this new project of the Rathenau Instituut will be to examine - through case studies<sup>13</sup> - the societal meaning and significance of developments towards making cities ‘smart’. Particular attention will be devoted to (a) mapping who is (not) involved in specific initiatives, (b) the extent to which these initiatives (could) change the relation between policy-makers, cities and companies, and (c) what governance structures are needed to safeguard central societal values such as democratic decision-making, transparency, inclusiveness, sustainability, well-being, and the livability of cities.

Recognizing that smart city initiatives are often initiated by local governments (faced with important societal challenges) and companies (developing technical options to meet these challenges), the Rathenau Instituut will specifically map *the way in which* citizens are involved and can be involved in concrete smart city initiatives. This way the project aims at including the input of citizens in such a way to support that smart cities will also be livable cities, i.e. places in which citizens are able to lead a good life, enjoy a high level of well-being, and will remain to have an important say in the governance of the city.

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<sup>13</sup> Case studies will focus on energy, mobility, security, resources/ circular economy, the sharing economy, and the delivery of public services.

### 3. Innovation to feed the world with minimal greenhouse gas emissions

In order to feed the still rapidly growing world population in an environmentally sustainable, animal friendly and economically feasible way, present-day agriculture is increasingly using all kind of smart technologies. Present-day farms more and more become part of the ‘Internet of things’. By making use of drones, smart cameras, wearables, innovative fertilizing and feeding systems and sophisticated computer models, conditions for both crop production as well as animal husbandry can be monitored, analyzed and optimized. By supporting or even replacing human observation by electronic monitoring and analysis, agricultural production can become more productive, environmentally sustainable and animal friendly. At least, these are the promises of Smart Farming.

In an explorative study on Smart Farming, the Rathenau Instituut has explored to what extent present-day farmers in the Netherlands incorporate smart technologies in their daily practices (Bos, 2015). Although the concept of Smart Farming is appealing, the practice of Smart Farming appears to be multiform. The way in which smart technologies are implemented in agricultural practices, strongly depends on the precise purposes and context. Nevertheless, the following issues can be depicted as deserving further attention and research: to what extent is it feasible to replace human observation by electronic monitoring and analysis (e.g. with regard to the handling of animals and related animal welfare issues); to what extent a broad implementation of smart technologies would further a large-scale, industry-like type of agriculture; to what extent a broad implementation of smart technologies would turn farmers into data managers, losing all connotations to agriculture as a ‘natural’ practice?

Rathenau Instituut will continue its research on smart farming during the next few years.

### 4. Citizen’s involvement in the use of smart technologies

In the period ahead the mobility system and our mobility behavior are expected to change drastically. The more vehicles and roads are equipped with smart technology, the greater will be the stream of data that they exchange. That data can be used for new applications and new revenue models, but it also raises questions regarding privacy, ownership, and reuse. What should car manufacturers be permitted to do with that data? What about insurance companies? And should the authorities be allowed to use this data in investigations?

Although cautious public discussion is beginning about what uses the digital data generated by smart cars may be put to, the Rathenau Instituut concluded in the project on ‘smart cars’ (<http://www.rathenau.nl/publicaties/publicatie/converging-roads.html>) that civil-society organizations and the public currently hardly play any significant role in the development of smart and self-driving vehicles (whether that means the cooperative or the robot car). Indeed, they are conspicuously absent. Users are not seen as inevitably involved in the social embedding of the self-driving car. The closed nature of the innovation process derives partly from conflict avoidance. Controversial issues, such as variable road pricing and privacy, are often avoided, even though the associated functionalities arise almost of their own accord. The process of strategy development in the current Dutch policy program (Better Informed on the Road) was deliberately not set up too broadly because building trust between market and

government was seen as a critical task. But the rate of current developments demands the input and involvement of users, the public, and civil-society organizations. The input of all these parties is necessary, specifically now that self-driving cars are leaving the confines of the test circuit and start driving on public roads. Only by involving citizens it will be possible to reach policy goals such as saving energy, reducing congestion and increasing road safety.

Part of the new project of the Rathenau Instituut ‘smart cities’ (mentioned above), is to explore how smart technologies, such as sensors, smartphones and apps, might empower users to participate in measuring energy savings, carbon emissions, and how such data will be used by citizens, companies and governments to make changes in their policies / living areas or (driving) behaviors. Insurance companies are now starting to experiment with smart measuring devices for cars, that give users real-time feedback on their driving style, and may either receive discounts for a ‘sustainable’ and ‘safe’ driving style.

## **Conclusion**

The Rathenau Instituut continuously monitors developments regarding innovations and emerging technologies that foster sustainability and that diminish the disastrous effects of climate change. One of the major themes is the way in which ICT related technologies can play a role in the transition towards a more sustainable society. The development of smart cities, smart cars and smart farming are key in the projects we currently conduct. Herein, the involvement of citizens in the design of those technologies and in measuring trends and collecting data seems to be essential.



# Norway

## Background: The Norwegian Climate Agreement

Oil and gas are Norway's most important export and driver of the economy. It is also this sector that emits the most climate gasses. The Norwegian government has therefore given priority to a green transition to further both economic and environmental sustainability.

The Norwegian climate policy is based on a broad political agreement made in 2012. In addition to the overarching objectives on emission reductions, the agreement describes a series of measures that will be implemented in Norway. These include:

- phasing out fossil heating oil ;
- stricter energy requirements for the building sector ;
- contributing to developing biogas in Norway ;
- the car taxes shall be used to contribute to getting a more environmentally and climate-friendly vehicle fleet ;
- strengthening the role of the railway in the transport system.<sup>14</sup>

## Innovation for energy efficiency of buildings

Energy use in private households stabilised at around 44-46 Twh in the mid-1990s, following a period of 2% annual increase from the 1970s.<sup>15</sup> However, policy makers see a reduction in this sector of 1,4-3 Twh as realistic.<sup>16</sup>

Norwegian homes are to a large extent heated by the use of electricity, which accounts for about 70% of energy spent. It should be noted, however, that because the electricity in the Norwegian power grid is mainly hydropower, the amount of greenhouse gases emitted is relatively low.

In 2012 the Norwegian Government put forth three goals for sustainable energy use in buildings:

- Use of energy should be considerably reduced by 2020.
- Regulations should ensure that new buildings are constructed as to require energy below allowed regulated levels.

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<sup>14</sup> <https://www.regjeringen.no/en/topics/climate-and-environment/climate/innsiktsartikler-klima/agreement-on-climate-policy/id2076645/>

<sup>15</sup> Norwegian Water Resources and Energy Directorate (2011).

<sup>16</sup> Meld. St. 28 (2011–2012) Gode bygg for eit betre samfunn, white paper on buildings for a better future, p 76.

- Support schemes and information should help make existing buildings more energy efficient.<sup>17</sup>

### 1. A public enterprise for green energy

Enova is a public enterprise owned by the Ministry of Petroleum and Energy, established in 2001 in order to drive forward the changeover to more environmentally friendly consumption and generation of energy in Norway. In order to achieve this, Enova works closely with public and private enterprises in order to reduce energy consumption and simultaneously increase power generation from renewable sources.

In 2014 Enova according to their annual report joined 1400 new projects in the private and public sectors, and supported 4500 new energy measures in residential buildings. This was the first year it granted more support for innovation and technology development than spread of familiar technology in the markets, which is an interesting shift in light of the energy and climate challenges we are facing. These challenges cannot be solved without innovation and technology development.

Enova provides funding for projects that lead to more sustainable energy consumption. One example of a project supported by Enova is Statkraft Varme's installation of a district heating line between two neighbourhoods in Trondheim municipality. During the period 2009-2014 the project received support of 19,1 mill NOK. Renewable heating is one of the markets ENOVA is engaged in, as it holds the potential for being a more reliable and sustainable form of energy for the future.<sup>18</sup>

### 2. Passive houses and zero emissions

In both 2015 and 2020 the Norwegian regulations on energy use in buildings will become stricter. The regulations of 2015 are at passive house levels, while regulations in 2020 will approach zero emissions.<sup>19</sup> The relevant actors in the construction sector have been notified of the changes a few years in advance in order to give the construction industry enough time to adjust and be encouraged to innovate before the regulations take effect.

Furthermore, the political agreement on climate policy says that fossil oil heating in households is to be prohibited by 2020. In addition to reducing greenhouse gases, local pollution will be reduced and the risk of leakages will be eliminated. As an alternative to fossil oil, bio oil will remain available.

In July 2010, new regulations that include demands on energy efficiency in buildings (Tek 10) were introduced in Norway.<sup>20</sup> It sets the minimal requirements buildings must satisfy in terms of materials used and alternatives for heating. For instance Tek 10 says that buildings of more

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<sup>17</sup> Meld. St. 28 (2011–2012) Gode bygg for eit betre samfunn, white paper on buildings for a better future, p 73.

<sup>18</sup> ENOVA (2015), pp. 60–73.

<sup>19</sup> Meld. St. 28 (2011–2012) Gode bygg for eit betre samfunn, white paper on buildings for a better future, p 10.

<sup>20</sup> <http://www.innovabygg.no/energi-og-varme/tek-10>

than 500 m<sup>2</sup> must attain more than 60% of its heating from other sources than direct acting electricity or fossil fuels. For smaller buildings the limit is set at 40%.

## **Innovation for transportation and mobility**

Over the past 15 years, the Norwegian Board of Technology (NBT) has conducted several projects that are either directly or indirectly related to cleaner and greener road traffic. Both hydrogen fuel and biofuel have been discussed. Even though these have interesting potentials, the NBT in 2009 stated that electric vehicles and hybrid cars were the most promising technologies and should be made widely available. This was suggested as a part of a scheme to reduce Norway's combined CO<sub>2</sub>-emissions by 2020.<sup>21</sup>

### 1. Norway as an early market for electric vehicles

As a part of reaching the goal of reducing CO<sub>2</sub>-emissions in the transport sector, the government has implemented extensive tax cuts and benefits to encourage consumers to choose electric vehicles (EVs) instead of their fossil fuelled counterparts. In addition to putting a CO<sub>2</sub>-component to car VATs this makes it cheaper to buy cars that produce low emissions. The NBT suggested this solution as early as in 2006.<sup>22</sup> Additional fiscal and non-fiscal measures directed specifically at EVs have been implemented:

- zero VAT policy on buying EVs ;
- heavily reduced annual car tax (435 NOK annually as opposed to normal rates of 3060 – 3565 NOK)<sup>23</sup> ;
- no fees on toll roads ;
- free public parking ;
- free use of ferries ;
- free charging at public charging stations ;
- access to bus lanes.

The favourable conditions for EVs have made Norway one of the biggest markets for EVs globally, second only to California, and Norway is now in a favourable position to test and develop new technologies and solutions for greener driving.

So far the incentives have had a large impact in leading Norwegians to buy EVs, and might even fall victim to their own success. The measures were set to last either through 2017 or up to 50.000 EVs in total sold. During the first few months of 2015 EVs stood for 19% of all new cars sold, and the sales goal of 50.000 was met in April 2015. This has led to public

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<sup>21</sup> Norwegian Board of Technology (2009).

<sup>22</sup> Norwegian Board of Technology (2006).

<sup>23</sup> Meld. St. (2014–2015): p. 78–79.

debate on the EV incentives. For instance the high number of EVs in the area surrounding Oslo has congested the bus lanes during rush hour, and on some ferries as much as 20–25% of cars are EVs riding for free. Still the program has been extended through 2017.<sup>24</sup>

## 2. “Cities of the future”: Towards zero emissions

In 2012, the Norwegian government stated that the growth in passenger transport in major urban areas should be absorbed by public transportation, bicycling and walking.<sup>25</sup> This has been dubbed the “zero growth goal”, and frames the debate on innovation in this sector.

To achieve this, an increasing number of urban area buses are running on non-fossil fuels. Ruter, the administration company for public transport in Oslo and its suburbs, is operating busses running on hydrogen, bio fuels and bioethanol. The aim is to use exclusively renewable sources by 2020. So far, bio fuels have been favoured, as it significantly reduces emissions and can be used by adjusted diesel engines.

The “Cities for the future” programme is collaboration between the state and 13 major Norwegian cities. The programme facilitates the option of walking or biking, as an alternative to other forms of transportation. Some of the measures are:

- reward schemes for increased public transport and reduced car traffic ;
- increased number of charging stations for EVs ;
- improved facilities for biking.

The program includes an option for the state and individual cities to committing to holistic city environment deals. These deals are to contain concrete goals towards reducing car use and fostering environmentally friendly transport.<sup>26</sup>

## **Food and Environment**

### 1. Tracing the carbon footprint

In 2008 the NBT published a report on food and climate<sup>27</sup>, which pinpointed the two-fold challenge of creating a stable food supply while climate gas emissions must be reduced.

The NBT suggested introducing “carbon footprinting” as a common methodology for calculating and documenting the impact at different stages. Furthermore it pointed to the need for a common international method that can provide the carbon footprint for the entire life cycle of a product.<sup>28</sup>

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<sup>24</sup> Meld. St. (2014–2015): p. 92. [http://www.statsbudsjettet.no/upload/Revidert\\_2015/dokumenter/pdf/stm2\\_2015.pdf](http://www.statsbudsjettet.no/upload/Revidert_2015/dokumenter/pdf/stm2_2015.pdf)

<sup>25</sup> Meld. ST. 21 (2011-2012): pp. 9–10.

<sup>26</sup> <https://www.regjeringen.no/no/tema/kommuner-og-regioner/by--og-stedsutvikling/framtidensbyer/test-artikkel/id547993/>

<sup>27</sup> Norwegian Board of Technology (2008a).

<sup>28</sup> Norwegian Board of Technology (2008b).

If implemented, a carbon label directed at consumers can facilitate three functions:

- giving authorities tools to map emissions over time ;
- providing the food sector with a guide to cut costs ;
- informing consumers about the carbon emissions from the products they buy.

A standard for carbon footprinting for sea food was launched by the standardization body Standards Norway in 2013. As more and more market actors, as well as costumers, demand documentation of carbon footprint, this standard gives an advantage to climate friendly products.<sup>29</sup>

## 2. A national strategy for the bioeconomy

The Norwegian government is currently initiating a task force developing a national bioeconomy strategy which should be presented by the end of 2015. The aim of the new strategy is to facilitate a “green turn” which makes Norway less dependent on the production and consumption of fossil fuels, as well as making greener business avenues more innovative.<sup>30</sup>

The bioeconomy is a circular economy meaning that the by-product(s) from one value circle is a valuable raw material for another value circle. This economy is based on the potential of turning biomass into, among other things, food, fuels, chemicals and materials.

The Research Council of Norway initiated a research program in 2012, BIONÆR, which is focusing on the further development of the bioeconomy in Norway. This is the most dedicated program for the development of the Norwegian bioeconomy, and has provided support for more than 330 projects. Among these is "Sustainable path creation for innovative value chains for organic waste products", an interdisciplinary research program on the transition to the bioeconomy.<sup>31</sup>

Moreover, a new Norwegian Institute of Bioeconomy Research (NIBIO) was established in August 2015.<sup>32</sup> NIBIO will be a ministerial agency with separate powers and independent leadership. With more than 650 full-time employees, this is now one of the largest research institutions in Norway.

## 3. The potential of the oceans

Salt water covers 70 % of earth’s surface. 50 % of the biological production takes place in salt water, but without any cultivation taking place as in agriculture. However, only 2 % of the global human food intake comes from the oceans, whose most productive parts are the shallow coast and fjord areas.

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<sup>29</sup> Standards Norway (2014):*Årsrapport 2013*.

<sup>30</sup> <https://www.regjeringen.no/no/aktuelt/nasjonal-bioekonomistrategi/id2402513/>

<sup>31</sup> <https://www.forskningsradet.no/prosjektbanken/#!/project/244249/no>

<sup>32</sup> <https://www.regjeringen.no/en/aktuelt/Norwegian-Institute-of-Bioeconomy-Research-has-been-established/id2426068/>

Norway was the first country to start fish farming in salt water and, after about 45 years of growth, has a leading position globally. The growth potential for Norway as well as other nations is very high and this will be one of the future low emission production systems for food. However, to be able to obtain that higher amount of raw materials, fjords and coastal areas should be utilized.

One example of a Norwegian company that focuses on finding innovative ways of producing bio mass and bio energy sustainably along the Norwegian coast is Ocean forest. Partly founded by the environmental organization Bellona, combatting climate change is a key focus. As such, one of their goals is to find production methods which eliminate more CO<sub>2</sub> than they emit. The idea is to use algae, salt water and CO<sub>2</sub> to produce products such as food and fuels. The company aims at commercializing their solutions within five years after start-up.<sup>33</sup>

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<sup>33</sup> <http://bellona.no/prosjekter/ocean-forest>

# Poland

## General issues

Poland's CO<sub>2</sub> emission in 2013 were estimated at 320 million tonnes. The main emission source was fuel combustion that contributed 92% of total CO<sub>2</sub> emission (in that category energy industries contributed 52%, manufacturing and construction 9%, transport 14%). Polish per capita emissions (8,3 tonnes of CO<sub>2</sub>/year) are about the average for the EU.

Poland is one of the more energy intensive countries of the European Union. The emissions level in Poland is relatively high because of the energy sector reliance on coal. Almost 90% of Polish electricity and heat generation is derived from coal. Coal industry constitutes an important part of the Polish economy and the state owns considerable shares in power plants. Both factors contribute to the fact that there is limited political interest in diminishing the role of coal as an energy source. Domestic deposits of coal are also perceived as an important asset from the point of view of energy security. Energy security reasons disfavour switching to cleaner natural gas which would have to be imported.

Poland is often perceived as a country that strongly opposes the EU climate policy. However it is worth noting that Poland has managed to substantially reduce its GHG emissions during its economic transformation. As a result of the structural shift towards less energy-intensive sectors, the country's overall GHG emissions fell by around 30% between 1988 (Polish base year under the UNFCCC) and 2013. Since the early 2000s, annual GHG emissions have remained broadly stable, despite the significant growth of GDP in that period. This reflects efforts to include more renewable energy in the energy mix and investments in more energy-efficient technologies. However energy efficiency of Polish economy, although improving, still remains well below EU averages.

Poland does not have specific climate change policy (beyond the commitments adopted under international treaties and EU legislation). The climate issues are dealt within the framework of other sectoral policies, most notably energy policy. *Energy Policy of Poland until 2030* (adopted in 2009) is mostly focused on improving energy security, efficiency and competitiveness. The *Energy Policy 2030* is now being revised aiming at more robust diversification of energy mix towards gas, nuclear power and renewables. At the same time, Poland is in the process of formulating a national plan for reducing GHG emissions, the *National Programme for a Low-Emission Economy Development* (the document is currently entering the final stage of ministerial approval). So far Poland's main instrument of climate policy is the EU Emission Trading Scheme (EU ETS), that covers around half of the country's GHG emissions. Emissions in sectors not covered by the EU ETS (primarily the residential, transport and agriculture sectors) are set to rise 14% above the 2005 level by 2020.

## **Energy Efficiency of Buildings**

The *Energy Policy 2030* strategy lists a number of measures addressing energy demand, some of them are relevant for building sector. These include for instance (i) setting energy efficiency national objectives and introducing systemic support mechanisms; (ii) using mandatory energy performance certificates for buildings and apartments upon their marketing or renting; (iii) determining energy intensity of devices and power-consuming products, introducing minimum standards for power-consuming products; (iv) committing the public sector to serve as a role model of efficient energy usage; (v) supporting investments in energy saving through preferential loans and grants from domestic and European funds.

Improving Energy efficiency has been declared a priority of Poland's energy policy. Many activities in that area follow the EU legislation. Implementing the provisions of Directive 2006/32/EC on energy end-use efficiency and energy services, in April 2011 Poland issued its *Act on Energy Efficiency*. Following the obligations established by the Directive 2010/31/EC on the energy performance of buildings, the Polish government prepared National Energy Efficiency Action Plan (EEAP) which covers among others buildings sector. The EEAP adopted in 2011 established an energy savings target of 11% by 2016 compared to 2001-2005 average. Under new EU legislation (2012/27/EU) Poland's 2014 EEAP set an indicative target for 2020 of stabilising primary energy consumption at the 2010 level. This will require strengthening energy efficiency in all sectors. According to many studies there is significant potential to improve energy efficiency in housing and public buildings, but also in district heating systems.

Public support for thermal improvement investment in existing buildings is available through Thermo-modernization Fund, overseen by the Ministry of Infrastructure and Development and managed by the state owned bank (Bank Gospodarstwa Krajowego). It provides subsidised loans mainly to local governments and building owners to renovate apartment buildings. The fund targets "best practice" renovations focusing on projects that would not be attractive under normal lending conditions. Besides, the programme has helped to develop energy audit services.

## **Transport**

Poland's transport sector has experienced very high rates of emission growth in recent two decades - it has grown by almost 75% since the beginning of economic transition. In 2013 transport sector contributed 14% of the country's total GHG emission. Moreover, Poland still has relatively low rates of motorization, what suggest that the growth of road transport will continue. This problem is exacerbated by a high share of ageing vehicles, which tend to be more fuel inefficient and polluting. As in other transition economies, Poland has been investing heavily in roads, which have accounted for 90% of transport infrastructure investments in recent years. Despite significant investments, the density of motorways remains among the lowest in the EU and the rail network is substantially underinvested. In the



case of both the passenger and cargo transport, the most conspicuous change is the growing importance of road transport: it accounts for 95% of total inland passenger transport and 75% of freight . In the road transport, the fuel consumption grew and the number of cars increased. The only positive trend was a decrease in the energy intensity indices of the means of transport.

Until recently, little progress has been made in addressing the environmental impact of transport. The *Transport Development Strategy* was adopted by the Council of Ministers in 2013. The main goal of the Strategy is “to enhance territorial accessibility and to improve the safety of traffic participants and the efficiency of the transport sector by creating a consistent, sustainable and user-friendly transport system at the local, national and European level”. One of the detailed objectives is to “limit the adverse impact of transport on the environment”. However there is little direct reference to climate or GHG emission reductions needs. One of the proposed measures is to gradually increase the share of bio-components in transport fuels. In addition, the obligation to consider emissions-related factors and energy consumption of all vehicles purchased in the public procurement procedure has been introduced.

## **Agriculture**

Polish agriculture is characterised by ample land resources, with a simultaneous large share of poor and acidified soils, a substantial fragmentation of farms and persisting traditional production methods. The total area of farms in Poland in 2012 was about 18 million ha, representing about 58% of the total national territory. Since 2000 the agricultural land area has decreased significantly while other land uses, including for housing, services and infrastructure, have increased.

So far Poland has not adopted policies and measures that aim directly at reducing GHG emissions in agriculture. However, in the framework of the EU climate 2020 package Poland is obliged to limit the rise in GHG emissions in sectors not covered by the EU ETS to max. 14% above the 2005 level. So far this goal has not been supported by specific policy measures.

## **Promotion of eco-innovation**

Between 2007 and 2013 Poland’s gross domestic expenditure on R&D rose from 0,57% of GDP to 0,9% driven by significant increases in the national research budget and EU funding. Despite this effort, Poland’s innovation performance is one of the poorest in the EU, where the average R&D capacity stands at 2,4% of GDP. Polish firms spend very little on R&D and innovation, as the business spending is mostly allocated to technology absorption. To address this challenge the government reformed the system of cooperation between economy and science and research sector. The reform included creation of agency for applied research and introduction of more competitive funding schemes. In 2013 the Council of Ministers adopted

the *Strategy for Innovative and Efficient Economy* which includes measures to support business innovation and sets priorities for granting EU funds. Eco-innovation mirror's Poland's general innovation trends. Despite relatively poor performance some positive initiatives may be highlighted, most notably the GreenEvo program oriented towards supporting exports of green technology and the GEKON programme, jointly implemented by the National Environmental Fund and the National Centre for Research and Development that stimulates co-operation between science and industry on environmental technology. EU funds have helped establish eco-innovation oriented clusters such as the Silesian Environmental Technology Cluster, the Baltic Eco-Energy Cluster, the Clean Energy Cluster of Southern Poland. The Climate-KIC (Knowledge and Innovation Community) located in Wroclaw is the largest public-private innovation partnership in the country which focuses on climate change and consists of private companies, academic institutions, and representatives from the public sector. There is a clear focus on research and development in the area of renewable energies, biofuels and clean coal technologies. Research in the field of energy-efficient buildings (including zero-emission standard) are carried out by the Cracow University of Technology and by the Building Research Institute in Warsaw.

# Russia

## Innovation for transportation and mobility

The project of the Integrated Eurasian Transport System aims to ensure a transcontinental transport mobility through an optimal balance of energy consumption and environmental safety

The idea of building a transcontinental transport route Eurasia – North America dates back to the beginning of the XX century, ever since remaining in focus of interest by scientists and politicians.

Back in the 90's much deliberation at major international conferences was held over a project of overland link between the continents of Asia and North America.

Lately developed an upgraded megaproject known as “Integrated Eurasian Transport System” (IETS) or “Trans-Eurasian Belt RAZVITIE” (TEPR) involves construction on the Russian territory of the transport network link between Western Europe and the Far East, the North America and the South-East Asia. The project concept was developed by the Center of research and implementation of the megaproject *IETS* in the Institute of Social and Political Studies (ISPS) of the Russian Academy of Sciences (the corresponding report was published by Dr. V. Yakunin and Academicians G. Osipov and V. Sadovnichy)<sup>34</sup>. The project implies the establishment of integral infrastructure system providing flexible unity of the transport (rail and road routes), energy and telecommunication systems.

Main ideas of the project have been several times brought to the discussion at the Council of the Federation, as well as at the Baikal Economic Forum. On November 30, 2011 the Council of the Federation held parliamentary hearings “International transport corridor Europe – Russia – Asia-Pacific region as a space for innovation”<sup>35</sup> to review the *IETS* draft submitted by the ISPS Director, Academician Gennady Osipov.

The recommendations of the parliamentary hearings have stressed, in particular, the necessity “to consider under the EU-Russia Summit and Russia – APEC the feasibility of establishing and developing international transport corridors North America – Russia – Southeast Asia (Alaska – the Bering Strait – Yakutia – Siberia – China)”.

In March 2014 the project "Integrated Eurasian transport system" was presented by Dr. V. Yakunin (former President of the JSC "Russian Railways") and approved by the Presidium of the Russian Academy of Sciences.

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<sup>34</sup> Yakunin V.I., Osipov G.V., Sadovnichy V.A. *The Uniform Eurasian Infrastructure System*. – M.: ISPS of RAS, 2013.

<sup>35</sup> "International transport corridor Europe – Russia – Asia-Pacific region as a space for innovation" / Analytical News Bulletin of the Council of the Federation № 2, Moscow, 2012.

The elements of the integrated infrastructure shall include: construction of 47 thousand Km of railways, 120 thousand Km of main roads, laying of 23 thousand Km of fiber-optical cable<sup>36</sup>. Therewith, traffic volumes would interact with the energy flow, knowledge and technology capacities. Thus, creating innovation environment in the region to forming a center for scientific developments and the production center based on advanced technologies provided by many countries involved.

According to the developers' evaluation, the implementation of the megaproject can reduce the delivery time of goods between the Western Europe, and the Far East, the South-East Asia and the North America to 5-6 times and reduce delivery costs to two or three times<sup>37</sup>. The developers of the project are convinced that the functional role of the railways in the world will increase. First of all, it is environmentally friendly compared to other transport systems and its development is more efficient in terms of minimizing CO<sub>2</sub> emissions. Secondly, most railways are safe, and finally, more comfortable for the individual.

The project potentiality enables optimization of traffic flows on the global level and the balance of the interests between major economic regions of the world, serving as an important tool of global geopolitical security. It is to no exemption that the implementation of the Russian IETS project may take place in cooperation with plans of the construction of China's Silk Road Economic Belt and the Maritime Silk Road of the XXI century (the development strategy initiative known as "One Belt, One Road").

Construction of these transport systems will allow Russia to substantially increase its transit capacities, to combine the efforts with a number of countries having a strong potential for economic growth.

## **Innovation for Agriculture, Food and Environment**

### 1. On counteraction to global climate change: new technologies for utilization of greenhouse gases

The Climate Doctrine of the Russian Federation<sup>38</sup> states that "climate change is one of the most crucial world problems of the XXI century, which goes beyond the scope of scientific problems and constitutes a complex of interdisciplinary problems, encompassing environmental, economic and social aspects of sustainable development of the Russian Federation". The Council of the Federation of the Federal Assembly of the Russian Federation has consistently advocated for intensification of joint efforts of the international

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<sup>36</sup> <http://www.council.gov.ru/media/files/41d56050809b3f319188.pdf>

<sup>37</sup> *Op. cit.*

<sup>38</sup> Approved by Order of the President of the Russian Federation on December 17, 2009, #861-rp.

community to combat global climate change, limiting the harmful effects on the environment<sup>39</sup>.

Since 2008, the Council of the Federation in collaboration with the Interparliamentary Assembly of the Commonwealth of Independent States has been holding Nevsky International Ecological Congress<sup>40</sup> – the largest environmental forum in Russia.

VII Nevsky Congress, which took place in May 2015, focused on the strategy of ecological safety. Particular attention was given to the terms of support and implementation of advanced scientific research that would contribute to reduction of industrial impact on the environment. In particular, the final document of the Congress refers to the project *Synthesis* on production of hydrocarbons by utilizing greenhouse gases<sup>41</sup>.

Earlier the Council of the Federation has sponsored discussion on the Project in various format: at the meeting of the Scientific Expert Council headed by the Chairperson of the Council of the Federation (April 2012), at the Nevsky Congress, and at the Baikal International Economic Forum (2012).

## 2. Production of hydrocarbons by utilizing greenhouse gases (project *Synthesis*)

Today the concentration of carbon dioxide (CO<sub>2</sub>) in the atmosphere is two times higher than at the beginning of the Industrial revolution. Currently, the world is in search of different means to achieve reduction of greenhouse gases emission, including carbon dioxide capture and its burial underground in deep porous layers, brined, or depleted oil and gas fields. However, in general it requires very expensive technical methods that do not guarantee prevention of the carbon dioxide release from the Earth's surface burials.

Scientists of the Russian Academy of Sciences have developed the technology of recycling of the industrial emissions of carbon dioxide into organic synthesis products (project *Synthesis*) that produces the carbon turnover, similar to the natural one. Carbon dioxide serves as raw material for production of synthetic liquid energy carrier with improved environmental effects (motor fuel, dimethyl ether, high-octane gasoline, high-octane fuel oil, etc.).

Technology in general is unique and is introduced for the first time, patented by the Russian Federation on methods to produce synthesis-gas and organic synthesis products from carbon dioxide and water. Practical technology includes the following main stages:

- Extraction and concentration of carbon dioxide from diluted gaseous industrial emissions (from 7% to 97% CO<sub>2</sub> content) using the renewable amine based absorbents.

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<sup>39</sup> Russian senators have been addressing these issues at the PACE Sessions in September 2009 and January 2014, at the 22<sup>nd</sup> Session of the Asia-Pacific Parliamentary Forum (APPF) in January 2014, at the Second Summit of Global Legislators Organization for a Balanced Environment (GLOBE) in June 2014 and in number of other parliamentary meetings.

<sup>40</sup> <http://ecocongress.info>

<sup>41</sup> Project *Synthesis* has been introduced by the Scientific Council of the Program for Fundamental Research at the Presidium of the Russian Academy of Sciences.

- Reduction of carbon dioxide and water to produce hydrogen and carbon monoxide, i.e. synthesis-gas in parallel processes of electrolysis of water, chemical and catalytic reduction of carbon dioxide by using hydrogen electrolysis. Thus resulting electrolysis oxygen is utilized in a parallel process of partial oxidation of methane, which produces additional synthesis-gas and the excess (trade) hydrogen.
- Final stage of technology includes organic synthesis processes based on the conversion of synthesis-gas into methanol and oxygen-containing products or based on Fischer-Tropsch synthesis conversion into liquid hydrocarbons and synthetic fuels.

Perspective technology development will be set forward to achieve extraction of carbon dioxide also directly from the earth's atmosphere using a gas-selective membranes.

Currently provided preliminary project of a pilot plant of the carbon dioxide processing<sup>42</sup> with the capacity up to 5,000 tons per year of liquid hydrocarbons and up to 20,000 tons per year of organic synthesis products (intermediates) for further developing the production of clean gasoline and Diesel premium fuel of "Euro-3", "Euro-4" or higher standard, as well as of hydrogen fuel.

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<sup>42</sup> Project *Synthesis*. Pre-draft project of creation of experimental-industrial complex of the carbon dioxide processing with the capacity of 5,000 tons of hydrocarbons per year. – M.: ISPS of RAS, 2015. 124 p.

# Sweden

## **Innovation for energy efficiency of buildings**

Buildings and the residential sector account for 40 percent of Sweden's energy consumption. Sweden has set the target that all new buildings will be nearly zero-energy buildings in 2020 and an action plan to reach the goal has been developed<sup>43</sup>. Energy efficiency will be needed in the whole sector both in new constructions and renovation as well as the daily operation of buildings. Priorities will not only be given to make buildings more energy-efficient but also to learn more about consumer choices, decisions and lifestyles that affect energy use. One of the biggest challenges identified concerns the existing building stock and to make it more energy efficient. The Swedish Energy Agency highlights the construction and building sector as a strategic priority area for research and innovation in the coming years and allocates 20 million SEK for a new research and innovation program. Additional funds for a larger collaboration program with the industry in the field will also be a priority. A Government assigned evaluation of existing and new low energy buildings showed that even if low energy buildings use less energy in the operational phase, greater investments in climate shells and installations can be difficult to get back in terms of reduced heating costs during the life of the building. However, from an environmental perspective, it is beneficial to build with a higher ambition in terms of energy. In terms of the building's entire life cycle, including operation stage, the climate benefits of building energy-efficient is clear<sup>44</sup>.

### 1. Energy-efficient refurbishment

A large part of the Swedish apartment blocks are built in the years 1965 – 1975. A successful energy-efficient refurbishment of this stock would result in a significant reduction in the total energy consumption of the residential sector. This is a priority for the government who allocates money to property owners to be invested in refurbishment of these buildings to make them more energy efficient and to stimulate innovation. The Government also intends to strengthen the consumer's role for improving energy efficiency through municipal energy and climate advice. A national strategy for energy-efficiency renovation of buildings has been outlined and the strategy include instruments that stimulate cost-effective renovations of buildings. The strategy also identifies barriers to energy efficiency.

### 2. A smart and energy-efficient city – the development of the Royal Seaport

A new area of Stockholm is developing with smart electricity grids. It will enable an increasing use of energy from solar and wind power and the electricity demand will be

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<sup>43</sup> Miljö- och energidepartementet 2012 Vägen till nära-nollenergibyggnader, Skr. 2011/12:131

<sup>44</sup> Report 2015 by the National Board of Housing, Building and Planning and the Swedish Energy Agency *Utvärdering av lågenergibyggnader - en fallstudie*. Ett gemensamt regeringsuppdrag för Boverket och Energimyndigheten, rapport 2015:25

managed in a smarter way. The area will also contribute to knowledge building; Residents will be able to see what kind of energy they're using, how it affects the environment and how much it costs. And, perhaps most important of all, if they will make active green choices, with the help of a smart communication system and smart plugs, thermostats and appliances.

### 3. Incentives to increase energy efficiency in buildings

An initiative to reduce energy use in buildings was introduced in 2006 through a law requiring building owners to declare energy use and indoor environment for their houses, so called energy declarations<sup>45</sup>. The energy declaration includes, amongst others, information on the heated area of the house, energy use for heating, comfort cooling, domestic hot water and proposals for actions to reduce energy consumption. The energy declaration provides recommendations about cost-effective measures to improve the energy performance of the houses.

Green Leases are established with the purpose of reducing the environmental impact from commercial premises. The leases describe what actions tenant and landlord have agreed on to reduce the environmental impact, energy and indoor environment, materials and waste. The green leases can offer a common incentive to implement energy efficiency measures but case studies show that it can be difficult to change the existing lease structures as changes are associated with transaction costs and agreements involving different parties can split incentives regarding energy efficiency. Furthermore, a short lease length weakens the incentive to conduct major energy investments. In conclusion, separation of ownership and usage may not be optimal from an energy efficiency point of view<sup>46</sup>.

### 4. Large research program in the field of energy-efficient building and living

E2B2 is the largest research programme in Sweden to date in the field of energy-efficient building and living. The aim is to contribute to enhanced energy efficiency in the built environment through research, development, innovation and demonstration. It is a broad programme that includes research on buildings across their entire life cycle – from planning, production, renovation and redevelopment to deconstruction and demolition. Research on how human habits, choices and lifestyles can impact energy use is also included in the programme<sup>47</sup>.

## **Innovation for transportation and mobility**

About 40% of Sweden's greenhouse gas emissions comes from transportation (aviation included). After a peak in emissions around 2005, emissions have decreased slightly. Road

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<sup>45</sup> Ministry of Sustainable Development 2006 Energy declarations of buildings, Government Bill 2005/06:145

<sup>46</sup> Bonde M, 2012. Difficulties in changing existing leases – one explanation of the “energy paradox”? Journal of Corporate Real Estate

<sup>47</sup> <http://www.e2b2.se/english#sthash.XfhcpgOT.dpuf>



transportation accounts for the greatest share of the transport sector's greenhouse gas emissions. Emissions increased from 1990 to 2005 before stagnating, and have since then been decreasing somewhat as a result of an increased share of renewable fuels, higher energy efficiency and reduced fuel consumption in combination with the economic downturn in 2008-2009.

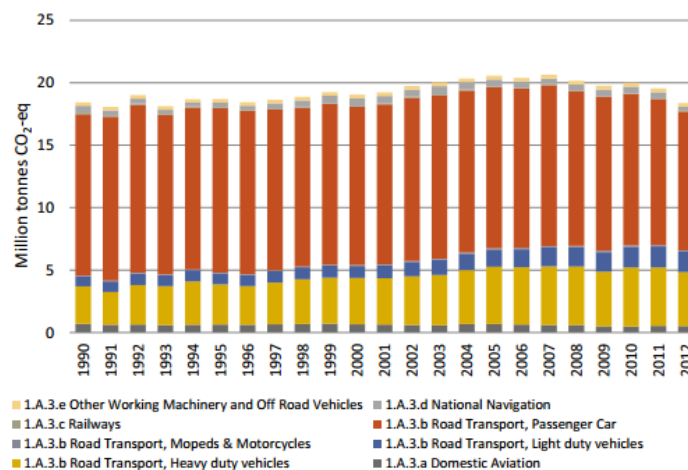


Figure 2.16. Emissions of CO2 eq. from the transport sector, total and per subsector

## 1. Government's initiatives to reduce the environmental impact of transport sector

The carbon tax has since the early 1990s been central to reduce carbon emissions in Sweden. Other instruments, such as technology procurement, information, differentiated vehicle taxes and investment grants, has also contributed to reduced greenhouse gas emissions. The current Swedish climate strategy puts emphasis on general financial instruments such as carbon tax and emissions trading. In the transport sector, the regulation of carbon dioxide emissions from new cars has contributed to decreasing carbon dioxide emissions in Sweden<sup>48</sup>. The present Government has appointed a researcher to submit a proposal for a so-called bonus-malus system for new light vehicles where environmentally friendly vehicles with relatively low carbon emissions could be rewarded with a bonus when purchased and vehicles with relatively high emissions of carbon dioxide obtain higher taxes<sup>49</sup>.

## 2. Strategic innovation programs in the transport sector

Infrasweden2030 is a new strategic innovation program with the aim to create new ideas and innovations but also a plan how these will be implemented in society. It is not just about the technical aspects, but also social and institutional. A holistic approach will be applied on how different technologies interact and how people use the technology. It will bring together the latest technology from material sciences, automotive technology, information and communication with road and rail technology, standardization, business and game simulation for creating a strategy for innovation. **Automated Transport Systems**, is a strategic program

<sup>48</sup> Miljödepartementet 2014 Sveriges sjätte nationalrapport om klimatförändringar, Ds 2014:11

<sup>49</sup> Finansdepartementet 2015 Ett bonus-malus-system för lätta fordon, Dir. 2015:59

with the aim to investigate the driver's role in the transport system and how the driver can be assisted or replaced by advanced ICT systems that will operate in both the vehicle movements, and the entire infrastructure<sup>50</sup>.

## **Innovation to feed the world with minimal greenhouse gas emissions**

Agriculture's greenhouse gas emissions (GHGE) in Sweden are equivalent to approximately 10 million tonnes of carbon dioxide every year. The major part of emissions consists of carbon dioxide from plant cultivation and animal husbandry, and is primarily nitrous oxide from fertilizers and manure and methane from enteric fermentation and manure management. These emissions have fallen by 16 percent since 1990. Swedish agricultural production also indirectly causes GHGE in other countries through the use of imported mineral fertilizer and imported fodder. The Swedish Board of Agriculture has mapped how climate may affect agriculture within a 25 year period. The climate-change scenarios indicate an increasing production potential at northern latitudes, with positive opportunities for Swedish agricultural production, but also indicate increasing risks for, e.g., new plant and animal pests and diseases, and extreme weather events such as heat waves, flooding, and draught.

### 1. Future agriculture – an interdisciplinary research initiative

Future Agriculture - Livestock, Crops and Land Use is a multidisciplinary research platform initiated by SLU (Swedish University of Agricultural Sciences) researchers together with industry, interest groups and government agencies. The work focuses on Sweden and the Nordic countries, but has also a global perspective. Within the programme, researchers together with the agricultural sector, governmental agencies, and nongovernmental organisations develop research on sustainable use of natural resources, with an emphasis on agricultural production and land use. Six overarching challenges for agricultural research emerging from five future scenarios have been identified: Reduction of the environmental impact of agriculture and mitigation of climate change; Responses to societal values and contribution to policies; Adaptation of agriculture to a changing climate; Management of present and potential risks; Agriculture and rural development; Resolution of conflicting goals of agriculture and land use.

### 2. Improved efficiency and recycling of nutrients – crucial aspects

When it comes to reduction of the environmental impact of agriculture, improved efficiency is a key tool. High-productivity systems involving minimal waste of energy and materials will be needed. The recycling of nutrients and other materials within the farm, as well as between urban and rural areas, is also a central issue. An important question concerns the degree to

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<sup>50</sup> VINNOVA, Sweden's innovation agency

which efficiency can be improved and impacts mitigated by integrated production systems (e.g. crops and livestock, or crops and trees) at farm, landscape or regional level, taking transport needs into account. The potentials and limitations of using new technology should be explored and evaluated for whole production systems. This requires an advanced understanding of agriculture as an ecological system, and an appreciation of the way technology can be used to reinforce ecological processes<sup>51</sup>.

## **Citizens' involvement in the use of smart technologies**

### 1. Smart sustainable cities – ICT solutions need to be carefully investigated

Several studies have highlighted how ICT can be used to achieve cities' climate targets by lowering energy use and greenhouse gas (GHG) emissions from different sectors such as power, transportation, agriculture, building, manufacturing and consumer and services. A recent study focusing on a consumption-based lifecycle perspective, concluded that “hotspots” where household functions with a high energy use and opportunities for ICT solutions overlap, are the areas with greatest potential for energy reductions. ICT solutions are enabling technologies integrated in large socio-technical systems where factors other than merely technical potentials play a role. This means that without careful implementation in combination with other measures, ICT solutions might result in increased energy use instead of a reduction, either directly or in other parts of the energy system or society, often called the rebound effects. A Swedish study shows that a mismatch between a city's climate targets and the opportunities presented by ICT solutions can be found. The climate targets of the City of Stockholm only cover 50 to 60% of the total energy use, according to consumption-based calculations. Such a target not only implies that there is no monitoring of a large proportion of energy use, but also risks resulting in a whole range of measures being overlooked. In order to turn the potentials into real savings, cities need to explore the opportunities thoroughly and investigate how they can best support the implementation of different ICT solutions<sup>52</sup>.

### 2. Together with residents – new innovative solutions are developed

An example of citizens' involvement in the use of smart technology can be found in the West Harbour of Malmö in Sweden. Seven smartly designed rental apartments, owned and managed by the energy company E.ON, are used to demonstrate new ways to generate and use energy through interaction with its customers in the houses. This part of the city is powered by solar energy, wind, water and organic waste. The residents produce their own energy, control energy use and test the energy solutions that are most effective, without

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<sup>51</sup> Bengtsson et al., 2010 Future Agriculture– Livestock, Crops and Land Use, A Strategic Programme for Research, Swedish University of Agricultural Sciences (SLU)

<sup>52</sup> Kramer et al. 2014 Smart sustainable cities - Exploring ICT solutions for reduced energy use in cities. *Environmental Modelling & Software*

sacrificing comfort. In addition, most of the tenants have access to electricity or biogas, so that solutions for sustainable transportation can be evaluated. The plan is to implement smart solutions to other areas based on the experience from these houses. However, both organisational and legislative barriers have been identified after an evaluation with the energy company, residents and other institutions involved. The organisational barriers are related to the complexity of the business model and the limitations of some companies to cooperate in a holistic energy system model. Legislative barriers are related to the limitations to make a business of selling locally produced renewable energy to the grid<sup>53</sup>.

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<sup>53</sup> City of Malmö 2013 e-harbours WP 3.7 Application of Smart Energy Networks Organisational and Legislative Analysis Summary results of showcase at City of Malmö

# Switzerland

## Swiss climate policy

Switzerland pursues an active policy on reducing greenhouse gases and is contributing to the international goal of limiting global warming to two degrees. The CO<sub>2</sub> Act, the heart of the Swiss climate policy, intends to reduce Switzerland's domestic emissions by at least 20% in comparison to their 1990 level by 2020. The Act primarily concerns fossil thermal and motor fuels, but also includes other important greenhouse gases in addition to CO<sub>2</sub>. It also assigns to the federal government the role of coordinating climate change adaptation activities (Federal Office for the Environment FOEN, 2015a).

In 2013, the greenhouse gases released into the atmosphere within Switzerland amounted to 52.6 million tons of CO<sub>2</sub> equivalent, this results in a per capita release of 6.5 t (FOEN, 2015b). With 31%, the transport sector accounts for the largest proportion of Swiss greenhouse gases emissions. They have risen by 10% since 1990 and road traffic is the largest source with 99% of transport emissions (FOEN, 2015c). Given the large contribution from this sector, this paper focuses on the domain of transportation and mobility. It describes two TA-SWISS studies examining the potential and challenges of 2<sup>nd</sup> generation biofuel technology and electric mobility.

## Innovation for transportation and mobility: 2<sup>nd</sup> generation biofuels

Biofuels made from renewable resources have come under heavy criticism. Energy crops stand in direct competition with food production or biodiversity conservation, and the environmental impacts of biofuels production are often greater than those of fossil fuels. New hope is being placed on the 2<sup>nd</sup> generation of biofuel technology, where not only oils, sugar and starch but also ligno-cellulosic compounds are transformed into fuels. This leads to a higher conversion efficiency and facilitates the use of alternative feedstocks like wood, grass or biowaste, which serve as more sustainable feedstocks.

The TA-SWISS study shows on the value chain level that the sustainability of 2<sup>nd</sup> generation biofuels depends mainly on the choice of feedstock. The use of waste feedstocks like manure, biowaste or residual wood usually results in a high sustainability potential and large greenhouse gas savings. However, if a 2<sup>nd</sup> generation feedstock has to be cultivated by agriculture or forestry, as it is the case for grassland or short-rotation wood, land consumption will be substantial for relevant volumes of fuel. This increases land use pressure on natural areas, while biodiversity is generally threatened.

Although sustainable production of biofuels is generally possible, the large-scale production of 2<sup>nd</sup> generation biofuels is restricted either by limited land availability, limited waste feedstocks or – in the case of fuels from algae – high costs and energy consumption.

As all biofuel and electric mobility pathways considered are not yet economically competitive, policy regulations will have a major influence on the success of 2<sup>nd</sup> generation biofuels. Of primary importance is the increase of the tank-to-wheel efficiency of internal-combustion engines. A reduction in average fleet consumption from currently 7.9 l/100km to 4l/100km in the year 2030 would double the potential of sustainable bio-based mobility in Switzerland to 15%, while sustainability would also be increased.

In summary, 2<sup>nd</sup> generation biofuels allow a more sustainable mobility than both fossil and 1<sup>st</sup> generation biofuels based on agriculture. Due to the limited availability of both waste feedstocks and cultivation area, however, sustainable bioenergy-based mobility is restricted to clearly less than 8% of individual mobility in Switzerland, if constant mobility and fleet efficiency is assumed. Nevertheless, 2<sup>nd</sup> generation biofuels may play a relevant complementary part in supplying our future mobility, in particular for long distance transport and aviation where electric mobility is less suitable.

Five proposals for exploiting the potential of biofuels<sup>2</sup>:

- Improvements in vehicle efficiency and the sustainable use of first generation biofuels should be promoted in parallel – likewise the use of second generation biofuels combined with electrical mobility
- Initiatives must be launched to integrate all of the relevant actors into sustainable resource management at national and international level.
- The main focus must be the supply of sustainable raw materials, and therefore to promote the use of waste material and wood, as well as the cultivation of crops on areas of land that were previously of relatively little interest to the farming industry.
- Broadly supported and accepted methods must be developed to record and prevent undesirable and indirect side effects of biofuels.
- The perspective for the assessment of biofuels must move away from one-sided emphasis on the CO<sub>2</sub> balance and increasingly include social and ecological aspects as well.

### **Innovation for transportation and mobility: Electric mobility<sup>3</sup>**

Electric cars are seen as the great hope for a sustainable or at least less polluting mode of transport. Generally speaking, electric cars increase the energy efficiency of travel and reduce dependency on conventional fuels such as petrol and diesel. Thanks to its energy mix, of which a large part comes from hydroelectric power, Switzerland has the right conditions to generate environmentally friendly energy for electric vehicles. Furthermore, the planned

major expansion of renewable energy production may be supported by electric vehicles as a form of local energy storage.

However, in order to reap the ecological benefits of alternative fuels, many conditions need to be met. The benchmark against which electric cars are measured is becoming even more rigorous as conventional combustion engine vehicles are continually technically refined to make them more efficient and ensure lower CO<sub>2</sub> emissions. By 2035, a compact car which today uses on average 7.5 l/100km could be using only 4.8 l/100km; this corresponds to a reduction of more than one third. The same compact car which runs on electricity could cut its energy use from 24 kWh to 16 kWh per 100 kilometres by 2035 through improvements in auxiliary systems such as heating and battery conditioning. This corresponds to a reduction of around 30% in CO<sub>2</sub> emissions.

Due to environmental pollution during the manufacture of the car, the life cycle assessment of electric cars is not substantially better than that of conventional vehicles: If the entire life cycle is taken into consideration, 90% of greenhouse gas emissions from battery-powered vehicles are produced during manufacture. This compares with 25% for mid-sized cars with combustion engines today, increasing to 40% over the longer term.

During operation, environmental pollution depends on how much fuel the vehicle consumes, or in the case of electric cars, the electricity mix. In comparison with other countries, Switzerland has one of the lowest CO<sub>2</sub> producing electricity mixes, based on hydroelectric and nuclear power. Operating an electric car powered by Swiss electricity therefore produces 70% fewer greenhouse gas emissions than a comparable combustion engine vehicle. By contrast, if the electric car is charged using the average EU electricity mix, of which 52% comes from fossil fuels, the CO<sub>2</sub> reduction in comparison with a conventional car is reduced to 20%.

The authors estimate that in 2025, on average one in ten new cars will run on electricity, and in 2035 every second new car will be an electric car. According to this, the greenhouse gas emissions from transport are expected to decrease by 10% until 2020 compared with today, despite a calculated 24% increase in mobility. For 2035, 20-30% reduction in greenhouse gases is predicted.

The more actively energy policy measures promote energy efficiency for new cars, the more likely it is that electric mobility will increase. Electric cars have high energy efficiency and small and mid-sized cars in particular are well suited to running on electricity – thanks to advances in battery technology, which will mean increasingly fewer compromises in future. Accordingly, targeted drive-specific support for electric cars does not seem to be necessary.

In future, the energy efficiency of road vehicles will improve more rapidly than the rate of total mobility. This will mean not only a reduction in CO<sub>2</sub> emissions, but also in income from fuel taxes. Electricity for electric cars is not taxed any higher than «normal» electricity. The higher the rate of electric mobility, the greater the pressure to switch to a taxation system based on kilometres travelled will become. The TA-SWISS study recommends also basing this kind of distance travelled-based taxation models on primary energy efficiency; this would avoid the risk of such a system change slowing the market penetration of electric cars. In

order to prevent negative feedback effects, an increase in the general cost of mobility is needed to ensure that more environmentally friendly and less expensive vehicles do not result in an increase in the general traffic.

The most important recommendations for a sustainable use of electric mobility<sup>4</sup>:

- Introducing mobility pricing models in order to offset the dwindling income from fuel duties.
- Duties relating to driving performance should be structured in such a way that they foster efficient vehicles and the combined usage of public and private modes of transport.
- Efficient vehicles should also be given preferential treatment when granting approval for passenger cars. This should take into account not only the vehicle's energy consumption during its operational lifetime, but should also assess its environmental impact over its lifecycle as a whole.
- In order to prevent negative feedback effects, an increase in the general cost of mobility is needed to ensure that more environmentally friendly and less expensive vehicles do not result in an increase in general traffic.
- Design and recycling guidelines need to be drawn up so that the materials used can be recycled and the dependency on primary raw materials can be reduced.

## **Conclusion**

The two TA-SWISS studies show that both biofuels and electric mobility could help to limit harmful CO<sub>2</sub> emissions and to reduce Switzerland's dependency on fossil fuels. For both technologies, however, the respective energy source has to be taken into account: Biofuel is only sustainable if it is produced from waste materials; while electric mobility can only be considered environmentally friendly if the batteries are charged with electricity from renewable or low CO<sub>2</sub> energy sources.

Electric mobility overall seems to have a higher potential than 2nd generation biofuels. Nevertheless, 2nd generation biofuels may play a subsidiary role, in particular for long distance transport and aviation. Therefore, the two technologies should be regarded as complementary and ways must be found to promote them both simultaneously, together with improved vehicle efficiency.



# United Kingdom

## Innovation for energy efficiency of buildings

In 2012, energy usage in UK buildings accounted for approximately 37% of UK carbon emissions, 24% from residential buildings and 13% from non-residential buildings.<sup>54</sup> A series of UK public sector organisations estimate that energy efficiency innovations have the potential to reduce cumulative emissions by up to 29 million tonnes of CO<sub>2</sub> (MtCO<sub>2</sub>) by 2020 and up to 159 MtCO<sub>2</sub> by 2050<sup>55,56</sup> and help the UK to achieve its EU Energy Efficiency Directive target of a 20% reduction on projected energy consumption by 2020.<sup>57</sup> Current UK innovations in building energy efficiency can be split into three main areas: construction, refurbishment and development of new materials and components.

### 1. Construction

Improved methods for constructing new buildings can lead to better energy efficiency than that achieved by previous approaches.

Innovations for new builds aim to lower carbon emissions from the build process and reduce the cost of constructing low carbon buildings. Such innovations include:

- The production and use of more sustainable materials for use in building frames, such as lightweight timber<sup>58</sup> or composite materials partly made up of crop materials (e.g. straw and hemp) which have negative embodied carbon.<sup>59</sup>
- The development of transportable factories for the production of whole structures, such as walls and beams. These factories allow the structures to be built close to the construction site, reducing the carbon footprint of transporting them. They also reduce the carbon emissions of construction projects by increasing the speed of completion by up to 30%<sup>60</sup> and could enable the use of robotics in construction, further improving efficiency.<sup>61</sup>

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<sup>54</sup> Committee on Climate Change, 2013. *Meeting Carbon Budgets: 2013 Progress Report to Parliament - Chapter 3: Progress reducing emissions from buildings*

<sup>55</sup> Technology Innovation Needs Assessment, 2012 *Domestic Buildings Summary Report*

<sup>56</sup> Technology Innovation Needs Assessment, 2012 *Non-domestic Buildings Summary Report*

<sup>57</sup> European Parliament, 2012. *Council Directive 2012/27/EU of 25/10/2012 on energy efficiency.*

<sup>58</sup> Innovate UK, *Innovative thinking to help deliver low carbon buildings* [Online] Available: [https://interact.innovateuk.org/zh/press-release-display-page/-/asset\\_publisher/u5igfmj8gOAF/content/innovative-thinking-to-help-deliver-low-carbon-buildings](https://interact.innovateuk.org/zh/press-release-display-page/-/asset_publisher/u5igfmj8gOAF/content/innovative-thinking-to-help-deliver-low-carbon-buildings) [Accessed 25 August 2015]

<sup>59</sup> University of Bath Department of Architecture and Civil Engineering. *Low-carbon materials* [Online] Available: <http://www.bath.ac.uk/ace/research/cicm/low-carbon-materials/> [Accessed 3 September 2015]

<sup>60</sup> Skanska, 2013. *Skanska secures government grant to trial new construction method* [Online] Available: <http://www.skanska.co.uk/news--press/display-news/?nid=zvBcN758> [Accessed 3 September 2015]

<sup>61</sup> Skanska, 2015. *Skanska wins grant to develop construction robots* [Online] Available: <http://www.skanska.co.uk/news--press/display-news/?nid=1x1pU3JM> [Accessed 3 September 2015]

## 2. Refurbishment

The energy efficiency of buildings can be improved through refurbishments. Innovative refurbishment techniques developed in the UK include:

- The use of laser technology to measure rooms and fit internal wall insulation. This minimises waste in materials cut, ensures rooms are fully insulated and speeds up refurbishment projects, all of which ultimately reduce GHG emissions.<sup>62, 63</sup>
- Two new energy efficient ventilation and temperature regulations systems. The first enables cool air to circulate around a building without a need for a fan, by incorporating air pipes and water coils into beams.<sup>64</sup> The second also allows heated fluids to pass through small tubes in a building's structure to allow both heating and cooling.<sup>65</sup>

## 3. Materials and components

New materials and components can enable buildings to be more energy efficient. Technologies being trialled include:

- New heat storage materials, known as phase change materials. These store heat from a warm room as they undergo a change of state, generally from solid to liquid and can release heat when a room cools.
- Development of materials that improve the absorption of solar heat. For example, Tata Steel are developing a micro-perforated, ridged steel that is treated to absorb high levels of solar radiation. This steel is attached to buildings, and creates a layer of warm air between the steel and the building wall. This warm air is then either pumped directly into the building.<sup>66</sup>
- Recovery systems to re-use water (and heat from water).<sup>67</sup>

## **Innovation for transportation and mobilities**

In 2013, transport was responsible for the emission of the equivalent of 116.8 million tonnes of CO<sub>2</sub> in the UK, over 20% of the country's total emissions.<sup>68</sup> To meet its greenhouse gas emission (GHG) reduction targets, UK Government and industry are exploring a number of

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<sup>62</sup> Technology Strategy Board, 2013 *Retrofit Revealed: The Retrofit for the Future projects – data analysis reports*

<sup>63</sup> Sustainable Homes, 2014. *Oxford whole house retrofit reduces CO2 by over 80%* [Online] Available; <http://www.sustainablehomes.co.uk/blog/bid/206447/Oxford-whole-house-retrofit-reduces-CO2-by-over-80> [Accessed 3 September 2015]

<sup>64</sup> ECA Energy Technology list, 2015. *Active chilled beams*

<sup>65</sup> University of Reading School of Construction management and Engineering. Radiant heating and cooling system using capillary tubes. [Online] Available: <http://www.reading.ac.uk/CME/research/cme-Radiant-heatingand-cooling-system-using-capillary-tubes.aspx> [Accessed 3 September 2015]

<sup>66</sup> TATA Steel, *Sustainable Building Envelope Centre* [Online] Available: <http://www.sbec.eu.com/> [Accessed 26 August 2015]

<sup>67</sup> Buildings Research Establishment, *BRE Innovation Parks* [Online] Available: <http://ipark.bre.co.uk/index.jsp> [Accessed 25 August 2015]

<sup>68</sup> Department of Energy and Climate Change, 2015. *2013 UK Greenhouse Gas Emissions, Final Figures*. London: Department of Energy and Climate Change

innovation options. These include alternative fuels, new car usage models, improved cycle safety, better transport planning, single ticketing and new lightweight transport materials.

## 1. Alternative fuels

There has been some innovation and increased uptake of potentially lower carbon fuel alternatives, including electricity, hydrogen and natural gas.

Electrification of transport is increasing. A UK Government grant of up to £5,000<sup>69</sup> has been credited with accelerating the increase in purchases of private electric and electric-hybrid road vehicles, with a total of 35,705 eligible vehicles registered since the grant's introduction in 2011.<sup>70</sup> Currently around 40% of the UK rail network is electrified and there are plans to expand across key routes.<sup>71</sup> Electric bus numbers are also increasing. For example, in London numbers of diesel-electric hybrid buses are planned to rise from 800 in 2014 to 1,700 (20% of the fleet) by 2016.<sup>72</sup> Finally, new wireless charging technology has been deployed in Milton Keynes for a fleet of electric buses, allowing buses to recharge at stops.<sup>73</sup>

Hydrogen vehicle uptake has been slow. Zero emission hydrogen buses are in operation in London (8 buses) and Aberdeen (10 buses)<sup>74</sup> and innovative hydrogen production and bus refuelling stations have been jointly developed by UK gas production and power distribution companies.<sup>75,76</sup>

Natural gas use has been trialled in around 200 heavy goods vehicles (which are unsuited to electrification).<sup>77</sup> The vehicles tend to refuel at the companies' private fuelling stations, as public infrastructure for natural gas vehicles is limited. Using natural gas produces up to 28% lower GHG emissions (up to 65% in the case of bio methane) compared to diesel.<sup>78</sup>

## 2. Car usage models

In the UK, there has been a rise of business models that use web and app platforms to enable car sharing.<sup>79</sup> This could reduce emissions by encouraging people to combine car rental with

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<sup>69</sup> GOV.UK *Plug-in car and van grants*. [Online]. Available: <https://www.gov.uk/plug-in-car-van-grants/overview>. [Accessed 24 August 2015]

<sup>70</sup> 102 EV Registrations 2010-2015, SMMT <http://www.smmt.co.uk/category/news-registration-evs-afvs/>

<sup>71</sup> Network Rail, 2013. *Technical Strategy*.

<sup>72</sup> Network rail, *Electrification* [Online]. Available: <http://www.networkrail.co.uk/asp/12273.aspx>. [Accessed 20 August 2015]

<sup>73</sup> Transport for London, 2014 *New hybrid bus charging technology trial announced* [Online]. Available: <https://tfl.gov.uk/info-for/media/press-releases/2014/august/new-hybrid-bus-charging-technology-trial-announced>. [Accessed 20 August 2015]

<sup>74</sup> IEET and ITS-UK, 2014. *Local Authority Guide to Emerging Transport Technology*

<sup>75</sup> Aberdeen Invest Live Visit *Hydrogen Bus Project* [Online]. Available: <http://aberdeeninvestlivevisit.co.uk/Invest/Aberdeens-Economy/City-Projects/H2-Aberdeen/Hydrogen-Bus/Hydrogen-Bus-Project.aspx> [Accessed 27 August 2015].

<sup>76</sup> Air Products, 2014. *Bringing Hydrogen to London's Streets*

<sup>77</sup> Aberdeen Invest Live Visit *H2 Aberdeen: Who is involved?* [Online]. Available: <http://aberdeeninvestlivevisit.co.uk/Invest/Aberdeens-Economy/City-Projects/H2-Aberdeen/Hydrogen-Bus/Hydrogen-Bus-Who-is-involved.aspx> [Accessed 02 September 2015]

<sup>78</sup> C. L. Fevre, 2014. *The Prospects for Natural Gas as a Transport Fuel in Europe*. The Oxford Institute for Energy Studies

<sup>79</sup> C. Kluyver, 2014 *Foot on the gas?* National Grid [Online]. Available: <http://www.nationalgridconnecting.com/foot-on-the-gas/>. [Accessed 20 August 2015].

public transport.<sup>80</sup> Other schemes, such as the E-Car Club, encourage electric car use by taking the up-front cost away from the individual.<sup>81</sup>

### 3. Cycle Safety

To incentivise cycling in London, cycle safety innovations are being trialled. For example, large vehicles are being fitted with systems to electronically detect cyclists in blind spots.<sup>82</sup>

### 4. Planning and data

The UK is improving transport planning by collecting larger amounts of data and using more advanced data analytics. Data on aviation is being used to improve air traffic management and integration with other transport services. For public transport data streams such as social media can be used to ‘map sentiment’ to establish real time needs of transport users and enable dynamic timetabling.<sup>83</sup> These complement the existing use of large volumes of data about road and rail journeys that are used by transport authorities to increase travel efficiency.

### 5. Single ticketing

Examples include London’s Oyster card and acceptance of contactless debit/credit cards, which can be used across different forms of public transport. These are increasingly widespread across the UK. They can encourage use of public transport and also reduce idle times of buses, making journeys more efficient and lowering emissions.<sup>84</sup>

### 6. Lightweight materials

The UK is aiming to develop expertise in designing and researching lightweight materials that increase vehicle fuel efficiency. Funding has been awarded to a variety of projects, including research into the use of lightweight aluminium matrix composites to reinforce automotive components.<sup>85</sup>

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<sup>80</sup> Prakash, A. and Kar-Gupta, S., 2014 *Rise of the car-sharing apps poses threat to auto sector* Reuters [Online] Available: <http://uk.reuters.com/article/2014/12/18/uk-autos-apps-idUKKBN0JW1TJ20141218>. [Accessed 18 August 2015]

<sup>81</sup> POSTnote 496 Trends in Transport

<sup>82</sup> GOV.UK, 2015 *Crowdfunding investors celebrate successful exit from E-Car Club* [Online]. Available: <https://www.gov.uk/government/news/crowdfunding-investors-celebrate-successful-exit-from-e-car-club>. [Accessed 20 August 2015]

<sup>83</sup> Transport Research Laboratory, *Cycle Detection using Intelligent Transport Systems* [Online] <http://www.trl.co.uk/solutions/sustainability/cycling/safer-cycling-innovations/cycle-detection-using-intelligent-transport-systems/> [Accessed 27 August 2015]

<sup>84</sup> Transport Systems Catapult, 2013. *Transport Systems Catapult: Five-Year Delivery Plan to March 2018 (abridged)*

<sup>85</sup> School of Engineering - University of Portsmouth, 2009 *How Oyster Cards reduce the environmental impact of the London bus network* [Online]. Available: <http://mosaic.cnfolio.com/B101CW2008B180>. [Accessed 24 August 2015].

## Innovation to feed the world with minimal greenhouse gas emissions

Agriculture contributes 9% of the UK's greenhouse-gas (GHG) emissions burden and 10-12% globally. Although there is a long-term declining trend from UK agriculture, the sector in England has a carbon budget reduction objective of 3 million tonnes of carbon dioxide equivalent (MtCO<sub>2</sub>e) per annum set for the period 2018-2022 in line with the requirements of the Climate Change Act, an 11% reduction on 2008 emissions levels. Similar reductions are required for Scotland (1.3), Wales (0.6) and Northern Ireland (0.276). Nitrous oxide contributes more to global warming than any other gas emitted from agriculture (UK emissions - 30.3 MtCO<sub>2</sub>e) with soils are the main source of emissions (90%). It arises from microbial activity following application of man-made nitrogen fertilisers, farmyard manures and slurries and re-deposition of airborne nitrogen pollution to land. The main sources of agricultural CO<sub>2</sub> emissions are on-farm energy use and crop storage (UK emissions - 6.6 MtCO<sub>2</sub>e). The majority of methane emitted is from fermentation by livestock digestive systems and the anaerobic break-down of stored manures and slurries (UK emissions - 22.3 MtCO<sub>2</sub>e).<sup>86</sup>

However, along with any mitigation requirements agricultural systems will also need to adapt radically to meet the rising global demand for food,<sup>87</sup> decreasing water availability<sup>88</sup> and increasing pest resistance to available agrochemicals, such as herbicides.<sup>89</sup> The UK Agri-Tech Strategy was launched in 2013 to encourage innovation in agriculture to address these challenges. Combining UK research strengths in areas such as soil and crop science, robotics, and ICT could lead to products and services for export. Emerging key approaches to address GHG emissions include precision farming techniques, controlled-environment farming, alternative animal feeds and edible insects:

- Precision farming uses technology, agricultural engineering and data to help farmers apply treatments efficiently through the 4Rs: “right intervention, right time, right place, and right amount”. For example, farmers can target fertiliser where it is most needed, rather apply a uniform rate to the whole field, potentially reducing costs and overall use. In 2012, 22% of English farms used Global Positioning Systems and 20% used soil mapping to optimise treatments. More efficient use of inputs can contribute to sustainable intensification of food production – optimising yields while reducing environmental impacts, including GHG emissions. However, high initial capital costs are likely to limit adaption to larger farms.<sup>90</sup>

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<sup>86</sup> Innovate UK, 2012 *Competition winners announced for £56 million investment into low carbon vehicles* [Online] Available: [https://connect.innovateuk.org/web/energy-efficiency/article-view/-/blogs/competition-winners-announced-for-%C2%A356million-investment-into-low-carbon-vehicles?\\_33\\_redirect=https%3A%2F%2Fconnect.innovateuk.org%2Fweb%2Fenergy-efficiency%2Farticle-view%3Fp\\_p\\_id%3D33%26p\\_p\\_lifecycle%3D0%26p\\_p\\_state%3Dnormal%26p\\_p\\_mode%3Dview%26p\\_p\\_col\\_id%3Dcolumn-1%26p\\_p\\_col\\_count%3D1%26p\\_r\\_p\\_564233524\\_tag%3Dlightweight%2Bbodyshells](https://connect.innovateuk.org/web/energy-efficiency/article-view/-/blogs/competition-winners-announced-for-%C2%A356million-investment-into-low-carbon-vehicles?_33_redirect=https%3A%2F%2Fconnect.innovateuk.org%2Fweb%2Fenergy-efficiency%2Farticle-view%3Fp_p_id%3D33%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-1%26p_p_col_count%3D1%26p_r_p_564233524_tag%3Dlightweight%2Bbodyshells) [Accessed 26 August 2015]

<sup>87</sup> POSTnote 486, Emissions from Crops

<sup>88</sup> POSTnote 499, Novel Food Production

<sup>89</sup> POSTnote 385, Water in Production and Products

<sup>90</sup> POSTnote 501 Herbicide Resistance

- Technological advances in lighting, hydroponics and climate control are enabling farming to move into controlled indoor environments. Controlled environment farming is an extension of greenhouse-based horticulture, which allows total control of the growth environment, with crops grown all year round and protected from extreme weather events, such as storms, and from pest attacks. Controlled-environment farming can increase the yield of some crops and decrease resource use, but is not suited to staple crops like maize and wheat.<sup>91</sup>
- Sustainable sources of animal feed such as insects could reduce the dependence on feed soy from tropical rain forest areas. Insect meal is rich in protein and nutrients, and industrial rearing of some species in factories could be raised on manure and organic food waste; although manure cannot legally be used as feed under current EU regulations.<sup>92</sup> The UK Food and Environment Research Agency (FERA) is co-ordinating an international research project – ProteINSECT – investigating insect rearing for feed production, with large-scale production being commercialised by companies such as Entomotech in Spain.<sup>93</sup>
- Vegetable protein from nuts, soy, pea, chickpea and lupin could provide an alternative to livestock protein,<sup>94</sup> but more novel protein sources may also be needed. At least 1,900 insect species are known to be safe to eat for humans,<sup>95</sup> and although the nutritional content varies between species, the protein and nutrient profile of insects broadly resembles that of meat. **Erreur ! Signet non défini.** Insect rearing produces less greenhouse gas and ammonia emissions per kg of protein when compared to pig and cattle production, but there are likely to be issues around public acceptance.<sup>96</sup>

## Citizens' involvement in the use of smart technologies

Smart technologies enable accurate, detailed and real time information to be relayed to a user. This can help to facilitate changes in behavior that lead to lower greenhouse gas emissions.<sup>97</sup> Key smart technologies that have been introduced to the UK include smart meters of energy and water and those designed to facilitate more efficient travel.

### 1. Smart Metering

Smart metering improves the recording of energy and water usage and communication of this information to consumers and suppliers. Better communication to consumers can help them

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<sup>91</sup> POSTnote 505 Precision Farming

<sup>92</sup> POSTnote 499 Novel Food Production

<sup>93</sup> European Union, 2009. Regulation (EC) No 1069/2009 of the European Parliament and of the Council. *Official Journal of the European Union*, L 300: 1-33.

<sup>94</sup> POSTnote 499 Novel Food Production

<sup>95</sup> Day, L, 2013. *Trends in Food Science and Technology* 32: 25-42.

<sup>96</sup> Van Huis, A, 2013. *Annual review of Entomology*, 58:563-83.

<sup>97</sup> POSTnote 499 Novel Food Production

identify and reduce wasteful usage, as well as prompt the purchase of more efficient devices.<sup>98</sup>

Following the 2008 and 2011 Energy Acts, UK energy suppliers are obliged to take all reasonable steps to install electricity and gas smart meters and in home displays (IHDs) in all domestic and small non-domestic properties by 2020. The aim is to achieve close to 100% coverage, with an estimated 53 million smart meters to be installed, ensuring the UK is compliant with the 2012 EU Energy Efficiency Directive. In addition to financial savings to consumers, suppliers and operators, UK trials of smart meters suggest that they may reduce electricity and gas consumption by between 3-19% and 3-5% respectively.<sup>99</sup> The smart meter roll-out is also expected to provide an estimated nationwide benefit of £1.3 billion from reduced CO<sub>2</sub> emissions and improved air quality.<sup>100</sup>

Reduction in water usage contributes to energy savings (and thus reduced GHG emissions) by reducing the amount of energy used to distribute, treat and heat water. Research suggests that smart water meters with IHDs can reduce water usage by 3-4% over 18 months. However, most UK households are charged at a fixed annual rate for water and are not fitted with a meter. Water meters will be fitted to a property if customers request it, if the property is new or if the property is in an area the water company designates as 'water stressed'. A nationwide roll-out is unlikely due to technical and logistical obstacles, for example water meters are often outdoors and underground, so it would be difficult to transmit information from them in to a house.<sup>101</sup>

Smart technologies can also be used on larger non-domestic properties (such as offices) to energy savings by other means. For example, apps can encourage users to reduce their energy use through a points system with prizes for energy saving behaviour. The ability to compare data with other building users and forums for discussion with building users and maintenance staff. In one project these methods facilitated a 20% saving in gas use when trialled and was launched publically in 2012.<sup>102</sup>

## 2. Smart transport internet applications

These applications gather real-time data on transport timetables, congestion, delays and the location of the application user to allow users to plan the quickest (or another preferred) route to their destination. Informing individual transport decisions enables improved balance between transport supply and demand, reducing the need for new infrastructure, services or vehicles,<sup>103</sup> which in turn reduces GHG emissions from transport. One such app, CityMapper was developed and launched in London in 2012. Estimates suggest that CityMapper is

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<sup>98</sup> POSTnote 417 Energy Use and Behaviour Change

<sup>99</sup> POSTnote 417 Smart Metering of Energy and Water

<sup>100</sup> POSTnote 417 Smart Metering of Energy and Water

<sup>101</sup> National Audit Office, 2014. *Update on preparations for Smart Metering*

<sup>102</sup> POSTnote 417 Smart Metering of Energy and Water

<sup>103</sup> The University of Warwick, EMPOWER: Empowering empathic energy efficiency design [Online] [http://www2.warwick.ac.uk/fac/sci/wmg/research/experiential\\_engineering/projects/pastprojects/empower/](http://www2.warwick.ac.uk/fac/sci/wmg/research/experiential_engineering/projects/pastprojects/empower/) [Accessed 26 August 2015]

installed on approximately half the iPhones in London<sup>104</sup> and the app has been rolled out in a further 28 cities worldwide so far.<sup>105</sup>

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<sup>104</sup> Catapult: Future Cities, 2014. *How can the UK innovate for the world's cities?*

<sup>105</sup> CityMapper, 2015. *CityMapper* [Online]. Available: [www.citymapper.com](http://www.citymapper.com). [Accessed 25 August 2015]



# United States

## Innovation for energy efficiency of buildings

In 2014, U.S. buildings consumed 41 percent of the nation's energy and emitted about 39 percent of its carbon dioxide. Green building practices can create more resource-efficient buildings, lower operating costs, reduce pollution, and improve indoor air quality. Although there is no generally accepted definition for green building, analysis of various standards, such as the widely-used Leadership in Energy and Environmental Design (LEED) rating system, shows that a green building incorporates one or more of the following six generally recognized elements: (1) *energy conservation or efficiency measures*: to reduce energy consumption in a building or use renewable sources of energy; (2) *indoor environmental quality measures*: to enhance indoor environmental quality through ventilation and use of low pollution-emitting materials; (3) *water conservation or efficiency measures*: to reduce water consumption inside and outside the building; (4) *integrated design principles*: to plan and design using a project team with variety of stakeholders, such as architects, builders, and building engineers; (5) *sustainable siting or location measures*: to locate building so as to minimize impact on the nearby ecosystem; and (6) *measures to reduce the environmental impact of materials*: to reduce the environmental impact of materials, such as using sustainably grown materials and products with high recycled content, among other things.

U.S. federal laws have directed government agencies to foster green building practices in the “nonfederal sector.” This accounts for most of the nation's buildings and includes state and local government as well as private sector buildings. There are a large number of federal initiatives across multiple U.S. government agencies designed to promote green building practices in the nonfederal sector. The U.S. government is also taking steps to implement energy efficient building requirements in federal buildings, often by using energy savings performance contracts (ESPC), where private contractors finance the up-front costs of energy improvements. Agencies then repay contractors from the savings, such as those resulting from lower utility bills. Cost and energy savings that contractors reported to agencies for most ESPCs have met or exceeded expectations, but some of these savings may be overstated.

Use of renewable energy is another way for buildings to help ameliorate the effects of greenhouse gases on climate change. State policies requiring the use of renewable energy in electricity production, as well as U.S government funding and tax credits for renewable energy producers, were major factors that resulted in a 30-fold increase in production and a 19-fold increase in consumption of electricity from wind and solar energy in the United States during the years from 2000 to 2013. In particular, solar energy can be used to heat, cool, and power homes and businesses with a variety of technologies that convert sunlight into usable energy. Examples of solar energy technologies include photovoltaics, concentrated solar power, and solar hot water. Solar energy technology advancement activities are financed through both public and private investment. Majority of the initiatives funded by six U.S.

agencies have supported photovoltaic technologies. These government initiatives included multiple technology advancement activities ranging from basic research to commercialization by providing funding to various types of recipients including universities, industry, and federal laboratories and researchers, primarily through grants and contracts.

Additionally, since power plants are the largest major source of greenhouse gas emissions in the United States, President Obama and the Environmental Protection Agency have recently established the Clean Power Plan, which sets standards for existing power plants to reduce carbon dioxide emissions by 32 percent from 2005 levels by 2030. If successful, this plan would lead to 30 percent more renewable energy generation in the United States.

## **Innovation for transportation and mobilities**

Transportation accounts for 71% of U.S. petroleum use and 33% of the nation's carbon emissions, and predicted surges in population growth will trigger ever greater demand for fuel to power vehicles. Energy-efficient transportation strategies could reduce both oil consumption and greenhouse gas emissions. Using less motorized mobility, increasing vehicle efficiency, and using fuels that are less intensive in petroleum and carbon can reduce GHGs and petroleum use while still meeting transportation needs. In the United States, two key regulations—the fuel economy and greenhouse gas vehicle emission standards, as well as the Renewable Fuel Standard—have contributed to declining petroleum-based fuel consumption.

Another law requires that, by 2022, U.S. transportation fuels contain 36 billion gallons of renewable fuels, of which 15 billion gallons of renewable fuel may come from corn ethanol but the remainder must come from advanced biofuels, such as ethanol made from cellulosic sources like switchgrass, and forest and agricultural residues such as sawdust and sugarcane. There are several key challenges in meeting these requirements, including the lack of sufficient cellulosic biofuel commercially available to meet the mandate. Nevertheless, biofuels from sustainably-harvested biomass could supply significant shares of the markets for jet fuel, gasoline, and diesel if the U.S. government's biofuels technology goals are met, these markets are mature, and projected market conditions exist. The U.S. government also supports the development and use of alternative jet fuels from non-petroleum feedstocks, including renewable biomass (such as crop and tree residues, algae, or separated municipal solid waste). Achieving price competitiveness for alternative jet fuels is the overarching challenge to developing a viable market. As such, no alternative jet fuels are currently commercially available at prices competitive with conventional jet fuels.

An option for lowering greenhouse gas emissions from transportation is the adoption of electricity- and hydrogen-powered vehicles. However increased adoption of such vehicles depends on simultaneous and widespread development of infrastructure for hydrogen production, distribution, and fueling, as well as for electric vehicle charging. While developing this retail fueling infrastructure would be costlier than maintaining current infrastructure, infrastructure costs are only a small portion of total fuel costs. Strong policies and incentives may be needed to overcome consumer cost and range concerns, address

automaker production and deployment issues, and encourage energy suppliers to rapidly build infrastructure. Recognizing that uncertain consumer acceptance and fueling infrastructure development may create significant investor risks, the full transition from conventional vehicles could easily take 35-50 years.

## **Innovation to feed the world with minimal greenhouse gas emissions**

The agricultural sector is a major part of the U.S. economy and it emits about 6 percent of total U.S. greenhouse gas emissions, but U.S. lands (mostly forestlands) sequester enough carbon to offset 12 percent of total greenhouse gas emissions. Sources of these emissions include fuel consumption, fertilizer that can emit nitrous oxide, and methane emissions from livestock. Farmers can take certain mitigation actions to reduce greenhouse gas emissions and sequester carbon. For example, farmers can use energy-efficient buildings, vehicles, or farm equipment that runs on renewable energy, rather than fossil fuels. In addition, farmers can implement mitigation measures, such as no-till farming and precision agriculture. Adoption of precision agriculture can reduce environmental harm from the overapplication of inputs such as fertilizers and pesticides, which can reduce nitrous oxide emissions. Through the digestive process, livestock emit a considerable amount of methane, a greenhouse gas; reducing these emissions is another mitigation strategy. Work is being done to alter the diet of cattle and to improve manure management practices in an effort to reduce methane emissions.

Agriculture in the United States has been and will continue to be affected by climate change, which will likely cause an increase in temperature, rainfall intensity, and extreme events in some areas, and extreme climate conditions, such as sustained droughts and heat waves. Table 1 summarizes the potential impact of climate change on agriculture in the United States.

Category	Projected Changes	Examples of impacts on agriculture
Temperature	Increase in average U.S. temperatures of between 1.6°C and 5.5°C by end of the century.	Crop yield losses; Longer growing season; Increased irrigation needs in some areas; Increase in animal stress
Carbon dioxide	Increased levels of atmospheric carbon dioxide.	Increase in plant growth for some species
Water	Change in the timing, intensity, and amount of rain/snow mix; Increase in heavy rain as well as drought conditions.	Increase in water use due to higher temperatures; Less growth and lower yields; Challenges in getting water to crops at the right time; Increase in flooding events and erosion
Extreme conditions	Increase in droughts and more extreme precipitation events.	Increase in soil erosion; Altered water availability; Loss of organic matter in soil

Weeds, insects, and disease	Increase in weeds, insect population levels, and disease; Change in the geographic distribution of pests.	Change in yields and quality of crops. Potentially increased herbicide and pesticide use
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Table 1: Projected Impacts of Climate Change on Agriculture in the United States

The U.S. government’s climate change priorities for agriculture include, among other things, providing better information to farmers on future climate conditions. These priorities generally align with national priorities, which include promoting actions that reduce greenhouse gas emissions, advancing climate science, developing tools for decision makers, and developing better projections of future climate conditions. The government is engaged in research efforts aimed at better understanding climate change's impacts on agriculture and providing technical assistance to farmers. Through the use of existing conservation and energy programs, the aim is to reduce greenhouse gas emissions and sequester carbon so it is not released, or is actively withdrawn, from the atmosphere.

## **Citizens’ involvement in the use of smart technologies**

National surveys of U.S. public opinion have found broad public support for a variety of measures to increase energy efficiency and diversify the energy supply. Based on surveys, about three-quarters of the U.S. public strongly or somewhat support developing more fuel-efficient cars, power plants, and other such technologies; encouraging businesses to reduce their carbon dioxide emissions; and relying more on wind and solar power. About 65 percent of the public strongly or somewhat supports actions to encourage people to reduce carbon dioxide emissions—for example, by driving less or renovating their homes. About 45 percent strongly or somewhat support relying more on nuclear power because it reduces greenhouse gas emissions.

Research shows that citizens are more inclined to take action to combat climate change if they see their actions bringing benefits to themselves and the society; and if they have emotional feelings such as fear and anger at the present reality and future dangers. Their judgments and emotions depend on whether they give priority to moral outcomes. Because of this, messages about the consequences of climate change should be framed in the context of the values that are central to particular audiences. Simply providing information to citizens about the dangers of climate change is not likely, in itself, to stimulate effective action. Before information leads to action, citizens have to recognize personal responsibility for the problem and they must have information about specific actions that they can take to counter climate change.

The U.S. government disseminates such actionable information to citizens through agency websites. For example, one website points out how driving a car, using electricity to light and heat your home, and throwing away garbage all lead to greenhouse gas emissions and how citizens can reduce emissions through simple actions such as changing old appliances and light bulbs with ENERGY STAR products, powering down electronics, using less water, and

recycling. Such energy efficiency measures in homes and buildings could help counter effects of climate change because a large portion of total U.S. energy consumption occurs in homes and buildings. However, people tend to undervalue energy savings because of misperceived energy prices, imperfect information about energy efficiency, and biased reasoning about energy savings. Some options that could counter people's misperceptions would be to reflect the social costs of energy use in the price of energy, provide financial incentives for reduced energy use, improve energy-efficiency standards, and provide better information about energy efficiency. Many of these options are in use nowadays in the United States.

# European Union

Taking into account the specific character of STOA, which, unlike other EPTA members, advises the European Parliament (EP) and is not bound to a particular country, this contribution will address issues at a European level. The aim is twofold:

- to describe succinctly at the legislative level of the European Union (EU) the state of play and main challenges in the four headings proposed by the conference organisers, and
- to present the outcomes (identified and assessed policy options) of selected studies, relevant to the various headings, that STOA has recently carried out.

## Innovation for energy efficiency of buildings

### 1. EU legislation: the state of play

Buildings are considered to be one of the main sources of energy consumption at EU level and are, in fact, responsible for a major part of CO<sub>2</sub> emissions in the EU. They would therefore have to be taken duly into account by any European strategy to increase energy efficiency and fight climate change. The EU has adopted a wide range of energy-specific measures, but has also integrated energy efficiency clauses into existing instruments (e.g. applying procurement criteria that take energy efficiency into account). Besides these legislative initiatives, a series of financial instruments have also been adopted at EU level in order to boost the practical implementation of the measures in financial and social terms.

According to the Energy Efficiency Directive (2012/27/EU)<sup>106</sup>, EU Member States should:

- proceed with considerable energy-efficient renovation of central government buildings,
- purchase buildings only if their energy efficiency has been ensured, and
- develop long-term strategies for building renovation at national level.

Since 2010, the indicative target of a 20% improvement in energy efficiency<sup>107</sup> is expected to be achieved also through the implementation of the Energy Performance of Buildings Directive (2010/31/EU)<sup>108</sup>. The Directive imposes requirements concerning the need for issuing energy performance certificates when selling or renting buildings in the EU and

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<sup>106</sup> Directive 2012/27/EU of the EP and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC *OJ L 315, 14.11.2012, p. 1–56*

<sup>107</sup> Communication from the EC, Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth *COM(2010)2020: [http://ec.europa.eu/archives/growthandjobs\\_2009/pdf/complet\\_en.pdf](http://ec.europa.eu/archives/growthandjobs_2009/pdf/complet_en.pdf)*

<sup>108</sup> Directive 2010/31/EU of the EP and of the Council of 19 May 2010 on the energy performance of buildings *OJ L 153, 18.6.2010, p. 13–35*

introduces inspection schemes or equivalent measures for heating and air conditioning systems. For the first time, an EU legal instrument of this kind sets a specific deadline by which all new buildings should be of nearly zero-energy character (by 31 December 2020, for public buildings by 31 December 2018). The Directive also introduces minimum energy performance requirements for new buildings, major building renovation or replacement of building components. The Member States are asked to introduce financial measures at national level, in order to enhance the energy efficiency of buildings. The European Commission (EC) has recently increased the target for improvement in energy efficiency by 7% by 2030 (so, in total 27%) through the 2014 Energy Efficiency Communication<sup>109</sup>.

Although some Member States, among which France and Germany, provide special preferential loans and fiscal reduction of up to 30% of the cost for energy efficiency renovations, so as to achieve the targets of the Directive, the overall implementation of the directive has been deficient. A European Commission progress report from 2013 found that Member States had to make a lot more efforts in favour of nearly zero-energy buildings. According to the same report, the overall rate of increase in building energy efficiency has been limited to 1.4% annually, with 64% of space heaters still being inefficient and 44% of windows still being single-glazed<sup>110</sup>.

As main problems are identified a slow transposition process, the financial crisis that has minimised the capacity of certain Member States and parts of the society to benefit from investment in energy efficiency measures and lack of incentives that could strengthen the consumers' capacity to improve the energy performance of building elements and revamp the building renovation process. Among the measures that could strengthen the implementation of the Directive is the introduction of a binding target to boost public building renovation and of criteria in public spending favouring energy efficiency, as well as the deployment of Energy Service Companies (ESCOs) as catalysts for renovation.

## **Innovation for transportation and mobility**

### 1. EU legislation: the state of play

The Intelligent Transport Systems (ITS) Directive (2010/40/EU)<sup>111</sup> set the basis for the coordinated deployment and use of ITS across Europe through six priority actions:

- the provision of EU-wide multimodal travel information services and (b) real-time traffic information services;

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<sup>109</sup> Communication from the EC to the EP and the Council, Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy *COM(2014) 520 & SWD(2014) 255*

<sup>110</sup> Report from the EC to the EP and the Council, Progress by Member States towards Nearly Zero-Energy Buildings *COM(2013)483*

<sup>111</sup> Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of intelligent transport systems in the field of road transport and for interfaces with other modes of transport *OJ L 207, 6.8.2010, p. 1-13*

- data and procedure for the provision, where possible, of road-safety-related minimum universal traffic information free of charge for users;
- the harmonised provision of an interoperable EU-wide eCall;
- the provision of information and (f) reservation services for safe truck parking places.

The implementation and specification (mostly through implementing acts) of the ITS Directive has proven to be a success in general, especially given the recent adoption of Regulation 2015/758<sup>112</sup> concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service. Nevertheless, the rapid deployment of new transport-related technologies has pointed to the need for introducing new priorities, beyond what is currently referred to in Annex I of the Directive.

The main challenge has been the adoption of necessary specifications – including functional, technical, organisational or service provisions – to ensure that ITS are deployed and operated in a compatible and continuous manner for those priority areas (real-time traffic and multimodal travel information services), where no EU legislative action has been taken.

## 2. Relevant STOA studies

With the increasing scarcity of fossil fuels and the more and more alarming impact of greenhouse gas emissions, it is becoming crucial to consider alternatives for the technology and the fuels employed in transport. In addition to making transport more efficient and friendly to the environment, consumer awareness and readiness to change behaviour are imperative in order to move towards a sustainable transport future.

Transport issues are covered by the STOA priority area '*Eco-efficient transport and mobility*'. In recent years, STOA has carried out a number of studies examining the options available for policy action to achieve eco-efficient transport, thus reducing the dependence of Member States on oil imports and helping Europe address climate change.

The main conclusions drawn by the above-mentioned STOA studies are listed below:

- Economic growth will benefit from transport becoming more efficient and respectful of the environment. The STOA study '*Eco-efficient transport futures for Europe*' (2013)<sup>113</sup> ([options brief](#) / [full study](#)) established that, to optimise eco-efficiency, one has to adopt a broader approach and a systemic perspective. Policy options comprise improvements on the fuel and information technology side, tackling non-technical factors (technology costs, infrastructure issues, lack of policy coordination) and paying attention to end-user concerns, preferences and habits.

<sup>112</sup> Regulation (EU) 2015/758 of the EP and of the Council of 29 April 2015 concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC *OJ L 123, 19.5.2015, p. 77–89*

<sup>113</sup> '*Eco-efficient transport futures for Europe*', EP 2013 (IP/A/STOA/FWC/2008-096/LOT2/C1/SC1/SC9); authors: J. Schippl, M. Edelman, M. Puhe, M. Reichenbach (Institute for Technology Assessment and Systems Analysis (ITAS), Karlsruhe Institute of Technology (KIT))



- Transport systems could change dramatically through the use of new technologies. Realising that an increase in urban transport can have a disastrous impact on the health and the quality of life of the urban population and on the quality of the urban environment, the 2012 study '*Technology options in urban transport*'<sup>114</sup> ([options brief](#) / [full study](#)) proposed a strategy for facilitating the development and deployment of more efficient transport systems based on: (i) reducing carbon use (clean fuels and propulsion technologies, optimised transport flows); (ii) encouraging users to shift towards more environmentally friendly modes of transport; and (iii) reducing the need to travel through virtual accessibility, making use of technology (e.g. video-conferencing).
- There are various decarbonised alternatives to the present European transport system and, although there is a consensus about the need to move in this direction, the relative performance of the alternatives has to be assessed. In this context, STOA published, in 2014, a study entitled '*Methanol: A future transport fuel based on hydrogen and carbon dioxide?*'<sup>115</sup> ([options brief](#) / [full study](#)). The study identified as the main challenge to the use of methanol as a fuel the development of efficient processes for capturing CO<sub>2</sub> and converting it to methanol, while preferably avoiding the addition of hydrogen via hydrogenation, as this would result in additional energy consumption.
- Renewable energy systems will increasingly replace fossil fuels in the energy mix of EU Member States. The 2011 STOA study '*Future metal demand from photovoltaic cells and wind turbines*'<sup>116</sup> ([study](#)) looked into one kind of potential difficulties that the deployment of renewable energy systems might encounter: the need to ensure an adequate supply of raw materials used in solar panels and wind turbines in the face of an ever increasing demand. It is imperative to prevent bottlenecks in the supply of raw materials, which may delay the transition to a low-carbon economy as part of climate change policy.

## Innovation to feed the world with minimal greenhouse gas emissions

### 1. EU legislation: the state of play

The social and environmental sustainability of biofuels has become a major issue of attention concerning the relationship between food production and climate change. The increasing

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<sup>114</sup> '*Technology options in urban transport: Changing paradigms and promising innovation pathways*', EP 2012 (IP/A/STOA/FWC/2008-096/LOT2/C1/SC8); authors: J. Schippl, M. Puhe (ITAS, KIT)

<sup>115</sup> '*Methanol: A future transport fuel based on hydrogen and carbon dioxide?*', EP 2014 (IP/A/STOA/FWC/2008-096/Lot1/C1/SC3); authors: S. Faberi, L. Paolucci ((Institute of Studies for the Integration of Systems (ISIS)) D. Velte, I. Jiménez (Tecnalia)

<sup>116</sup> '*Future metal demand from photovoltaic cells and wind turbines: Investigating the potential risk of disabling a shift to renewable energy systems*', EP 2011 (internal study); author: I. Öhrlund (STOA)

worldwide demand for biofuels and bioliquids, and the incentives for their use provided for by EU law have led the EU to introduce sustainability criteria for biofuels and bioliquids. A pan-European certification system of sustainable biofuels is, however, lacking; instead, EU legislation on biofuels pursues compliance via national or voluntary schemes.

The production of biofuels relates directly to land use change, as the former can displace food production to previously non-agricultural land, such as forests, resulting effectively in an increase in net greenhouse gases. To combat indirect land use change, the amendment of the current EU biofuels legislation (primarily the Renewable Energy Directive<sup>117</sup> and the Fuel Quality Directive<sup>118</sup>) has been proposed, but without success.

Moreover, the Europe 2020 Strategy - A resource-efficient Europe<sup>119</sup> calls for an increase in resource efficiency, to: "... find new ways to reduce inputs, minimise waste, improve management of resource stocks, change consumption patterns, optimise production processes, management and business methods, and improve logistics", without, however, specifying the means or setting binding targets for the achievement of these objectives.

The Roadmap to a Resource-Efficient Europe<sup>120</sup> follows up on this and emphasises the erosion of Europe's natural resources through increasing global demand, especially in the food sector. The Roadmap calls for "incentives to healthier and more sustainable production and consumption" and for halving food waste in the EU by 2020. At the same time, the Commission undertook to look into ways of limiting food waste through the full supply chain and reducing the impact of food production and consumption on the environment.

The EP 2011/2175(INI) report<sup>121</sup> on "how to avoid food wastage: strategies for a more efficient food chain in the EU" also strongly supports action in this area, calling upon the Commission "to take practical measures towards halving food waste by 2025 and at the same time preventing the generation of bio-waste".

## 2. Relevant STOA studies

### *'Technology options for feeding 10 billion people' (2013)*

Ideas about the future of the global food system are remarkably diverse. Increasing agricultural productivity will not suffice by itself to tackle the challenges lying ahead. EU Member States can draw upon a productive agriculture and food system, relatively robust

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<sup>117</sup> Directive 2009/28/EC of the EP and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC *OJ L 140, 5.6.2009, p. 16–62*

<sup>118</sup> Directive 2009/30/EC of the EP and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC *OJ L 140, 5.6.2009, p. 88–113*

<sup>119</sup> Communication from the EC to the EP, the Council, the European Economic and Social Committee and the Committee of the Regions, A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy *COM(2011)021*

<sup>120</sup> Communication from the EC to the EP, the Council, the European Economic and Social Committee and the Committee of the Regions, Roadmap to a Resource Efficient Europe *COM(2011)571*

<sup>121</sup> EP resolution of 19 January 2012 on how to avoid food wastage: strategies for a more efficient food chain in the EU (2011/2175(INI))

soils, a variety of efficient farming systems, good infrastructure and support services, a highly skilled workforce, an adequate investment capacity and first-class research institutions. This comprehensive STOA project, comprising five studies and a synthesis report, identified some key challenges that will confront Europe in a highly competitive global agri-food system and provided a set of policy options to address them. Two of these challenges – climate change and biodiversity losses – were the subject of one of the studies.

According to this study<sup>122</sup>, ‘sustainable intensification’ is key for increasing the productivity of agricultural land in the face of a changing climate. Changes in consumption patterns (particularly a decrease in meat consumption) and a greater effort over time to reduce food wastage are also necessary. The options identified by the study include: (i) incentivising farming practices that are resilient to climate change and respect biodiversity; (ii) implementing policies and regulations for constraining unsustainable practices; (iii) innovation for a productive climate-resilient agriculture that benefits biodiversity, whilst ensuring environmental safeguards for new technologies; (iv) funding to stimulate research; and (v) reducing adverse external impacts of agricultural practices and imported biofuels.

*‘Sustainable management of natural resources with a focus on water and agriculture’ (2013)*

Over 40% of Europe's total area is under agricultural use. Therefore, land management is critically important for maintaining natural resources, including water. Water resources are essential for all sectors of the European economy, but particularly for agriculture. Both water quality and quantity are important for sustainable water use and efficiency. Climate change is expected to exacerbate existing pressures on water, such as more frequent and more severe droughts and floods, affecting agricultural soils and requiring adaptation by water users, farms, regions and the EU Member States.

According to this study<sup>123</sup> (options brief), a major change is needed in approaches to water use and water efficiency in all sectors, and in approaches to sustainable soil and water management in agriculture, to meet EU targets for a good water conservation status. Key areas for improvement include: (i) effective implementation and enforcement of relevant legislation to protect Europe's waters; (ii) better integration and implementation of EU-level water priorities at sectoral, national and regional level; (iii) reducing water losses, and increasing water savings and efficiency; (iv) encouraging, also at national and regional levels, sustainable farming practices, promoted by the CAP<sup>124</sup>, to prevent soil erosion and loss of organic matter, capture soil carbon and improve water retention; (v) ensuring effective and

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<sup>122</sup> *‘Interactions between climate change & agriculture and between biodiversity & agriculture’*, EP 2013 (IP/A/STOA/FWC/2008-096/Lot3/C1/SC5-SC9); authors: E. Underwood, J. Poláková, B. Kretschmer, A. J. McConville, G. M. Tucker (Institute for European Environmental Policy (IEEP)), E. Dooley, A. Frelih-Larsen, S. Naumann (Ecologic Institute), S. Berman, M. Sarteel, C. Tostivint (BIO Intelligence Service), N. M. van der Grijp (Institute for Environmental Studies (IVM)), VU University), N. Maxted (School of Biosciences, University of Birmingham)

<sup>123</sup> *‘Sustainable management of natural resources with a focus on water and agriculture’*, EP 2013 (IP/A/STOA/FWC/2008-096/LOT3/C1/SC7); authors: J. Poláková, A. Farmer (IEEP), S. Berman (BIO Intelligence Service), S. Naumann, A. Frelih-Larsen, J. von Toggenburg (Ecologic Institute)

<sup>124</sup> Common Agricultural Policy: [http://ec.europa.eu/agriculture/cap-overview/2012\\_en.pdf](http://ec.europa.eu/agriculture/cap-overview/2012_en.pdf); <http://ec.europa.eu/agriculture/cap-post-2013/>

efficient use of EU funds for water management; and (vi) improved provision of information and tools for better decision-making in water and soil management.

## **Citizens' involvement in the use of smart technologies**

### 1. EU legislation: the state of play

The use of smart technologies as a means for the empowerment of citizens has recently become an issue of legal attention through various initiatives taken at the EU level. In the field of energy consumption, this empowerment becomes evident through the possibility, via smart grids and smart metering systems, of providing information on real-time consumption that allows consumers to manage their energy consumption actively.

The EC 2015 Energy Union Communication describes a vision, “where citizens ... benefit from new technologies to reduce their energy bills, participate actively in the market, and where vulnerable consumers are protected”<sup>125</sup>. It further stresses the need to reform energy markets and reinforce the power of consumers, who should have permanent access to comprehensive and accurate information, allowing them to make educated choices.

The strategic plan of the EU to replace at least 80% of electricity meters with smart meters by 2020<sup>126</sup> does not come without challenges, especially the need to protect consumers' privacy and personal data, as well as to address the digital divide within the EU.

### 2. Relevant STOA study

The deployment of smart grids raises a variety of challenges directly relevant for policy-makers and stakeholders. The 2012 STOA study ‘*Smart grids/Energy grids*’<sup>127</sup> (study / options brief), addressed issues raised by the large-scale deployment of smart electricity grids in Europe for policy-makers, industry, operators, regulators and society at large.

Among other things, the study found that, despite an increasing electricity demand, an increase in the cost of distributed generation may contribute to giving off-grid options a competitive advantage. It also discusses privacy and security issues, concerns about possible health effects, and the concomitant need for utilities to actively involve and empower end-users. The study argues that radical changes in operators' business models are necessary, based on a fair distribution of benefits among actors. It finally calls for a new regulatory framework to stimulate investment, while ensuring a level playing field in the sector.

Some of the study findings are explained in more detail below:

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<sup>125</sup> Communication from the EC to the EP, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy *COM(2015)080*

<sup>126</sup> EC Report, Benchmarking smart metering deployment in the EU-27 with a focus on electricity *COM(2014)356*

<sup>127</sup> ‘*Smart grids/Energy grids – The techno-scientific developments of smart grids and the related political, societal and economic implications*’, EP 2013 (IP/A/STOA/FWC/2008-096/LOT1/C1/SC2); authors: A. Ricci, S. Faberi (ISIS), N. Brizard, B. Bougnoux (Enerdata), M. Degel (IZT), D. Velte, E. Garcia (Tecnalia)

### *Technology and Innovation*

Smart Grids rely on a variety of technological advances, many of which have already proven their technical value. More innovation is needed and expected (notably in energy storage), but the real key to a successful deployment of smart grids will be the capability to integrate individual technologies and devices into a multi-layer, multi-actor service framework. Although technological changes are well on their way in all three layers of smart grid systems (energy technologies, market applications, information and communication), the most decisive progress is expected in information and communication technologies, which will play a fundamental role in ensuring the necessary integration.

### *Regulation*

The smartening of electricity grids is driven by a combination of economic interests and technical feasibility. The deployment of smart grids requires a stable, predictable policy framework to guarantee that the necessary resources, including investments, are mobilised. Current regulation models primarily aim at achieving cost-efficiency and are not designed to promote innovative investments, high R&D levels or ambitious targets. These models are likely to lead grid companies to keep to traditional approaches and postpone investments in technologies necessary for smart grid deployment. Regulatory models must therefore provide incentives for utilities to invest in smart grid technologies and applications.

### *Citizens' involvement*

Customers are at the centre of the transition towards smart grids, which will only take place if users shift from the traditional passive mode to an actively participative role. For this to happen several basic conditions must be met, including notably: (i) credible monetary savings (at least 10%); (ii) ease of use of home automation systems and other enabling technologies; and (iii) retaining control over one's own consumption. In order for smart grids to actually deliver benefits to the customer, utilities must drastically change their communication behaviour and engage in reciprocal actions.

# Conclusions and proposals

**Many considerations emerge from reading all these contributions.**

First, we note that innovation has already, in each country, a relatively significant position in political decisions regarding greenhouse gas emission reduction. This shows that, at governments' level, the pursued strategy of modifying technical infrastructures in order to gain better control of these emissions, while maintaining standards of living, prevails over drastic approaches consisting in a compelled return to nature. It is a way to take into account the need to work through a sustainable change, regarding technical infrastructures, rather than applying restrictions, always subject to reversibility.

The technological solutions considered are quite diverse among EPTA members. Even if some options seem genuinely prominent, such as energy storing, the idea that one invention will, by itself, radically resolve the problem of greenhouse gas emissions tends to pragmatically fade away behind an all-out strategy, which aims to achieve a cumulative set of relatively accessible gains. The explored range is widely shared. According to its natural or geographical advantages, in terms of biomass, for example, a particular country put special emphasis on one or the other technology.

Technological solutions have mostly been subject to evaluations by our counterparts from EPTA, which helped to give them proper weight in national strategies, reflecting the strategy defined by the European Union for its Member States. These assessments highlight the importance of life-cycle analyses, which sometimes lead to questioning the relevance of some options, and at least have resulted in a relative reframing of public support, as it was the case for first-generation biofuels, and photovoltaic solar power.

User behaviour is considered in all countries as an integral part of innovative technical processes. By being more or less suitable to these innovations, users can ensure the full effectiveness of the process, or otherwise reduce its scope, up to jeopardize the economic balance of innovation. Users' taste for comfort threatens all efforts made in building energy savings with a "rebound" effect. Car sharing innovative methods depend on the trust that users give to online services regarding the management of their private data, whereas agricultural innovations must take into account consumers' visceral fear of poison.

**Besides these general observations, confirming the need to devote explicit funding to innovation from climate change policies allocations, in particular to enable parallel pursuits of promising new technological opportunities, conducting life-cycle assessments and developing user involvement mechanisms, some elements directly related to the four areas covered by the different monographs stand out.**

In the housing sector, responsible for an average of 20% of greenhouse gas emissions, it is clear that it will be easier to achieve quick tangible results for new constructions, and that a longer term effort must be made to renovate older buildings, even if they were built recently.

In many countries, the so-called “passive” and “neutral” houses, energetically speaking, appear as a realistic goal. The technical solutions seem ready, but economic and financial barriers have yet to be overcome. In order to know if the investments being made are appropriate, tangible energy efficiency measurements have to be standardized. Occupants’ involvement is essential to the success of thermal renovation efforts, since it implies the adoption of new energy consumption behaviours. The use of non-carbon energy sources for electricity generation, the development of smart grids tracking buildings energy production, the widespread use of smart meters and active energy management systems, are considered to be the main targets to rapidly achieve.

In the transport sector, responsible for 20% of greenhouse gas emissions, the emphasis is being made on the need to reduce gasoline consumption per 100 kilometres and manage, as a first stage, to manufacture vehicles consuming only 2 litres per 100 kilometres. Rapid development of electric cars is considered, even if it still remains quite slow, in particular due to the lack of charging infrastructures, and to the insufficient autonomy of nowadays batteries used in these vehicles. Research and innovation are still needed to improve batteries, as well as designing new engines and producing cleaner fuels (such as biofuels of second or third generation, compressed air, hydrogen, or natural gas). The focus is finally put on the need to think in terms of mobility and intermodal means of transport. Adaptation to new forms of mobility (carsharing, change of attitude regarding possession) is absolutely necessary.

In the field of agriculture, responsible for 10% of greenhouse gas emissions, it appears that new techniques can be used to reduce farming carbon footprint, in particular regarding livestock. Several studies show the benefits of the transition towards precision farming, based on large-scale computer processing of vast amount of available data (Big Data), while mentioning the difficulties to generalize this approach. Research studies appear promising for specific crops with high protein content.

In all these areas, citizens’ involvement is crucial. But this cannot be decreed. Providing better information to citizens is certainly necessary but it is not a panacea. Increasingly, citizens want to be genuinely involved in decisions and no longer accept policies developed in technocratic ways and imposed from above. Democratic debate methods must be improved, and shared decision-making process must be put in place. But it is not only a matter of raising collective commitment; it must also lead to a change in everyday behaviour. Social innovation is now essential, but it is still in its early stages.

Innovation, which served as a frame to this report’s reflexions, appears as a fundamental dimension of climate change policies. It overcomes Malthusian approaches and their reversible effects, by providing sustainable solutions, integrated into basic technical infrastructures of society, in ways maintaining the standards of living in developed countries, and improving the quality of life in developing countries.

It must be ensured, however, that innovation does not raise new fears. Therefore its cultural acceptance as well as its ergonomics must be of primary concern.

Innovation cannot be an adjustment variable of climate change policies. It must be at the very core of their priorities.

# Appendix: Contributors to this report

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