THINK

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Some THINKing
on European energy policy

Think Tank advising the European Commission on mid- and long-term energy policy

Final Project BOOKLET
January 2012 - May 2013

SEVENTH FRAMEWORK PROGRAMME

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THINK was a project funded by the 7th Framework Programme from June 2010 until May 2013. It provided knowledge support to policy making by the European Commission in the context of the Strategic Energy Technology Plan. The project was organized around a multidisciplinary group of 23 experts from 14 countries covering five dimensions of energy policy: science and technology, market and network economics, regulation, law, and policy implementation. Each semester, the permanent research team based in Florence worked on two reports, going through the quality process of the THINK Tank. This included an Expert Hearing to test the robustness of the work, a discussion meeting with the Scientific Council of the THINK Tank, and a Public Consultation to test the public acceptance of different policy options by involving the broader community.

Norela Constantinescu (DG Energy) presents the THINK project

This final booklet complements the mid-term booklet published in January 2012 (http://think.eui.eu) and brings together the research output of the second half of the project (January 2012-May 2013).

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Introduction

Magdalena Andreea Strachinescu Olteanu
Head of Unit
New Energy Technologies, Innovation and Clean Coal
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40 years ago, the world experienced the first oil crisis.
About 30 years ago, the oil prices started to fall from 75 $/bbl. to 20 $/bbl. within less than 5 years, while every economist predicted that the "correct" oil price would be about the double value.
20 years ago, the oil price was still as low as 20 $/bbl.
15 years ago, the European Commission started to reflect how to merge the Directorate General for Energy with the Directorate General for Transport, with the argument that energy has never been as abundant as today, never as cheap as today and never as clean as today.
10 years ago, the oil prices were around 30$/bbl.; forecasts that oil prices could reach 50 $/bbl. were called apocalyptic.
But today the oil price is above 100$/bbl.
10 years ago, the European Commission started to reflect on how best to combine energy policy and climate change policy into one policy, based on win-win for both sides.
7 years ago, the US Department of Energy forecasted the energy future for the USA without taking into account the boom of shale gas.
None of these changes was foreseen or predicted. All energy experts believe that the energy market is very large, very stable and that changes are very slowly, while history tells us the opposite.
In these tumultuous waters of the energy world, the THINK tank, under the guidance of Jean-Michel Glachant, has accepted the extremely difficult task to have a robust and scientific look at the possible (r)evolutions of the energy market; and they did it with great courage, while basing it on sound science. I hope that this report makes us all THINK… and create new visions, based on solid science.

THINK Report
Policy *briefs*

January 2012 – May 2013

Introductory video

TOPIC 7

How to Refurbish All Buildings by 2050

Project Leader: Péter Kaderják
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Comments to the report
by Paul Hodson (DG Energy)
At FSR Brussels Conference 2012

The European Union will not achieve its long-term decarbonisation goals without significantly increasing the rate of building renovations and the energy savings in which these renovations, on average, result. Numerous studies have showed that this also makes economic sense as the initial investments will be offset through lower energy bills, while the economy and public budgets are set to benefit from greater economic activity associated with building refurbishments. The report therefore rightly focuses on the 'how' rather than on the 'if'.

This THINK report is timely. Certain key provisions of the Energy Efficiency Directive are just now coming into force; the effects of the Energy Performance of Buildings Directive are becoming apparent; and the Commission is engaged in a reflection on the policy framework beyond 2020. All of these processes tie into the questions that the report attempts answering, such as what policy instruments can most effectively overcome the existing market barriers and what role should EU institutions play in setting those policies. I am happy to observe that some of the key recommendations of the report are actually being enacted – under the Energy Efficiency Directive Member States are preparing long-term strategies for mobilising investment in building refurbishment, while the Commission is working on an EU-wide energy performance certification scheme for commercial buildings.

The report addresses the issue of building refurbishments in a structured but generic way. It is therefore a good starting point for exploring further some specific issues related to that topic. The first pertinent issue is how to decarbonise the built environment in the most effective way, in other words how to strike the optimal balance between insulating buildings and investing in decarbonised or low-carbon heating and power sources. The second issue is how to structure the market for energy efficiency, in-

cluding putting in place the right price signals. And finally, a third issue relates to the level and coherence of the regulatory framework- how to ensure for example that building codes and product-specific efficiency requirements result in an optimal energy use of those products from an energy efficiency standpoint when they are part of building systems.

Paul Hodson
Head of Unit: Energy Efficiency
Directorate General for Energy | European Commission

Highlights

[Presentation of the report by Leonardo Meeus]

- The objective of the 7th THINK report is to provide policy recommendations for the European Commission (DG Energy) on how to refurbish all buildings by 2050. The report is summarized in this policy brief.
- Buildings account for 40% of the total energy consumption of the EU and they are one of the most significant sources of greenhouse gas emissions (36% of the EU total). In order to achieve the 2050 EU building sector target, the energy performance of existing buildings will need to be improved substantially (excluding those planned for demolition). This can be done either by integrating the use of renewable energy sources into existing buildings, by replacing building components and systems in order to reduce energy consumption, or to use electricity which will be decarbonised by 2050.
- It is essential to improve price incentives and to further develop the building refurbishment market to minimise the associated costs. However this in itself will not be enough to meet the target. The expected investments in existing building stock that are considered beneficial for society are not economical at today's prices for individual decision makers. Therefore, regulatory instruments will be needed to encourage owners and users to refurbish, and also to ensure that refurbishment leads to improved energy performance.
- EU institutions should allow member states enough freedom to tailor their building refurbishment policies to their own needs. However, the institutions nevertheless have an important role to play. In order of importance, our recommendations are:
    1. To abolish to end-user regulated prices for electricity and gas
    2. To internalize the cost of carbon in building refurbishment decisions
    3. To establish national building refurbishment targets or to at least mandate the development of national building refurbishment action plans
    4. To create an EU energy performance certificate scheme
    5. To facilitate the design of a building refurbishment market framework
    6. To continue to widen and strengthen technology standards and the labelling of building refurbishment technology, products and materials
    7. To develop an EU building refurbishment technology roadmap
    8. To use EU funding to support the implementation of the previous recommendations

Background

The roadmaps presented by the European Commission in 2011 show that the greenhouse gas emissions in the building sector will need to be reduced by 88 - 91% by 2050 in comparison to levels in 1990 in order to achieve the EU strategic objectives.

The path towards the 2050 building sector target includes three challenging trade-offs. First, the renewal of buildings can be accelerated or there can be greater investment in refurbishing buildings. Second, investing more in building refurbishment can be either to refurbish them more frequently or else to be more ambitious when refurbishing them. Third, regarding the timing and type of investments, we can follow a linear path, or we can make greater efforts at a later stage when technology will be more advanced. Thermal insulation can be used to reduce the energy consumption of buildings and the behaviour of users can be modified. The energy consumption of buildings can be further reduced by replacing energy consuming systems and components in buildings. Alternatively, buildings can move to using electricity or can integrate renewable energy generation as the objective is to reduce their greenhouse gas emissions.

Only a few studies have considered these trade-offs for the EU or at member state level, however three key observations can be made. Each study shows the need not only to increase the current rate of refurbishment, but also to increase the greenhouse gas emission savings that are achieved by refurbishing a building. The studies also emphasise that there will continue to be a 'deepness mix' with some buildings becoming net zero energy buildings while others will only undergo moderate, minor or even no refurbishment. For instance, a holiday house that is only used for short periods of the year should not necessarily be refurbished and there are protected historical buildings which have to adhere to strict guidelines regarding their refurbishment. The studies also show that there are significant differences between different member states concerning the nature of their building stock and the usage of these buildings.

Why should expected investments be regulated?

In order to achieve the 2050 building sector target, 600-1800 billion euros will have to be invested in the building sector. Most of this is expected to come from private building owners and users. With the exception of public buildings and infrastructure investments (e.g. district heating and cooling, and smart metering), the investment concerns the building itself, and its components and systems, and a large share of the buildings is privately owned and used.

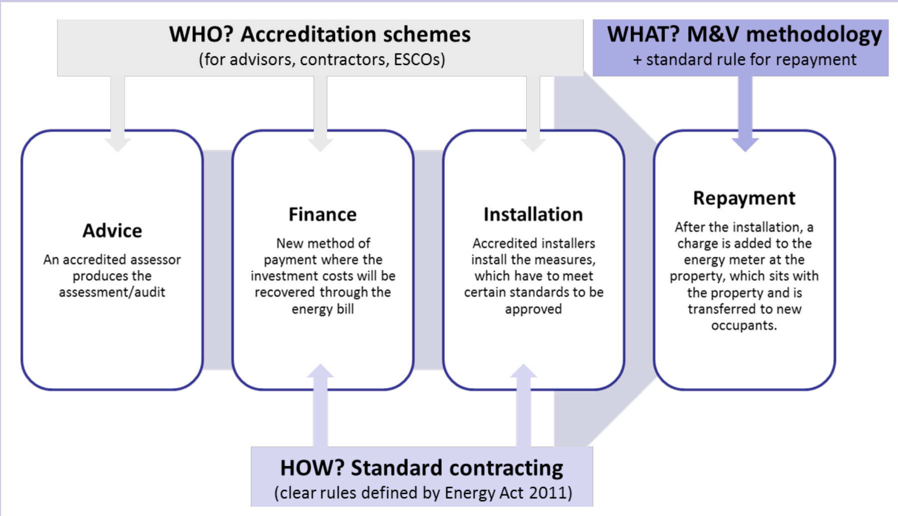
Price incentives are important not only to give building owners and users correct economic signals to refurbish, but also to guide them towards the right choices when refurbishing and to provide them with incentives for the efficient use of energy in buildings. Currently, these signals are often distorted, for instance, because of end-user price regulations for electricity and natural gas, and because the cost of carbon has not yet been fully internalized into the building refurbishment decisions.

Comments to the report
by Jorge Vasconcelos (NEWES)
At FSR Brussels Conference 2012

Moreover, there are market failures (i.e. information problems, high transaction costs, and externalities), and building owners and users are not always qualified to make complex refurbishment decisions. This is especially the case for households. This issue can be remedied by improving the awareness of market players, and by developing a market framework with accreditation, standard contracting and a measurement and verification protocol, as illustrated by the UK Green Deal (Box). However, simply developing the market for building refurbishment will not be enough to meet the target as the expected investments that are considered to be beneficial for our society, are not economical at today's prices for the individual decision makers. Increasing public support for building refurbishment could also be an option, but it can only address part of the problem considering the magnitude of the investment needs, and public budget constraints, especially in the current context in Europe. Therefore, regulation of building construction and refurbishment is needed.

Box: UK Green Deal, a framework to enable the development of the building refurbishment market

The Energy Act 2011 includes provisions for the Green Deal which has been established by the UK government to enable British households to undertake building refurbishment. It is an organised market framework that provides support to building owners and users along the building refurbishment decision process, as illustrated by the diagram below. It includes clear rules on who to contract with, how to contract them, and what is contracted, with accreditation of market players, contract standards, and measurement and verification (M&V) methodologies.



How to regulate expected investments

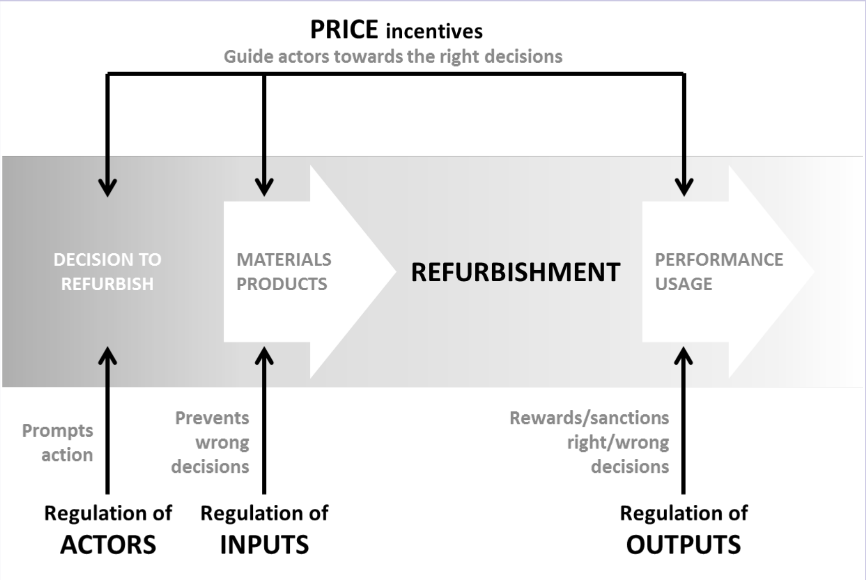
As illustrated in Figure 1 (below), regulatory instruments can be used to prompt the refurbishment of a building (i.e. regulation of actors), to then also prevent actors from making inappropriate decisions when refurbishing (i.e. regulation of input), and to ensure that the refurbishment leads to improved energy performance (i.e. regulation of output). For each of these regulatory instruments, this report illustrates the rationale, limitations, and possible role for the EU in facilitating the implementation of these instruments.

Regulation of actors

For the regulation of actors, we can distinguish between requirements that are made of building owners or users, and requirements that are made of third parties, such as energy suppliers and distribution system operators.

Rationale: It can be necessary to induce actors to act because the expected investments are not always economical from the point of view of the individual decision maker. There are many different practices that imply such requirements and the experience is that it is difficult to generalise what works best, as this can be context-specific.

Figure 1 – Analytical framework for regulatory instruments



Limitations: These depend on who the requirement is made of. Energy suppliers and distribution grid operators, for instance, have privileged information to identify promising investments, and they already have contractual relationships with building owners and users. However, their core business is to deliver energy so it is against their interests to save energy. Alternatively, requirements can be made of building owners and users to conduct individual building inspections to monitor compliance. These may already exist to monitor other aspects of buildings, such as for damp in Sweden and safety in Denmark, but they do not yet exist to monitor energy performance.

EU involvement: the Energy Performance of Buildings Directive requires buildings that undergo a major renovation to comply with minimum requirements defined at the member state level. There is a rationale for obligations, but it is not clear on which actor they should be put, and what works best can be context specific. Therefore, it may be better to leave that choice of actor up to member states.

Regulation of input

For the regulation of input we can distinguish between technology standards (i.e. minimum energy efficiency requirements) and labelling for building products and materials (i.e. providing energy efficiency information).

Rationale: because we have unqualified decision makers and market failures, it can be necessary to avoid (with standards) or reduce the risk (with labelling) that actors make inappropriate decisions in selecting material and products when refurbishing.

Limitations: energy performance is not only about choosing the right products and materials during refurbishing, it is also determined by their installation and the behaviour of building users and owners following the installation. The performance of certain building systems and components depends on the entire building and how it interacts with other systems and components. For instance, the installation of a very efficient boiler will not guarantee a high level of energy performance for the building as a whole, as the building may not be sufficiently insulated.

EU involvement: some examples are the EU Energy Star programme (2001), the Energy Labelling Directive (2010), the Ecodesign Directive (2009), and some provisions of the Energy Performance of Buildings Directive (2010). It would be good to continue this ongoing process to avoid that decisions are biased towards products and materials that are not yet classified at EU level.

Regulation of output

For the regulation of output we can distinguish between: performance regulation and usage regulation. Performance regulation imposes energy performance requirements, such as the establishment of minimum energy performance level for refurbished buildings. Usage regulation imposes minimum requirements on how energy is used, such as behavioural constraints like the establishment of minimum and maximum indoor air temperatures.

Rationale: to address the lack of skills of the actors and market failures, it can be necessary to regulate the energy performance of buildings, and their systems and components, and to incentivise actors to use energy in a manner that is efficient, and compatible with the greenhouse gas emission reduction targets. Output regulation can reward or sanction both good and inappropriate decisions.

Limitations: the main limitations of output regulation are related to their administration and enforcement. For instance, energy performance regulation relies on energy performance certificates. The Energy Performance of Buildings Directive has already made such a scheme mandatory in each EU member state, but it does not yet apply to all buildings. Also, some member states have not yet properly implemented this scheme. Enforcing compliance with behavioural constraints is even more challenging.

EU involvement: the EU already requires member states to introduce an energy performance certification scheme. This could be used to introduce energy performance regulations for buildings at the national level. There are however problems with the national implementation of this scheme, as the scheme should be a reliable tool to ensure its compliance with existing, and future, output regulations.

Recommendations for the European Commission

EU institutions should allow member states enough freedom to tailor their building refurbishment policies to their own needs. However, the institutions nevertheless have an important role to play, particularly in ensuring that there is a commitment at national level to addressing the building refurbishment problem and to facilitate the implementation of solutions to this problem.

Prerequisites for refurbishing all buildings by 2050 are to provide correct economic signals:

1. <u>Abolish end-user regulated prices for electricity and gas.</u> There are already on-going infringement procedures against practices that are not in line with the EU liberalisation legislation, however additional action could be taken in order to speed up their abolishment. The EU could avoid inconsistencies such as providing subsidies for energy savings' investments to member states which are keeping energy prices artificially low.

2. Internalize the cost of carbon into the building refurbishment decisions. Currently, the cost of carbon is only partly internalized so that the decisions are biased towards fossil fuels, which is inconsistent with the EU climate and energy objectives. The recent EU Energy Tax Directive proposal was a first step in this direction, but more is needed.

The primary action to refurbish all buildings by 2050 is to ensure that the EU 2050 building sector target is reached:

3. Establish national building refurbishment targets or, at the least, mandate the development of national building refurbishment action plans. This is essential to ensure that there is commitment at national levels to addressing the problem. The establishment of targets has already proven to provide commitment in other energy policy areas. However, if targets are politically unfeasible, member states should at least be required to submit a plan so that the European Commission can monitor their progress. These plans will also be instrumental for the development of national building refurbishment policies.

4. Create an EU energy performance certificate scheme. As mentioned previously, regulation will be needed in order to get the expected investments in building refurbishment. This will be context-specific, but it will typically include obliging actors to refurbish, and ensuring that this refurbishment also leads to improved energy performance. Energy performance certificates are key to the implementation of these regulations as they can be used to administer and enforce them. The EU's main role, therefore, as facilitator of national solutions to the building refurbishment problem is to make sure that there are adequate energy performance certificate schemes for buildings.

The proposed Energy Efficiency Directive already introduces stricter requirements which provide the opportunity for the establishment of an EU scheme to which member states could voluntarily subscribe. In any case, member states will have to change their national energy performance certificate schemes to adhere to the new requirements. Such certificates could also provide the information required for the development of national building refurbishment action plans, especially if they apply to more buildings than currently is the case. Increasing standardization of energy performance certificates would also make it easier to compare different national plans.

Secondary recommendations for refurbishing all buildings by 2050 are about minimizing the costs of achieving the EU 2050 building sector target:

5. Facilitate the design of building refurbishment market frameworks. As member states have only just begun to experiment with organised markets for building refurbishment (e.g. the UK Green Deal), it would be difficult to agree on an EU design. However, any national market framework should include accreditation, standardised contracting and measurement and verification protocols for building refurbishment. EU institutions are already involved in these three areas, however more could be done such as the establishment of a quality label for energy service providers, the development of contract templates and a standard measurement and verification protocol.
6. Continue to widen and strengthen technology standards and labelling of building refurbishment technology, products and materials. This is an ongoing process that needs to be finalised to avoid decision bias. Note that the rationale to do this at least partly at EU level is that national regulations for building materials and products can create barriers for the internal market.
7. Develop a building refurbishment technology roadmap. The development of a roadmap is essential to map and coordinate building refurbishment research, development and demonstration activities. It would also be used to track the progress of technology that is of strategic importance in achieving the objectives of the building sector. Several roadmaps have been developed as part of the SET-Plan, but these do not yet consider building refurbishment technology.
8. Use EU funding to support the implementation of the previous recommendations. EU funding should be allocated on the basis of national building refurbishment action plans, which should therefore be a condition to receive funding. The allocation of funding should be performance-based, which would require the use of energy performance certificate schemes for buildings in member states. Public funding should also be leveraged with financial mechanisms.

Introductory video

TOPIC 8

Electricity Storage: How to Facilitate its Deployment and Operation in the EU

Project Leader: Jorge Vasconcelos
Research Team Leader: Sophia Ruester
Research Team: Xian He, Eshien Chong, Jean-Michel Glachant
Project Advisors: Dörte Fouquet, Nils-Henrik von der Fehr

Comments to the report
by Jean-Marie Bemtgen (DG Energy)
At FSR Brussels Conference 2012

Energy storage is a new fashion word in the world of energy. Many experts believe that energy storage can solve all problems of the energy system of today and of the future, but they also agree that today energy storage does not make any business sense. The same experts do not know who should pay for storage. A large majority of experts think inside silos, and lack an integrated vision of the complex integrated energy chain. This report makes a solid assessment of the situation of today and it shows new paths for our energy future. The report succeeds to create a solid scientific basis; it stays technology neutral and it clearly addresses the paths that will bring solutions to our future energy system. Thanks to the very large overview provided by this report, the future discussions will have a more solid and common basis for constructive discussions.

Jean-Marie Bemtgen
New Energy Technologies, Innovation and Clean Coal
Directorate General for Energy | European Commission

Energy storage will play a key role in enabling the EU to develop a low-carbon electricity system. It is one of the sources that can supply more flexibility and balancing to the grid, providing a backup to intermittent renewable energy. Locally, it can improve the management of distribution networks, reducing costs and improving efficiency. In this way, it can ease the deployment of renewables, accelerate the decarbonization of the economy, improve the security and efficiency of electricity

Comments to the report
by Matti Supponen (DG Energy)
At FSR Brussels Conference 2012

transmission and distribution (reduce unplanned loop flows, grid congestion, voltage and frequency variations), stabilize market prices for electricity, while also ensuring a higher security of energy supply.

Currently, there are limited storage potentials in the EU with pumped hydro storage being by far the most widely used technology with more than 127 GW of operating capacity worldwide. Other forms of storage – batteries, electric vehicles, flywheels, hydrogen-based systems, etc. – are either minimal, or at a very early stage of development. The Commission, therefore, started to give more attention to the issues around energy storage with a view to addressing them more effectively in EU energy policy, as also pointed out in a recent DG ENER Working Paper on "The Future Role and Challenges of Energy Storage", published in 2013.

The THINK report on "Electricity Storage: How to facilitate its deployment and operation in the EU" in fact surprised me. Electricity storage (and in the broader perspective energy storage) actually is no "piece of cake". The authors convincingly demonstrate the complexities and challenges accompanying its successful deployment and operation in European electricity markets. For instance, storage cannot be strictly categorized as a purely market-based business, but instead might be considered as a semi-competitive area with certain projects being dedicated to deliver ancillary services to system operators. As storage technologies, together with an increased penetration of distributed generation and active demand response, are changing today's power systems substantially, also a wider revision of grid tarification procedures is urgently needed. Moreover, various market design issues arise. ACER has developed ambitious Framework Guidelines, and the ball is now with ENTSO-E to deliver respective ambitious Network Codes. There is a lot of work to do, and I hope that many of the aspects raised will be taken into account.

Matti Supponen
Internal Market II: Wholesale Markets; Electricity and Gas
Directorate General for Energy | European Commission

Highlights

- Many claim today that greater variability and intermittency of supply must inevitably go with a significant development of electricity storage. However, what the future power system needs is not electricity storage per se, but rather a well-adapted system architecture which allows for decarbonization while also ensuring system reliability and supply security, and thus, reacting amongst others to increasing variability and intermittency of generation and the proliferation of distributed energy/power resources.
- Alternative means of flexibility – including a more flexible operation of generating units as well as various demand-side measures – are all able to react to the system requirements of up-/ downward adjustment and also include the opportunity to benefit from inter-temporal arbitrage. The main differences relate to quantity and degree, i.e. response time, power rating, and energy rating. One flexibility means is not necessarily superior to another and the often expressed need for electricity storage to enable decarbonization is a technical and economic question.
- To reveal the overall value of electricity storage, multiple services need to be aggregated and multi-income streams need to be maximized. Viable business models can be categorized by the nature of the main target service, with a distinction between a deregulated-driven business model (where the main income comes from activities in electricity markets), and a regulated-driven business model (where the main income comes from offering services of which a regulated actor is the only buyer).
- The future role of the EU is to ensure a level playing field for all alternative means of flexibility, including electricity storage. An investigation of current market design and regulation shows that it is necessary to improve market price signals and to adjust regulatory incentives in order to better reflect the value flexibility means can provide. A relaxation and harmonization of market rule setting in balancing markets could allow small, decentralized market players (including storage operators) to access these markets, which would facilitate the cross-border exchange of flexibility resources. Regarding the provision of ancillary services, the use of competitive tendering instead of bilateral contracts wherever possible could help to evaluate and quantify value. As regards tendering, performance-based and source-neutral remuneration schemes should be adopted.

[Presentation of the report by Sophia Ruester]

- The future role of the EU is also to provide smart direct public support for innovation. The coordination between Member State and EU support policies should be improved and public support should target a balanced portfolio of identified key technologies, including both centralized and decentralized energy storage technologies. Of particular interest are areas where European players already have a strong position in RD&D and/or manufa turing and which have potential for future growth.

Background

The future electricity system will face various challenges originating from both supply and demand side, including an increase in variability and intermittency of generation, and the proliferation of distributed energy/power resources like distributed generation, controllable demand and electric vehicles. Adaptations in system architecture are required to allow for decarbonization while ensuring the stability and reliability of the system. Electricity storage technologies are one possible type of means, amongst others like flexible generation and demand side management, to provide various services to the system (e.g. capacity firming, voltage and frequency control, back-up capacity, or inter-temporal arbitrage).

The renewed interest in electricity storage is due to both new features of the European power system, as well as technical advancements and cost reductions of storage. Moreover, the difficulties and high costs associated with grid expansion have also focused more attention on the storage solution. To face up with the challenges of the future power system, a comprehensive approach to assess how to enable the deployment of electricity storage (and in the broader sense also of other flexibility means), and thus, how to establish a level-playing field where alternative means can show their potential, needs to be developed.

Electricity storage: A special class of assets for the future power system?

Alternative means of flexibility – including a more flexible operation of generating units as well as various demand-side measures – are all able to (a) react to the system requirements of up-/ downward adjustment and (b) also include the opportunity to benefit from inter-temporal arbitrage. Dissimilarities come from the form of energy in the conversion and the accumulation processes. The main differences relevant for the final services that alternative means of flexibility can provide are expressed in quantity and degree, i.e. response time [ms-s-min]; power rating [kW-W-MW]; and energy rating [kWh-MWh]. One flexibility means is not necessarily superior to another and the often expressed need for electricity storage to enable decarbonization is a technical and economic question.

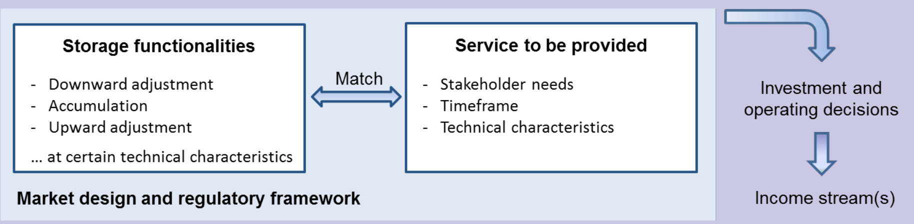
Hence, the value of storage needs to be assessed under a double uncertainty. First, there is uncertainty concerning the direction and timing of innovations in storage technologies themselves, as many are still highly immature or not technically proven. Second, there is uncertainty concerning the pace of change in generation-, demand- and grid flexibility as well as concerning the configuration of the future power system. It will also make a difference for storage technology choice and scale if we move towards 'Europe-wide energy superhighways' or if instead we move towards a system of increasing local energy autonomy, featured by a further increased penetration of small-scale distributed generation and widespread demand-side management.

Viable business models for electricity storage

The core of the business model for electricity storage is how the storage facility's functionalities (regarding up- and downward adjustment and accumulation) are matched with the services to be provided (Figure 1). Numerous studies have shown that by focusing on only one specific application, electricity storage typically cannot reach profitability in the current market context. Today's challenge is how to aggregate multiple services and how to maximize multi-income streams.

Figure 1: Illustration of the electricity storage business model

Source: Own depiction

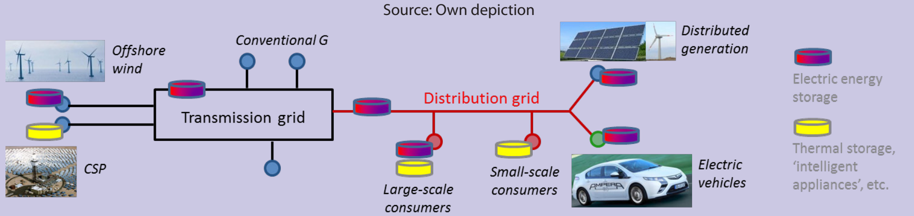


The report provides a systematic approach to the search of viable business models for storage. First, the location of storage is decisive in deciding which main target service storage will provide. Previously, electricity storage was mainly employed in the form of bulk, centralized units providing storage over relatively long durations (mainly PHS) as well as some systems providing fast response (batteries, flywheels). Today, there is an emerging interest in small-scale, decentralized storage and, in the future power system, electricity storage could fulfill a variety of functions and provide benefits to various stakeholders. It might be connected directly to transmission or distribution grids, to renewable generators, or to consumers (Figure 2). Hence, electricity storage could be located closer to generation or closer to load; it could be operated in a more centralized or in a more decentralized manner; it could be a 'shared resource' benefiting the whole system or a more 'dedicated resource' benefiting a single actor.

Second, business models are categorized by the nature of the main target service. In the *deregulated-driven business model*, the main income originates from activities in electricity markets.
Spare capacity may be used to provide services to regulated actors. Storage facilities which fall into this category are, for instance, large-scale storage units directly connected to the transmission grid such as pumped hydro. In contrast, in the *regulated-driven business model,* the main income originates from offering services where the sole buyer is a regulated actor. Spare capacity may be used for competitive activities. An example are battery systems, supporting quality of supply and being directly connected to the distribution grid.
Box 1 highlights some interesting international experiences on which factors have led to a more ambitious development and use of storage in selected non-European countries. Reasons include individual industry structures, strong public support for innovation, and also specific rules in market design and regulation facilitating the participation of storage in ancillary service markets.

Figure 2: Possible locations of electricity storage applications in the future European power system

Source: Own depiction



Box 1: International experiences

Several factors have led to a more ambitious development and use of electricity storage in other countries. US experience has shown that the emerging policy framework at federal level supports both development and deployment of electricity storage. First, public (co-)funding which comes from organized programs is explicitly targeting RD&D in the area of electricity storage, and is triggering numerous research activities. Second, with the FERC orders 890, 719, and 755, recent changes in regulation modifying tariffs and market rules (such as that non-generation resources can fully participate in established markets alongside traditional generation and that providers of frequency regulation receive just and reasonable remuneration) make the electricity storage business case more attractive.

Japan, in contrast, has a particular energy industry structure which is highly dependent on primary energy imports from third countries. The Japanese experience is interesting as its energy storage technology development results from a strong industrial policy. For example, the 'Moonlight Project' was dedicated not only to developing energy storage technologies, but also to the search of alternative solutions to ensure Japan's energy independence. TEPCO's project on NaS batteries was among the alternative projects that were developed with this industrial support. Even today, various publicly financed projects seek solutions to particular problems, and energy storage technologies benefit from funding as they may be part of a solution. The Fukushima accident has had a substantial impact on the country's energy strategy, and has also stimulated interest in small-scale energy storage systems directly connected to end-consumers to develop resilience at the individual household level.

Need for a renewed EU involvement?

Current EU involvement related to the facilitation of electricity storage development and deployment is limited and it mainly involves some public co-funding of RD&D, as well as the general definition of underlying principles for electricity market system operation, dispatching and balancing, and the provision of ancillary services. The following paragraphs summarize proposals for improvements in market rule setting and direct support to innovation.

Market design and regulation

Manufacturing costs and technical parameters are often cited as major barriers to the deployment of electricity storage; however, there are various non-technical issues preventing its adoption as well. Major obstacles for an efficient pricing in spot and balancing markets have been identified, including ad-hoc peak load arrangements implemented in some markets, frequent inconsistencies regarding price fixation mechanisms in day-ahead and balancing markets, and restrictive bidding requirements. There is also wide heterogeneity regarding the implementation process of the 3rd Package and, so far, a low degree of compatibility of market designs has been achieved. This situation does not only create obstacles for the transition to a single European market, but it may also hamper an efficient participation of 'new' sources of flexibility in ancillary service markets. The future role of the EU is to ensure a level playing field for all alternative means of flexibility, comprising well-functioning markets and efficient regulation.

Energy-/balancing markets: The negative effects of heterogeneity in national balancing mechanisms on competition and the completion of the internal market should be recognized in the Framework Guideline on Electricity Balancing, due to be published by ACER this year. The proposals made in the first draft (April 2012) call for an integrated balancing market approach and the facilitation of the participation of alternative flexibility sources in balancing markets. This would go some way to removing certain barriers to the adoption of alternative flexibility means such as electricity storage. However, the proposal remains silent on concrete balancing market design issues. Market rules should be modified to relax minimum bidding requirements and rules which require symmetric up- and downward bids in order not to impede market access for small, decentralized market players. This will allow storage and other flexibility means to valorize services they can technically provide, which will probably also have a positive impact on market liquidity.

Ancillary services: The co-existence of several forms of procurement and remuneration (including mandatory provision, bilateral contract, tendering, or spot markets) can be justified on economic grounds. The suitability of certain options depends on the service targeted. However, replacing bilateral contracts wherever possible with competitive tendering could help to evaluate and quantify the value of alternative flexibility means, including storage. In terms of tendering, it is recommended that performance-based, source-neutral remuneration schemes are adopted. Such measures pave the way for the emergence of transnational markets for ancillary services, leading to more efficient procurement and use of ancillary services across Europe. Political borders should not restrict the flow of ancillary services. It is the market that should create its own pliable borders, acknowledging technical and economic aspects. However, heterogeneity in the procurement of ancillary services might hamper an efficient sharing of flexibility resources in the European power systems.

Capacity mechanism: Capacity mechanisms are currently being extensively debated in several European countries. However, the necessity of such a mechanism to address the risk of long-term under-investment in (peak) generation capacity remains to be proven. Instead, to address the causes of the lack of investment incentives, the improvement of existing market signals is required, namely the quality of price signals transmitted in energy and balancing markets and for the provision of ancillary services.

Besides, heterogeneities in national market design and regulatory frameworks applied to storage could impose distortions in competition, and therefore should be the main focus of EU involvement. For instance, grid tariffs applied to storage or market access eligibility deserve more exhaustive survey and benchmarking. A proactive regulatory intervention could also be helpful in several areas to allow the emergence of new business models. This includes for instance the promotion of market access for aggregators which would allow for the participation of small-scale flexibility sources such as electricity storage in

Box 2: EU's position among storage manufacturers

To assist the European Commission in deciding how to effectively use RD&D to the benefit of the European citizens, the report also provides a review of on-going R&D activities of different storage technologies as well as a survey of manufacturers showing the EU's relative position in this specific industry. In fact, the market for energy storage is quite vibrant, with start-ups co-existing alongside well-established firms, reflecting the importance of innovation. For PHS, for instance, Alstom is one of the leading manufacturers worldwide, but smaller firms such as Gravity Power Inc. (US) or Riverbank Power (Canada) offer new alternative solutions based on traditional PHS technologies. The former exploits gravity power, while the latter offers underground storage solutions. While the first compressed air energy storage facility was developed in Europe, the US has witnessed a surge in firms offering this storage solution nowadays. Both American and European manufacturers are also very active in flywheel storage technologies. Asian companies seem to focus their commercial strategy on battery solutions.

energy-, balancing-, and ancillary service markets; or incentivizing renewable generators towards output firming or direct usage of own consumption. It is important to note, though, that any evaluation of which policy approach to advocate requires a careful assessment of which policies would be optimal from a societal perspective.

Innovation in storage technologies

Electricity storage has been identified as one of the key technology priorities in the transition of the European power system towards decarbonization, but the majority of possible technologies is not yet commercially available. Financial support for RD&D is already in place; however, support programs are hardly coordinated – neither between different Member States, nor between them and the EU. This restricts knowledge sharing, increases the likelihood of costly duplication of similar research and fails to exploit potential benefits from economies of scale and scope via a pooling of resources and active networking. The existing European energy technology policy (SET-Plan, launched in 2008) does not provide a comprehensive strategy for electricity storage development which takes into account the whole set of technologies and their possible applications. There is no clear vision of the future role of electricity storage in the European power system.

A renewed European energy technology policy, which goes beyond the SET-Plan horizon of 2020, should include a technology roadmap for electricity storage. Coordination between the support policies of Member States and EU need to be improved and public support should target a balanced portfolio of identified key technologies, including both centralized and decentralized energy storage technologies. The policy should consider an extended timeframe up to 2050 with intermediate milestones for 2020, 2030 and 2040, thus including also highly immature but possibly promising technological options. Areas where European players already have a strong position in RD&D and/or manufacturing and which have potential for future growth should be of particular interest.

Improved communication is of utmost importance, too. For instance, this could involve a knowledge pool to collect information on installed capacities of various technologies (commercial and also pilot and demonstration facilities) in different Member States, or the exchange of information regarding the functioning practice of ‘real-world’ pilot projects. The European Association for Storage of Energy should take an active role here.

[Introductory video]

TOPIC 9

A New EU Energy Technology Policy towards 2050: Which Way to Go?

Project Leader: Matthias Finger
Research Team Leader: Sophia Ruester
Research Team: Sebastian Schwenen, Adeline Lassource, Jean-Michel Glachant
Project Advisors: François Lévêque,Wladyslaw Mielczarski

In the process of building–up the EU initiatives the balanced assessment of options on which the European Commission can embark is the first step towards a good outcome. The choice of these possible paths needs sound arguments presenting realistically both sides of the coin.

The Think Tank project "A new EU Energy Technology Policy towards 2050: which way to go" fulfilled this requirement. During 6 months of intense work, of exchanges with experts including the Commission staff, the Think Tank team has managed to structure the information to provide an excellent base for arguments and ideas used afterwards in the Communication on Energy Technologies and Innovation adopted by the European Commission on 2 May 2013.

The challenge for the Think Tank Team was big. The Communication intended to provide a strategy for energy technologies and innovation which attempts to reposition the energy research policy within a significant changed world energy landscape induced especially by the shale gas revolution. The Communication also provides the energy technology perspective offer paving the way towards 2030 and 2050.

The work of the Think Tank team was carried out in a rather uncertain environment. As reference, the Energy 2050 Roadmap scenarios and an indication: which are the implications for delivering technology solutions by prioritising the energy system approach.

The team led by Sophia Ruester and Jean Michel Glachant worked on three policy options bringing for each case pro and against arguments assessed against a set of criteria similar to those used by European Commission in its Impact Assessments work.

The starting point was the SET Plan and its approach favouring technology achievements for a set of low carbon sectors identified as having high potential to achieve energy and environmental objectives by 2020.

One option was to continue to go on the SET Plan path and to extend it to 2030 and 2050 period. However the Think Tank team identified another departure point for two other paths: one driven by a more technology neutral support in a possible combination with a stronger carbon price, the other driven by technology targets.

These options were tested through multicriteria evaluation systems. The conclusions are very interesting. No path has an overall advantage over the others. The combination of elements of the three options might deliver better results. The wisdom is to pick the right one. I really believe that the Think Tank team managed in this report to provide us (European Commission) with the arguments for making a good choice which we used when we developed the Communication on Energy Technologies and Innovation.

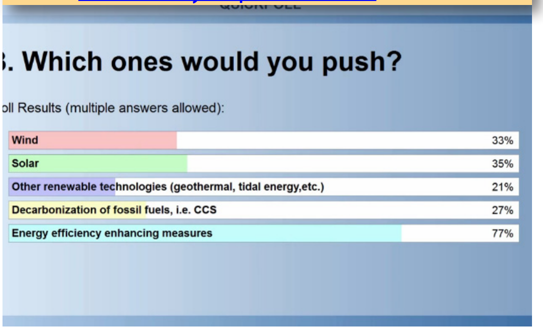
I also think that it is a good starting point for reflection in the broader context of Energy and Climate Strategy 2030.

Think Tank project consortia managed in its 3 years of work for DG Energy to bring us their valuable advice on a multitude of subjects.
My warm thanks to all of you for your support during the period 2010-2013.

Norela Constantinescu
New Energy Technologies, Innovation and Clean Coal
Directorate General for Energy | European Commission

Highlights

[Options for a New EU Energy Technology Policy towards 2050: What Way to Go? Webinar by Sophia Ruester]



- Market actors are calling for a post-2020 energy technology policy framework now. As a result, the policy is likely to be negotiated in a time of fierce global competition in clean-tech markets, financial crisis and institutional frictions in the EU. To contribute to the debate and to assist DG ENER to prepare a new Communication on 'Energy Technologies in a future European Energy Policy', our THINK report discusses a renewed EU energy technology policy towards 2050.
- A first possible policy path would be to extend the 2020 policies to 2030 and 2050. From this reference case, departures in two major ways are possible. Policy path 2 would rely on a strong carbon price signal and technology-neutral support to innovation. In contrast, an alternative policy path 3 would depart from a weak carbon price signal and technology targets.
- A multi-criteria evaluation shows that no single policy path is clearly superior to another. Therefore, a renewed SET Plan should allow for all possible future policy paths. Priority technologies that are key to achieve 2050 objectives and/or can help to support green growth within the EU should be identified based on a comprehensive *approach across sectors*.
- But not only the policy context is uncertain. There are also other possible futures not yet recognized in the EU Energy Roadmap 2050. First, *shifts in paradigm* of EU energy policy away from decarbonization and in favor of competitiveness or supply security might call for strong technology support. Second, *technological revolutions*, such as a global shale gas revolution, could result in the "rational" price of carbon falling extremely low.
- There are several reasons that justify some directed technology push, instead of building fully on technology-neutral support to innovation. Pushing energy efficiency enhancing and enabling technologies thereby offers a no-regret strategy in any future setting and dominates other push strategies in terms of implementability and robustness. Creating options for technology breakthroughs has to be a main pillar in any future SET-Plan.

[Mentioned in the DG Energy newsletter on 25 April 2013]

Background

There are huge challenges for policy makers if the EU climate policy goal of reducing greenhouse gas (GHG) emissions to 80-95% below 1990 levels by 2050 is to be reached. Moreover, the current period of austerity has imposed tight constraints on national budgets and has forced governments to rethink fiscal policies. Some Member States have recently abandoned several expensive energy policies, mostly those promoting clean energy technologies. In light of these changes, there is no doubt that a new and more stable energy technology policy design for the post-2020 period is needed. It is, however, not clear how exactly this new policy should address limitations of the current 2020 framework while, at the same time, taking into account the fierce global competition in markets for clean technologies. Market actors are calling for a new technology policy framework *now*, and so the policy will likely be negotiated in a time of financial crisis and institutional frictions in the EU.

There is certainly a *need for public support*. Policy intervention is required to correct market failures originating from environmental and innovation externalities, to account for capital market imperfections and to fully exploit international trade opportunities in clean technologies. Policy intervention, therefore, can be motivated by both market failures and strategic industry and trade policy issues. There further is a *need for EU involvement* to coordinate market failure corrections between Member States and to combine national forces.

The role of the SET Plan will depend on the context of carbon pricing

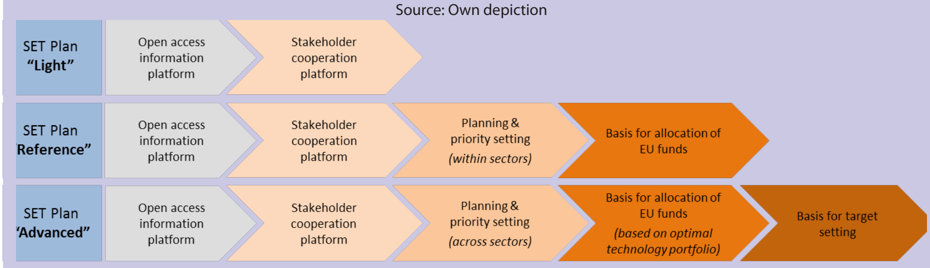
To capture the broad spectrum of policy options, we introduce three possible future pathways for an EU energy technology policy. Departing from a **reference case**, i.e., the improvement and extension of 2020 policies to the 2050 horizon, we identify two other possible directions for future policy. **Policy path 2** departs from a *strong carbon price signal* and will mainly involve technology-neutral support to innovation. In this path, after having delivered its initial push, the SET Plan as an instrument to prioritize among technologies and projects ceases by 2020. From that point, it would rather function in a 'light' version as a platform for open access information exchange and stakeholder coordination and cooperation. In this form, the SET Plan would preliminary become a tool that supports innovators' and investors' decision making and that could help to attract private funds. In contrast, an alternative **policy path 3** departs from a *weak carbon price signal* and technology targets. Directed technology push prioritizing certain technologies would play a major role to enforce these targets. In this path, an ‘advanced’ SET Plan would also be a tool to determine an optimal portfolio of low-carbon technologies and research activities across sectors and would then also provide the basis for target setting and an optimal allocation of public (and especially European) funds.

Today it can be doubted that, based on the current scheme and the currently determined emission cap, carbon prices in the magnitude of those reported in different EU Energy Roadmap scenarios and those needed in policy path 2 can be implemented.[1] Nonetheless, design improvements have the potential to make the EU ETS a stronger policy instrument: The future ETS design should aim to include the highest possible base under the scheme and broaden the impact of the common carbon price, while also aligning non-ETS carbon prices.

No policy path is clearly superior to another. A multi-criteria evaluation of these policies (see Table 1) shows that, whereas price signals are in theory the most cost-efficient way to achieve climate goals, in practice the signaling effect of carbon prices might not be strong enough. Policymakers face considerable difficulties in implementing ‘high-enough’ prices and in including all GHG emissions into the scheme. Technology targets and directed push, on the other hand, have a relatively larger potential to enhance green growth and to give (even if biased in magnitude) strong signals to investors. Moreover, technology targets could account for different national technology push programs and could adjust the burden of decarbonization between Member States. In times of economic and institutional crises, these burden sharing and coopera-

Figure 1: Role of the SET Plan in different possible future policy paths

Source: Own depiction



1. Carbon prices in the underlying simulation exercises (between 234 €/t and 310 €/t) are determined such that 2050 targets are reached, assuming equal prices/values for ETS and non-ETS sectors.

tion mechanisms increase the robustness and implementability of technology support. However, Member States are typically reluctant to give too much power to the EU and defining sectoral targets will also cause problems related to the subsidiarity issue.

Table 1: Summary of the evaluation of policy paths

Criterion	Evaluation
Climate-effectiveness	Assumption that decarbonization objective **can be reached under all policies**.
Green growth	**Path 3 is best able to enhance green growth** due to the strong role of directed technology push and the possibility to explicitly support domestic European firms. In contrast, *path 1* has a lower ability to enhance green growth and *path 2* has growth potentials only in the longer-run, due to the high carbon price, that, however, also attracts non-EU made abatement products.
Robustness to EU financial crises and institutional difficulties	**Path 3 is the most robust** option with sectoral targets providing stable investment signals. The ability to account for different national technology push programs and to adjust the burden of decarbonization among Member States is only given in this policy path. In contrast, *path 1* does not present adequate remedies, yet. *Path 2* is not robust to financial crises or institutional frictions, too, due to the lack of the ability to account for Member State heterogeneity.
Cost-efficiency	**Path 2 is the most cost-efficient solution.** Abatement costs across all sectors and abatement channels are minimized when implementing one common emission price. In contrast, *paths 1 and 3* suffer from weak carbon price signals.
Implementability	**Path 1 is most easy to implement**, as implementation efforts are low and subsidiarity compatibility is given. In contrast, *path 2* is not fully feasible as the implementation of a scheme with one unique and high enough carbon price covering all GHG emissions would pose sever political difficulties. For *path 3*, implementation barriers mainly relate to achieving an agreement on sectoral targets and the related burden sharing among Member States.

Implications for a renewed post-2020 SET Plan

A renewed post-2020 SET Plan should allow for all possible future policy paths. It should not exclude the possibility of acting within a certain future context and, hence, should be more focused than the current SET Plan and provide the basis for planning and prioritization among decarbonization technologies. In a first step and similar to the current model, stakeholders from individual sectors could work together within Industrial Initiatives to identify technological progress and future research needs. In a second step, priority technologies that (a) are key to achieve 2050 objectives, and/or (b) can help to support green growth within the Union should be identified based on a *comprehensive approach across sectors*.

Such targets have to be determined by carefully analyzing the growth potentials of European manufacturers and the degree of competition they face from foreign clean technology producers. Selected technology targets and EU funding of innovation should then be in line with the SET Plan prioritization. Key performance indicators, similar to those already specified in today's sectoral Technology Roadmaps, shall be used as a tool for monitoring and reviewing the progress of technology development, demonstration and deployment and should become an essential element and contributing factor for funding decisions.

Not only carbon pricing is uncertain

But not only carbon pricing is uncertain. The EU Energy Roadmap scenarios are designed around a menu of technologies that are essentially well-known. However, 2050 is 37 years from now. 40 years ago, there had not been oil crises, European energy markets had national structures and electricity generation from RES was close to zero. The optimal portfolio of decarbonization technologies has a very long time horizon, not only looking ahead to the 2050 target, but technological lock-ins will persist even beyond. It is not only this very long-term nature of the problem – also recent developments such as the Fukushima accident influenced possible future scenarios. Another example is the increasing interest in US unconventional gas resources. Whereas the International Energy Agency in its World Energy Outlook 2007 (when the 20-20-20 strategy was adopted by the European Council) did not mention shale gas at all, the World Energy Outlook 2011 is talking about a possible "golden age of gas".

Hence, there are not only substantial uncertainties regarding viable decarbonization technologies within the context of the EU Energy Roadmap, but there are also possible futures that are not yet recognized in 2050 roadmaps and these raise the need for technology push policies. First, it is not guaranteed that – given the triangle of energy policy goals with decarbonization, security of supply and competitiveness – long-run energy policy will maintain its decarbonization focus. *Shifts in paradigm of EU energy policy* away from decarbonization and in favor of competitiveness might weaken carbon pricing mechanisms, calling for an even stronger technology support. Similarly, a shift in favor of supply security requires a stronger push for decarbonization technologies in order to achieve balanced energy portfolios, as well as a strong push for enabling technologies such as networks to guarantee energy systems which function properly. Second, *technological revolutions*, such as a possible global shale gas revolution, could result in the "rational" price of carbon falling extremely low.

Implications for European technology push

There are several reasons that justify some directed technology push, rather than relying fully on technology-neutral support for innovation. First, certain low-carbon technologies are key to achieving the transition to a low-carbon economy and there are reasonable concerns that without such support they will not be developed and deployed on the necessary scale and/or on time[2]. Second, European technology push can have its justification as a means to respond to fierce global competition in green-tech markets and to help to keep wealth within the EU. The burden to finance market pull measures is always with consumers and tax payers but benefits can be reaped by both domestic innovators and producers, but also market entrants from outside the EU. In contrast, directed technology push can be designed such that it favors domestic European players. By explicitly targeting specific technologies, it would also allow policy makers to accelerate technology development and to support industrial leadership. This strategy is promising, especially for high-tech segments or parts of the value chain that cannot be outsourced to low-cost competitors.

Pushing energy efficiency enhancing technologies dominates other push strategies in terms of both feasibility and robustness. Without detailed cost- and technological data, it is not possible to give disaggregated technology-specific recommendations as to what

2. This could for instance be the case for CCS. All scenarios of the EU Energy Roadmap contain a substantial part of electricity generation using this technology (between 10% in the 'high RES' and 33% in the 'Reference' case in 2050) with CCS being viable from 2030 on.

technologies and research activities to push. However, from our analysis we can draw a general conclusion. The prioritization of low-carbon *production* technologies entails high risks of picking wrong winners. In contrast, pushing energy efficiency enhancing technologies is politically feasible: Opposing to a push for production technologies that often would benefit certain Member States in which major suppliers are located, energy efficiency enhancing technologies benefit all industries independent of geographic location and create jobs across all Member States. Such push also is robust with respect to future energy market developments: Consuming less is a no-regret policy and minimizes system interdependences of a directed push.

For similar reasons, pushing enabling technologies (such as grids, advanced metering or market facilitation via ICT equipment) is a no-regret strategy. As for the technology group discussed above, investments are typically quite domestically labor-intensive. However, for grid infrastructures – as for enabling technologies in general – the appropriate magnitude of investment will depend on the amount and type of renewable energy that enters the power system. The optimal system architecture will also depend on whether we move towards 'European-wide energy superhighways' with massive solar energy being imported from North Africa and huge amounts of offshore wind energy being produced in the North Sea, or whether we move instead towards a system of rising local energy autonomy, featured also by widespread demand side management.

The creation of options for technology breakthroughs has to be a main pillar in any future SET Plan. While strategies for technologies close to the market rely on shorter-run benefits like green growth stimuli up to 2020 or 2030, such push strategies have to be accompanied by long-run funding commitments for a wide range of immature technologies that might successfully be deployable after 2030 and towards 2050. As the stage of innovation involves basic research and very early R&D (i.e. projects that entail a low chance of success but a sufficiently high pay-off if successful), the argument for *broad* technology funding becomes important. Over time, and as the probability of success increases, funds should become more concentrated. Such funding of potential technology breakthroughs will not lead to lock-in effects or stranded investments once a modified SET Plan mandates new technology priorities, but would instead be disconnected from future policy paths.

It is then equally important to bring concepts that have been successfully developed in the laboratory to the manufacturing phase and to commercial deployment. European support for (incremental) innovation can help to bridge the "valley of death" and to bring to the market first prototypes of new technologies.

Member States are not homogenous with regards to their technology base and ability to finance. Political considerations, such as who are the beneficiaries of support, will impact on the planning and priority setting for technologies when drafting the SET Plan and the agreements on where funding comes from. On the one hand, there are countries that benefit from relatively low financing cost, available public money and a high consumer willingness to pay for energy policy. On the other, there are countries with rather limited private and public willingness and ability to pay for low-carbon innovation, such as countries currently suffering from the debt crisis. In addition, low-carbon technology bases range from strong low-carbon industry positions for e.g. wind energy in Germany or Denmark, to countries that do not have any of these or similar technology advantages yet. These differences hamper agreements for a unified approach for technology support. Therefore, designing an energy technology policy top-down is difficult to sustain, which highlights the need for decentralized solutions co-existing with European funding and support schemes.

The future energy technology policy also has to present a reliable and credible framework to investors and innovators, and also to consumers, who ultimately pay for these policies. In this vein, we present "no-regret measures" other than the above being also valid for any future policy (see Box 1). In contrast, there might be certain "regret measures" related to industry and trade policy. Current trade disputes related to clean technologies illustrate the complexity of such policies. There is a fine line between supporting technologies and subsidizing industries. Any industrial or trade policy which favors European players must be debated and designed with care and the grounds for introducing such measures should only relate to environmental or innovation externalities.

Box 1: Additional "no-regret" measures for any future EU energy technology policy

#1 – Enable an attractive and stable business environment: The stability of support policies, in the sense of predictability and transparency, is considered by far the most important factor for investors. Additionally, stakeholders complain about complex and lengthy permit granting procedures as a major barrier to investment and which increases project risk, which, particularly in countries with stressed capital markets, results in rising cost of capital. Recent policy initiatives are promising. Horizon 2020 aims to improve administrative procedures and also the implementation of an EU patenting system in 2014 will substantially decrease costs for innovators.

#2 – Engage consumers and citizens: Even where measures to reduce emissions on the consumer side are cost-efficient, various barriers still prevent action (lack of information, high transaction costs especially for small decentralized projects, regulated end consumer prices, etc.). These barriers need to be addressed by e.g. implementing regulatory measures such as minimum efficiency standards for appliances and buildings. Information policies can reduce ignorance and information asymmetries and also can encourage behavioral changes. Energy Service Companies can help to overcome constraints in paying possibly high upfront cost and can substantially reduce clients' search and information efforts.

#3 – Spend the available public money wisely: Experts agree that 2050 is technologically feasible, but that a key challenge will be the mobilization of the required capital. Subsidies are by far the preferred policy instruments to fund clean energy innovation of any type. However, this instrument should only be used as an instrument of last resort. The form of direct public support, considering also e.g. low-interest loans, loan guarantees, public equity and technology prizes, needs to be tailored to the features of each innovation project and to the type of entity best placed to undertake the respective RD&D. Moreover, spending public money wisely also involves a smart design of financing instruments. Furthermore, new funding sources should be considered. Existing fossil fuel subsidies need to be revised and policy makers could take into account a wider use of auction revenues from the EU ETS to fund innovation.

Introductory video

TOPIC 10

Cost Benefit Analysis in the Context of the Energy Infrastructure Package

Project Leader: Nils-Henrik M. von der Fehr
Research Team Leader: Leonardo Meeus
Research Team: Isabel Azevedo, Xian He, Luis Olmos, Jean-Michel Glachant
Project Advisors: Władysław Mielczarski, François Lévêque

Europe is moving towards the completion of an integrated internal energy market for gas and electricity and aims at further reducing greenhouse gas emissions. Trans-European energy infrastructures are a pre-requisite for reaching all these goals. Massive investments will be needed in the coming years, to enable the implementation of adequate transmission lines and storages at European level, to make this possible, the new Regulation on guidelines for trans-European energy infrastructures has been adopted and recently entered into force.

When it comes to decision making about such cross-border transmission lines, often the interests of the different Member States and stakeholders diverge. In particular electricity overhead lines face often fierce local opposition. The cost-benefit analysis will play a key role in tackling these difficulties: its results will be useful in order to identify the projects with highest European added value and to communicate these benefits to affected population to improve public acceptance. The cost-benefit analysis will be used also to address asymmetric distribution of costs and benefits among member states and will be used also when deciding about EU financial assistance to infrastructure projects under the proposed Regulation on the Connecting Europe Facility that puts aside 5,1 billion euros for the period between 2014-2020.

The work carried out by the Think project provided a precious academic and at the same time practical and pragmatic input to the development of the methodology for the cost-benefit analysis. Its analysis and recommendations will serve as reference for the involved parties in the process: for the European Network of Transmission System Operators for electricity (ENTSO-E), tasked to develop the methodology, for the Agency for the Co-operation of Energy Regulators (ACER) giving an opinion and finally to the European Commission responsible for approving it. The best proof for the timeliness and relevance of the work performed by the Think team was the fact that some of the recommendations even at drafting stage have already been implemented by ENTSO-E, and also ACER refers to the report and in particular to the recommendations on monetization in its opinion on the ENTSO-E draft methodology.

Kitti Nyitrai
Internal Market I: Networks and Regional Initiatives
Directorate General for Energy | European Commission

Highlights

- Cost Benefit Analysis (CBA) has proven to be a useful tool to support the economic appraisal of important projects in many sectors. In the energy domain, a single CBA method has been proposed at EU level to evaluate and compare electricity transmission and storage projects from different countries, which is unprecedented anywhere in the world.

The Future of Energy Infrastructure Development in Europe
by Leonardo Meeus
at IIEA event, Dublin

- The objective of the 10th report of THINK has been to advise the European Commission (DG Energy) on the development of this method in the context of the Energy Infrastructure Package. This brief is derived from that report. We provide recommendations for the scope of the analysis as well as the calculation of the net benefit. We also discuss how the method can be used to rank projects.
- Regarding the *scope of the analysis*, our recommendations are: (1) interaction between projects must be taken into account in the project and baseline definition; (2) data consistency and quality should be ensured; (3) the conventional time horizon is 20-25 years; (4) CBA should concentrate on a reduced list of effects and those should be monetized; and (5) distributional concerns should not be addressed in the calculation of net benefits.
- Regarding the *calculation of the net benefit*, our recommendations are: (6) infrastructure costs need to be disaggregated; (7) the model used to monetize the production cost savings and gross consumer surplus needs to be explicitly stated; (8) a common discount factor should be used for all projects; and (9) a stochastic approach that is consistent with the Energy Roadmap 2050 should be used to address uncertainty.
- Regarding the *ranking of projects*, our recommendation is: (10) the ranking should be primarily based on the monetized net benefit.
- ENTSO-E has already proposed a draft method for electricity projects. We will analyse to what extent this method is in line with our recommendations and will conclude that it is an important step in the right direction. However, improvements could still be made, as proposed in this brief.

Background

The European Commission estimates that about €200 billion needs to be invested in electricity and gas infrastructure in order to achieve the 2020 energy and climate objectives. There is a risk that almost half of this expected investment will be too late or not at all. The aim of the Energy Infrastructure Package is therefore to accelerate the development of selected projects by: (1) facilitating their permit granting process; (2) providing an enhanced regulatory treatment for these projects; and (3) providing EU financing assistance for the selected projects that are important to achieve the EU energy objectives, but which are not commercially viable.

The Energy Infrastructure Package has established a process to identify Projects of Common Interest (PCIs) in priority corridors and areas[1]. First, promoters nominate their projects to the Regional Groups which will be set up for each corridor or area. Member states and the European Commission will then rank the proposed projects in each Regional Group based on individual Cost Benefit Analyses (CBA). Finally, the European Comission will adopt an EU-wide list of projects based on the regional lists. The Energy Infrastructure Package has also introduced a procedure to develop a CBA method for electricity and gas which promoters will be required to use when they nominate their projects. The ENTSOs are expected to propose a method, and ACER, the European Commission and member states will provide opinions on these methods. The ENTSOs will then review the method and finally the European Commission will then approve it. ENTSO-E has already proposed a draft CBA method in anticipation of this procedure.

In this Policy Brief, we will focus on electricity (i.e. transmission lines and storage). We will provide recommendations for the scope of the analysis as well as the calculation of the net benefit of electricity transmission and storage projects. We will also discuss to what extent the ENTSO-E proposal is in line with our recommendations. We will recommend how the method should be used to rank projects, but do not discuss the other uses that have been foreseen for the CBA method in the Energy Infrastructure Package (i.e. cost allocation and regulatory incentives for infrastructure investments).

1. The priority electricity corridors include Northern Sea offshore grid, North-South electricity interconnections in Western Europe, North-South electricity interconnections in Central Eastern and South Eastern Europe, and the Baltic Energy Market Interconnection Plan in electricity.

Cost benefit analysis

We first define the scope of the analysis, to then discuss how the net benefit of transmission and storage projects should be calculated in the context of the Energy Infrastructure Package.

Scope of the analysis

Project & baseline definition

The purpose of CBA is to evaluate the economic effects of adding a project to a forecasted future, i.e. the so-called baseline. Therefore, scoping the analysis starts with the definition of the project and the definition of the baseline.

1. *Interaction between projects must be taken into account in the project and baseline definition*

In network industries, projects typically interact, i.e. they can be (1) complementary, or (2) competitive. Complementary projects should be dealt with in the definition of projects, i.e. they should be considered as a single project. Competitive projects should be dealt with in the definition of the baseline. Each project should be evaluated against two baselines (one with and one without all proposed projects) to detect competing projects.

The ENTSO-E proposal ensures that only projects that significantly contribute to the common goal of increasing the capacity on a certain border can be grouped. However, the objective should be to group together projects which are complementary in terms of their net benefit, i.e. the net benefit of both projects together is higher than the sum of the net benefit of the individual projects. Project promoters should be made responsible for providing evidence on the complementarities between investments that are proposed as a single project.

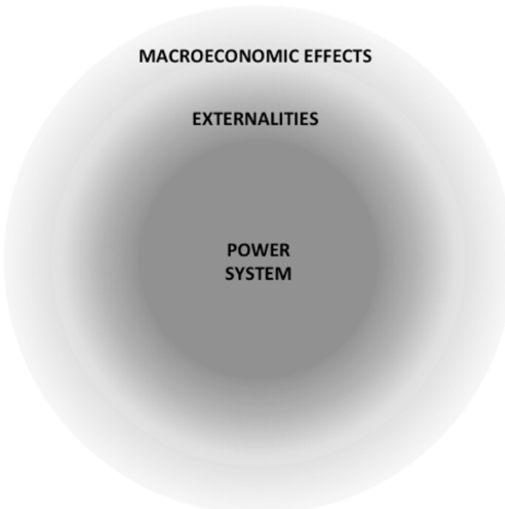
2. *Data consistency and quality should be ensured*

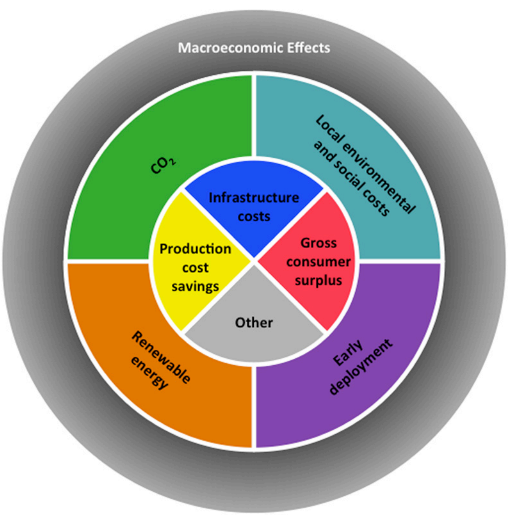
A public consultation is a good way to ensure the quality of the data that will be used in the baseline. ENTSO-E has already proposed such a consultation to validate the data, following the current practice in the context of the Ten Year Network Development Plan. It is also important to ensure the consistency of the scenarios with the Energy Roadmap 2050, which we will discuss along with the calculation of the net benefit.

3. Conventional time horizon is 20-25 years

There is a trade-off between capturing longer-term effects and increased uncertainty. The ENTSO-E proposal is already in line with the convential time horizon.

Box 1: Comprehensive list of effects (own depiction)





Effect mapping

The economic effects of developing electricity transmission or storage projects include (1) the impact on the power system, as well as the effects beyond the system, i.e. (2) externalities and (3) macroeconomic effects. The impact on the power system can be categorised into production versus consumption effects, infrastructure costs and other market benefits, such as improved competition and liquidity. The externalities are related to the impact of these projects on greenhouse gas emissions, renewable energy, local environmental and social costs, and the early deployment of innovative transmission or storage technologies (Box 1).

4. CBA should concentrate on a reduced list of effects and those should be monetized

There are several effects that can be disregarded for different reasons: (1) *macroeconomic effects*, such as economic growth and employment effects, are relatively similar for most projects so they will not significantly affect their ranking; (2) infrastructure investments can result in a more efficient dispatch of power plants so that *greenhouse gas emissions* are reduced. However there is a carbon price so this effect has been internalised in the production cost savings; (3) infrastructure investments can also reduce the spilling of *renewable energy*, which will reduce the renewable energy capacity that needs to be installed to achieve the 2020 renewable energy target. In other words, considering greenhouse gas emissions and renewable energy as a seperate effect would imply double counting.

There are also effects that can be dismissed for most projects, with exceptions: (1) infrastructure costs include *local environmental and social costs* because promotors have to do an environmental impact assessment and take measures to fullfill certain requirements, although the visual impact of a project for instance is not yet covered by these regulations; (2) *early deployment benefits* have also already been internalised in the infrastructure costs as there are several EU programs to support innovative infrastructure projects, although there can of course be exceptions in innovative projects that have received relatively limited support; (3) *other market benefits* are relatively similar for most projects and are usually very small compared to other relevant effects. Exceptions could be projects that significantly change the market structure in an isolated area.

To sum up, there remain three effects that should be monetized for all projects, i.e. (1) infrastructure costs, (2) production cost savings and (3) gross consumer surplus. There

Main recommendations presented at the North Seas Countries Offshore Grid Initiative meeting Brussels, 27 June 2013

are additional effects which may be relevant to specific projects and indicators should be used to identify these projects and to justify additional analysis to monetize also these effects. This can be the case for projects with an exceptional visual impact (e.g. projects in densely populated, protected or tourist areas) or for projects that significantly change the structure of a market (e.g. projects in isolated areas) or for projects that are exceptionally innovative (e.g. first of a kind projects, such as offshore infrastructures).

The ENTSO-E draft proposal lists nine benefits to be considered for all projects. A distinction is made between effects that are to be monetized, i.e. "*total project expenditures, social-economic welfare, and variation in losses*", and effects that are to be quantified as additional indicators, i.e. "*social and environmental sensibility, security of supply, RES integration, variation in CO2 emissions, technical resilience, and robustness*". If projects are then ranked based on the monetized net benefit in combination with these indicators, it implies an implicit monetization of effects that have not been monetized explicitly. Such an implicit approach is less transparent and allows for subjective judgment.

Distributional effects

5. Distributional concerns should not be addressed in the calculation of net benefits

The economic analysis of efficiency gains from infrastructure projects should be done without consideration of distributional effects. If there are concerns, they should be resolved with explicit political decisions by relevant authorities. The European Commission could for instance use regional quotas when defining the EU-wide list based on the regional lists.

ACER referred to this THINK report in its position

ENTSO-E referred to this THINK report in its proposal

The ENTSO-E draft proposal does not explicitly discuss distributional effects, but it does refer to the EU Regional Policy Guide. The guide proposes the use of social discount rates, which implies that the rates of developing countries are higher because they have a higher economic growth outlook. As a result, the projects of these countries will be ranked lower than projects with similar benefits in developed countries, which exacerbates distributional concerns. Below, we argue in favor of using a common discount factor for all projects.

Calculation of the net benefit

Monetization

6. *Infrastructure costs need to be disaggregated*

There should be a predefined list of cost components that promoters are required to report separately. The list of items proposed by ENTSO-E can be the starting point, but the costs incurred for mitigating environmental or social impact of the project should also be presented separately and included in the total project expenditure.

7. *The model used to monetize the production cost savings and gross consumer surplus needs to be explicitly stated*

There is no single model that adequately captures all the production cost savings and gross consumer surplus of all transmission and storage projects. It is therefore important that the assumptions of the model are clearly explained to allow for a proper interpretation of the CBA results. The choice of the model should also be coordinated with the data validation process of the baseline.
The draft ENTSO-E proposal leaves certain modeling choices to the Regional Groups, while also providing some model specifications.
ENTSO-E has proposed a minimum consideration of technical characteristics of power plants ("*efficiency rate and CO_2 emission rate*") and a minimum geographic scope ("*all member states and third countries on whose territory the project shall be built, all directly neighbouring member states and all other member states impacted by the project*").
Note that Regional Groups may choose a sophisticated model, for instance including more detailed technical characteristics of power plants. It will therefore be important to coordinate these modelling choices with the data validation process for the baseline.
ENTSO-E has also proposed an indicator to estimate the changes in the volume of en-

ergy non-served during contingency periods i.e. "*security of supply*". ENTSO-E referred to the lack of reliable data across Europe as the reason not to monetize this effect. The CEER has already provided guidelines on how these values should be established at a national level, and an intermediate solution could be that a value is agreed upon as part of the data validation process for the baseline.

Inter-temporal discounting of costs and benefits

8. *A common discount factor should be used for all projects*

Projects of Common Interest will have a similar regulatory treatment and might also be eligible for EU financial support. The label can also improve the confidence of potential investors and thereby facilitate access to capital. These projects are therefore likely to have similar access to capital so that a common discount factor should be used for all projects. The factor should be agreed upon through open consultation, together with the parameters of the baseline.

The ENTSO-E draft proposal is partially in line with this recommendation because there is a single discount rate for every region. However, ENTSO-E also proposes to follow the EU Regional Policy Guide, which would exacerbate possible distribution concerns across regions.

Uncertainty

9. *A stochastic approach that is consistent with the Energy Roadmap 2050 should be used to address uncertainty*

The Energy Roadmap 2050 already provides possible extreme scenarios for the future that are consistent with the EU energy and climate objectives. Based on these scenarios, a stochastic approach should be followed to capture the robustness of projects across these possible futures, which would result in a net benefit distribution.

The ENTSO-E draft proposal already refers to the use of multiple scenarios and the use of sensitivity analysis, but not yet a stochastic approach. Nevertheless, it has already been implemented by several TSOs in Europe for electricity infrastructure projects. We argue that this approach should be adopted at EU level and be consistent with the scenarios of the Energy Roadmap 2050.

Ranking projects

10. The ranking should be primarily based on the monetized net benefit

The method we recommend above is a stochastic approach that calculates a net benefit distribution against two baselines, i.e. one with and one without all proposed projects. However, to rank projects we need a single monetized value. This value could be obtained by taking the mean value of the net benefit distribution of a project against one of the baselines, but adjustments might then be needed for (1) competitive projects and (2) uncertainty.

The first issue is with competitive projects. If the ENTSO-E draft proposal were to be followed, the initial ranking would be based on the baseline with all proposed projects included. If two competitve projects are proposed and ranked against this baseline, they will be ranked low and both could even exhibit a negative net benefit, even if developing one of them could be strongly beneficial. To identify these kinds of cases, the baseline without the proposed projects could be used. However, if the ranking were based on the baseline excluding all other proposed projects, we would have the opposite problem. Competitive projects would both be ranked high, even in cases where it is only beneficial to develop one of them. In other words, there is no perfect baseline and adjustments to the initial ranking may be needed regardless for competitive projects.

The second issue is one of uncertainty. Even though the initial ranking is based on the mean value of the net benefit distribution of projects, policy makers (depending on their risk averseness) might wish to adjust the ranking of projects which exhibit a significantly different risk profile to the average project.

Conclusion

The draft method proposed by ENTSO-E is an important step in the right direction, however improvements could still be made, as proposed in this brief. It should also be considered a success in itself that a single CBA method has been proposed at EU level to evaluate and compare electricity transmission and storage projects from different countries as this is unprecedented anywhere in the world.

Presented at the Executive Seminar "Getting European electricity infrastructure financed?" Florence School of Regulation, 8 March 2013

Introductory video

TOPIC 11

Shift, Not Drift: Towards Active Demand Response and Beyond

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The introduction of economic incentives to consumers to change their consumption patterns by modulating energy use according to actual market conditions is essential to implement flexible demand in the retail market that would optimize the integration of increasing variable renewable generation sources. Regulatory developments are creating a momentum which needs to be sustained to deliver a wider choice of demand response options and greater potential benefits for consumers.

Demand response programmes have begun to emerge across the EU in recent years. The gradual rollout of smart meters, the development of network codes for the internal electricity market (particularly those on demand connection, system operation and balancing) and full transposition of the Electricity and Energy Efficiency directives create the right conditions for policy-makers, regulators, network operators and energy businesses to consider how to trigger more demand side participation in the market in the near term.

The THINK Project "Shift, not drift: Towards active demand response and beyond" addresses demand response in a smart and concrete way by focusing its analysis on the consumer's potential to participate in this market instrument, therefore giving to the relevant stakeholders and to the Commission a reliable and consistent basis to put forward the necessary instruments to make demand response happening.

Manuel Sanchez Jimenez
Internal Market III: Retail Markets; Coal and Oil
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Highlights

- European electricity systems are evolving towards a generation mix that is more decentralised, less predictable and less flexible to operate due to the large-scale integration of renewables. In this context, additional flexibility is expected to be provided by the demand side. This implies consumers must be shifted from the current 'passive' role to providing 'active' demand response.

- The objective of the 11th THINK report is to assess how to realise this **shift** towards active consumers, using a consumer-centred approach. We recognise the need for 'software', such as contracts, to engage consumers in addition to the enabling 'hardware', such as smart meters and appliances. We propose recommendations for consumer empowerment tools, as well as for market design and regulation that would allow the full take-off of active demand response.

- A prerequisite of consumer engagement is to have an adequate range of contracts that match different consumer categories. The Think report demonstrates that consumers are diversified both in their flexibility potential and in their preferences on a set of criteria that affect their willingness to participate in demand response. We propose a consumer profiling tool that not only empowers consumers to make informed and appropriate choices, but also facilitates intermediaries to valorise active demand response.

- Our analysis shows that one single market player might not have incentives to offer an adequate range of demand response contracts. Therefore, it is essential to have diversified market players acting as demand response intermediaries. The entry of new market players, such as consumer cooperatives or third parties from non-electricity sectors, needs to be facilitated.

- The THINK report further illustrates that the retail market design needs to be adapted to accommodate active demand response. All consumers should be able to make deliberate choices about their electricity supply, and to valorise their flexibility through active demand response. We propose one such market design referred to as 'real-time market'.

- Given the decentralised and local character of demand response, national authorities may be best placed to implement the necessary measures as proposed in the report. The EU's role should be focused on promoting contract pilot studies, disseminating the results of decentralised pilot projects, providing guidance or framework regarding consumer empowerment and protection, and rethinking the design of retail market.

Background

Shift, Not Drift: Towards Active Demand Response and Beyond Webinar by Xian He

Traditionally, electricity systems are operated in a 'load following' fashion, meaning that the flexibility to maintain the instantaneous balance between electric power supply and demand is mostly provided by the **generation side**, which is dominated by centralised, large-scale dispatchable power plants. Nowadays, the European electricity systems are evolving towards a generation mix that is more decentralised, less predictable and less flexible to operate, due to the large-scale integration of renewables to meet the 20-20-20 targets. In this context, additional flexibility is expected to be provided by the **demand side**.

Indeed, in the short term, demand response can both reduce congestion by shifting the load to times when there is idle grid capacity, and reduce the generation costs by shifting the demand to times when there is more renewable power available. As a consequence, the long term value of demand response lies in reduced or postponed investments in network and generation capacity.

The importance of demand response as a means of flexibility has been widely recognised among stakeholders and policy makers in Europe, e.g. in the Energy Roadmap 2050 (*"energy saving and managing demand: a responsibility for all"*), in the Internal Market Communication (*"stronger demand response in distribution networks"*) and in the Energy Efficiency Directive (*"demand response is an important instrument for improving energy efficiency"*). The gradual roll-out of smart meters at residential level and the deployment of smart grids are expected to provide the 'hardware' for demand response. Thus, how to engage consumers to participate in demand response is becoming a pressing issue.

There is, however, significant scepticism about consumer engagement. Some argue that the financial impact on consumers' electricity bills is too small for the consumer to react. Some claim that consumers do not like or cannot handle the additional complexity introduced by demand response. Privacy concerns and fear of reduced consumption autonomy make up two more arguments against a meaningful level of active demand response. Accepting these statements means that we leave consumers to **drift** on their

Presented at
THINK Luncheon Seminar
DG Energy, 3 June 2013

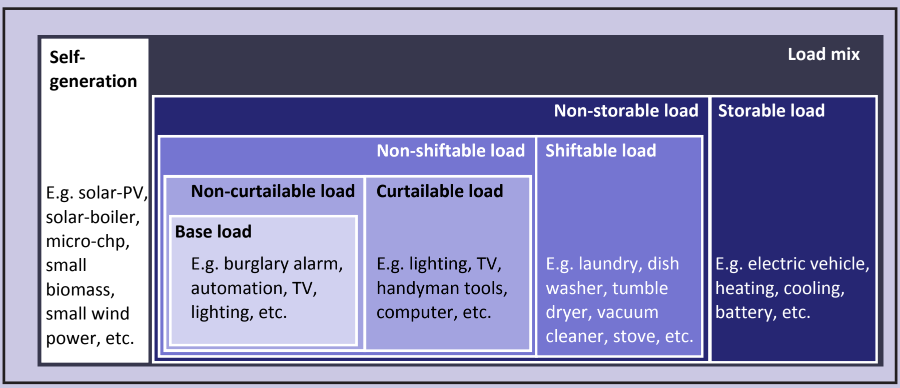
own and admitting that there is no future for demand response. In this report, we challenge that vision and provide an analytical framework to assess consumers' potential and willingness to participate in active demand response. On that basis, we present recommendations to empower and protect consumers in their **shift** to active demand response participants.

Consumers' potential and willingness to participate in demand response

Recent pilot studies show a divergent response by consumers: some consumers opt out or drop out of the studies, some show limited signs of responsiveness and other consumers effectively and significantly respond to signals. It is thus important to realise that consumers have diverse preferences which are engaged by different signals.

To capture this consumer diversity we propose a two-dimensional framework to categorise consumers: (1) according to how consumers are potentially able to participate

Box 1: Load mix decomposition (own depiction)



in demand response as reflected in their **load mix,** and (2) according to the **preferences** on a set of criteria that affect their willingness to participate in demand response.

Presented at the 16th Steering Committee Meeting of the Smart Grids Task Force DG Energy, 9 July 2013

Presented at Enhancing the Retail Market Functioning Vlerick Campus Brussels, 26 June 2013

Categorisation dimension 1: Consumer load mix

The potential of consumers to participate in demand response is determined by the flexibility of their load. It is noteworthy that such flexibility is related not only to the capacities of the smart appliances that a consumer possesses, but also to how the consumer uses his smart ***and*** dumb appliances. To capture this richness, we propose a categorisation of load as depicted in Box 1.

Consumer load, i.e. the electric power consumption, can first be categorised in (1) *storable load* (e.g. heating, fridge, electric vehicle, etc.) and *non-storable load*. Next, non-storable load can be further categorised in (2) *shiftable load* (laundry, tumble dryer, dish washer, etc.) and *non-shiftable load*. Non-shiftable load then is further categorised in (3) *curtailable load* (lighting, TV, kettle, stove, etc.) and *non-curtailable load*. The remaining non-curtailable load can be classified as (4) *base load* (TV[2], burglary alarm,

Box 2: Contract interpretation of consumer criteria

Contract	Price risk	Volume risk	Complexity	Autonomy/ Privacy loss	Financial compensation
Time of use pricing	Limited	None	Limited	None	Limited
Dynamic pricing	High	None	High	None	High potential
Fixed load capping	None	Limited	High	Limited	Limited
Dynamic load capping	None	High	High	Limited	High potential
Direct load control	None	None	None	High	Limited/ High potential

2 Depending on how a consumer uses an appliance to generate end-user services, an appliance can be base load (e.g. World Cup final on TV) one moment and curtailable (e.g. a re-run of a TV series) at other times.

automation, etc.). The load refers to net electric power consumption from the grid and is thus equal to the total power consumption corrected for (5) *self-generated* electricity by the 'prosumer'. The flexibility increases from the base load to storable load.
Together, the different proportions of these load types make up the consumer load mix. Consumers can then be categorised according to their dominant load type, indicating their degree of flexibility.

Categorisation dimension 2: Consumer preferences

The willingness of consumers to participate in demand response can be associated with the consumer preferences on a wide range of criteria that includes, but is not limited to, financial compensation, prosocial motivation, price and volume risk, complexity, and autonomy and privacy.
It is important to note that consumers are not homogenous in their perception of these criteria. For instance, loss of autonomy can be a cost for one consumer whilst a benefit for another; and different consumers might attribute different values to the same criterion as risk might be highly relevant for one consumer and a minor issue for another. Therefore, consumers' different preferences on these criteria will also condition the way they wish to participate in demand response. Consumers can then be categorised according to similar sets of preferences.

Demand response contract: the missing piece in the puzzle?

Contracts are currently a missing piece in the puzzle of demand response take-off; they have been relatively under-researched, especially regarding the consumer-oriented impact. However, contracts with demand response intermediaries (sometimes referred to as 'aggregators') are the 'software' for consumers to participate in demand response. The contract terms regarding the financial compensation, the periods of activation, the capacity requirement, etc. are closely related to consumers' potential and willingness to participate in active demand response. Without understanding the full implication of the contract, a consumer can hardly be mobilised into an active consumer. Therefore, the THINK report adopts a consumer-centred approach and focuses on demand response contracts.
Based on the established literature and experiences from industrial consumers' demand

response and pilot studies, we distinguish five generic[3] contract types: (1) price-based static contracts, e.g. time of use (TOU) pricing; (2) price-based dynamic contracts, e.g. dynamic pricing, real-time pricing, and critical peak pricing; (3) volume-based static contracts, e.g. fixed load capping; (4) volume-based dynamic contracts, e.g. dynamic load capping and interruptible contracts; and (5) control-based contracts, e.g. direct load control contract. We demonstrate that there is an interaction between the contract types and the consumers' load mixes/preferences.

The first interaction: consumer load mix and contract

Consumers' load mixes may determine whether they are able to meet the requirements of certain demand response contracts. For instance, a *curtailable load mix* can interrupt load instantly and is thus particularly able to respond to dynamic contracts, such as dynamic pricing and dynamic load capping. A *shiftable load mix* needs some planning of load and thus benefits from static signals that are notified well in advance and are less volatile during the day. Hence, it matches TOU pricing and fixed load capping.

The second interaction: consumer preferences and contract

The five retained contract types also give an explicit or implicit interpretation to the aforementioned consumer criteria[4]. As shown in Box 2, some contracts impose high risks to consumers (dynamic pricing and load capping contracts), whereas other transfer limited or even no risk to consumers (TOU pricing, fixed load capping and direct load control); complexity is higher for volume-based contracts and for dynamic contracts; autonomy/privacy loss is absent in pricing contracts, while high for direct load control; and financial compensation has a higher potential when more risk and complexity is passed on to consumers. As a result, consumers may prefer certain contracts depending on their preferences on these criteria.

A toolkit of consumer empowerment and protection

The above analysis demonstrates that there is no clear best contract for all consumers; the appropriateness of a contract depends on consumers' specific load mix as well as

3 The generic contract type encompasses a great variety in exact contract terms, i.e. the actual establishment of price, quantity, time intervals et cetera.

4 Except for prosocial motivation which is intrinsic to the consumer, and should apply equally to all contract types.

their preferences on a series of criteria. Hence, there is a need for an adequate range of contracts, including the five contract types discussed above. In other words, consumers need to be provided with enough options in order to be engaged in active demand response.

But this availability of contract options alone is not enough; consumers also need to be empowered to make informed and appropriate choices. Indeed, even if the adequate range of contracts exists, consumers may still face difficulties to choose the right contract because of a lack of knowledge about their flexibility potential, insufficient awareness of the implications of contracts, misalignment of their load mix and preferences, etc. The THINK report further proposes a toolkit of consumer empowerment and protection as follows:

1. Mandatory consumer profiling is key to raise consumers' awareness and to educate them on impacts of different options. The profiling should be the result of a standard survey on the consumer's load mix and preferences on a set of criteria that are implied by the contract. This profiling could also facilitate market players to establish their business models with consumers.
2. Independent contract comparison tool needs to be established. The provider of such tool should be certified and the methodology (e.g. included parameters) should be regulated. Transparent information, e.g. through disaggregated billing, should be mandatory to allow adequate contract benchmarking in the comparison tool.
3. Monitoring and optimisation of the range of contracts helps to limit the complexity of contract terms, while still allowing competition and innovation in contract design.
4. Adequate data protection is needed to raise consumers' trust to reveal personal information before and after signing a contract.
5. Effective dispute resolution is necessary as a fall-back option to enable efficient switching of contracts or intermediaries by consumers.
6. Vulnerable consumers should have access to assistance and protection to prevent them from being penalised for their inability to provide active demand response.

What is beyond? — The market design

While the aforementioned recommendations empower consumers to handle demand response contracts, these contracts are embedded in an existing market design, with market players freely proposing contracts to potential customers, valorising active demand response in different market places. Using the contract as a starting point, we then address the following issues:

How to guarantee there is an adequate range of contract for consumer choices?
Our analysis shows that one single market player might not have incentives to offer an adequate range of demand response contracts, because of their divergent business objectives and risk preferences. Therefore, it is essential to have a diversified set of market players acting as demand response intermediaries. We further identify what may hinder an adequate range of intermediaries to emerge, and propose the following measures for facilitating market entry for new market players:

7. A demand response license provides a 'quality label' for new actors to build trust with consumers.
8. Disaggregated billing allows better comparison of offers from intermediaries who offer bundled services (e.g. supply and demand response) and those who do not.
9. Non-discriminatory entry to the demand response market and freedom to offer services to consumers for intermediaries.
10. Non-discriminatory access to electricity markets, including balancing markets, and bilateral procurement mechanisms for ancillary services and congestion management.
11. Non-discriminatory access to data, e.g. to prevent the transfer of information from the regulated activities to the deregulated activities in an integrated supplier-DSO.

Is the current retail market design suitable to accommodate active demand response?
The current retail market starts from the assumption of low elasticity of demand, which is expressed by at least two facts: first, the supply contracts are by default offering unlimited electricity supply to consumers, and in many Member States, at a regulated retail tariff; second, balancing costs are socialised, partly by the supplier among his

customers, and partly by the TSO among all network users. Such arrangements severely reduce the incentives for consumers to become active. Therefore, in the long term, it is necessary to rethink the market design with the anticipated active role of consumers in mind. The THINK report proposes one such design referred to as '**real-time market'**:

12. The real-time market implies that both the supply and the demand side need to express their willingness to sell and buy guaranteed electricity in real time. It thus allows all consumers to make deliberate choices about their electricity supply, and to incorporate their flexibility into such choices. As a result, balancing costs are largely dissocialised, providing incentives for active demand response.

Conclusion

To sum up, the scepticism about consumer engagement is fallacious, as we have demonstrated in our original approach focusing on contracts, that **consumers can be engaged** if they have options that reflect their diversity and are adequately empowered to make choices. The THINK report also provides recommendations on **how to get there**, including a toolkit of consumer empowerment and protection, necessary adaptation of market rules and regulation, as well as a new retail market design. Therefore, the **shift** towards active demand response requires substantial efforts, but it is feasible and necessary. Indeed, a functioning retail market could not materialise without the active participation of consumers, and the decarbonisation targets can hardly be achieved without flexibility provided by the demand side. The long term paradigm shift of the electric power systems needs to be translated in a step-wise process that should start already now.

Introductory video

TOPIC 12

From Distribution Networks to Smart Distribution Systems: Rethinking the Regulation of European electricity DSOs

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With the deployment of Smart Grids, new tasks and responsibilities will emerge for existing or new actors in the energy market. For DSO's the task of modernizing their grids and at the same time becoming 'active' operators represents by itself a big challenge. It will require smart investments, employment of new technologies and advanced system design and planning. Member States will have to ensure that DSOs, as regulated business, will be in a position to deal with the new challenges they are facing and not be 'overloaded' with new tasks for which may better be assigned to other actors or left open to competition. Moreover, DSOs and other actors will need to further cooperate with ICT sector in order to explore synergies, such as sharing communication infrastructures, and develop new energy services which would be beneficial to the system and the customers themselves and will ensure their active integration into the internal energy market. In this transition, new market models for handling data may have to be considered.

The Think Projects "From distribution networks to smart distribution systems: Rethinking the regulation of European electricity DSOs" reconsiders the full spectrum of DSO-related regulatory intervention focusing on the need of smarter regulation to adequate DSO's remuneration in order to recognize changing cost structures and at the same time allow DSOs to become real "system operators", highlighting that stricter unbundling requirements should be mandated depending on system complexity and the number of tasks to be accomplished by DSOs and that the procedures and principles of coordination between DSOs and TSOs should be defined at a European level, though any EU involvement should to be kept at a minimum level.

Even though the European Commission has already identified the need of reconsidering the role of DSOs in its recent Communication 'Making the internal energy market work' (IEM Communication COM(2012)0663), the Think Project analysis all these aspects in a thorough way and serve as the basis for possible further analysis with Member States in the context of the Action Plan attached to the IEM Communication.

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Internal Market III: Retail Markets; Coal and Oil
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Highlights

- An emerging broad range of technologies for distributed energy resources (DER) is causing significant changes in the planning and operation of power systems. These changes cause challenges for power systems and regulators alike. However, DER – with the right regulation and market design – can at the same time be exploited to establish a more efficient and cleaner electricity system than our current one. To this end this THINK report discusses how adjustments to the regulation of European DSOs can incentivize the latter to effectively integrate DER into electricity markets and system management.

- A sound regulation that incentivizes DSOs to exploit DER for a more active system management has to take account of changing OPEX and CAPEX structures, the optimal choice among both, and of how to incentivize DSOs to favor innovative solutions. Furthermore, as grid users are becoming more complex and sophisticated agents, distribution cost should be recovered via grid tariffs that reflect the true costs (or benefits) of different types of load and generation for the system.

- As the complexity of the system increases with an increasing DER penetration, an insufficiently unbundled DSO could either stay with a restricted set of traditional system tasks, or the DSO could expand its portfolio of activities, but be accompanied with stricter requirements for unbundling.

- The general responsibilities of network operators with respect to grid management do not change, but the set of tools available to perform their tasks is enriched by DER. Products that system operators use to ensure reliable grids should be clearly defined in terms of geography and timing. Procedures of coordination between DSOs and TSOs have to be updated.

- In the European context, regulation should be kept at minimum level. We see neither the justification nor even the convenience for an EU-wide harmonization of the regulation of DSOs. However, we recommend setting clear minimum requirements in a few key regulatory aspects, as well as the publication of EU guidelines to spread, encourage, and monitor good regulatory practices in some of the critical areas identified.

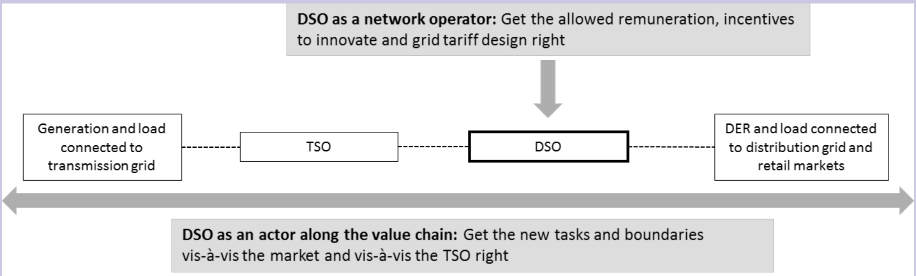
Background

Presented at the 16th Steering Committee Meeting of the Smart Grids Task Force DG Energy, 9 July 2013

Technological advances are reshaping today's electricity markets. More mature technologies for local renewable generation and decreased investment costs thereof, joint with national support schemes, led to a significant market penetration of distributed generation in many EU countries. Not only distributed generation but a newly emerging broad range of distributed energy resources (DER), including also local storage, electric vehicles or demand response, are driving or at least allowing for potentially significant changes in the operation of power systems. Today, some challenges are only a possibility, and might arise once technologies mature and are more widely deployed. Other challenges, foremost related to distributed generation and, for example, resulting volatile power flows, are already established facts observable in many EU distribution systems. However, the same technologies that are causing substantial challenges for power systems and regulators can – with the right regulation and market design – be exploited to establish a more efficient and also cleaner electricity system than our current one.

In the light of these changes, this THINK report discusses regulatory implications of changing local electricity markets. To this end this report sets the focal point on electricity distribution system operators (DSOs) as regulated local entities and local market facilitators. First, we shed light on where the current regulation of DSOs needs updates to allow for welfare-enhancing DER technologies to be adapted efficiently and in a timely fashion. A major challenge is to revisit regulation such that distribution companies are not negatively affected by the development of DER and are incentivized to foster the integration of viable new technologies into the market. Moreover, updates are needed to provide the right regulatory tools to DSOs such that they can benefit from the services DER can offer for system operation and planning. Ultimately, the priority task of regulation is not to try to predict what the future will be, but to design incentives that make possible all welfare-enhancing business models under any future market development.

Figure 1: Relevant areas of regulation



Existing regulation of DSOs needs to be reviewed in its full spectrum

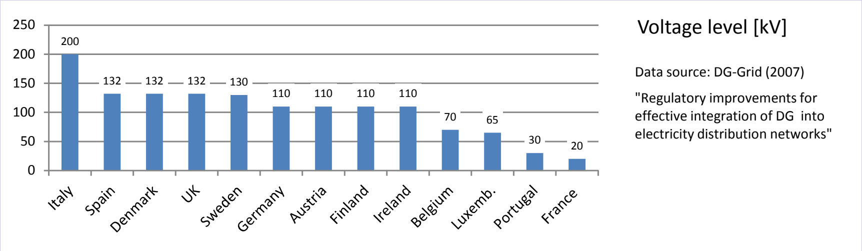
The market penetration of DER opens possibilities for decentralized trade of energy. These trade opportunities allow for new business models, mainly related to the aggregation and marketing of DER. Also DSOs can profit from employing DER resources in their daily tasks of ensuring system functioning and grid investments. However, to exploit the full range of potentials that DER offer, DSOs have to undertake significant upfront investments in grid (and related) infrastructures. For DER to flourish and to enable them to compete with resources connected to the transmission grid, DSOs also have to provide adequate conditions for network access and usage. The latter also includes adequate conditions for new business models related to the aggregation of DER. Successful integration of these new business models may potentially even lead to a paradigm shift that might shake up the traditional value chain and cause a radical change of the power market architecture as we know it today, replacing traditional downstream marketing of power by increasing reliance on local sources.

As a consequence, existing regulation needs to be reviewed in its full spectrum. This full spectrum of DSO activities can be distinguished according to, first, the DSO's function as a network operator and, second, its function as a market facilitator along the value chain (see Figure 1). Reviewing DSO incentives as a network operator implies revisiting regulatory schemes for allowed remuneration and resulting incentives to invest and to innovate, as well as revisiting network tariff design. DSOs are a natural monopoly for which allowed remuneration has to be regulated. This allowed revenue will be collected via grid charges and the structure and format of these charges will have an important impact on grid users' behavior. In contrast, reviewing DSO incentives as a key player

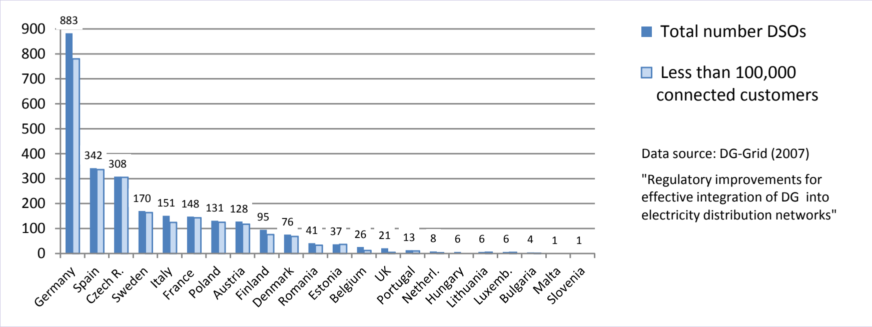
Box 1: Electricity distribution in the EU – A patchwork of national systems

Today's DSO landscape resembles a patchwork with diverse national implementations of relevant pieces of EU legislation and resulting heterogeneous end-user market structures in different Member States. Substantial differences regard, amongst others, operated voltage levels, designation procedures, the scope of activities, the size and number of DSOs in a country, the level of unbundling, and applied regulatory schemes. Also the degree of retail market liberalization and competition still varies significantly across the EU, even though full eligibility of customers is mandatory, and the choice of suppliers and tariffs generally increased over the recent years.

Boundary between transmission and distribution in terms of operated voltage levels:



Total number of DSOs in selected Member States:



along the value chain implies revisiting the regulatory base of DSOs both vis-à-vis the transmission system operator (TSO) and vis-à-vis energy and power markets.

However, a common European approach to DSO regulation is hampered by substan-

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tially heterogeneous existing regulation and distribution system structures throughout the EU. Box 1 illustrates the patchwork of different national distribution systems. Therefore, the advent of DER will have a different impact on different European distribution systems, and hence, also regulatory responses should differ, and when implemented on the European level, leave room for diverse national implementation.

System-specific regulatory responses are needed because it will make a difference whether adequate DSO remuneration and distribution tariff design, or infrastructure tasks of DSOs (that is, their regulated asset base) are discussed within a simpler system architecture, or whether in contrast system complexities increase with the massive penetration of DER. At one extreme are areas without a noteworthy penetration of DER and where investments in distribution grids are solely motivated by a renewal of aging infrastructure and the connection of new consumers. At the other extreme, there are systems with a substantial penetration of DER and small-scale consumers behaving as active prosumers. In such systems power flows will become much more volatile and the approach to system management changes, with DSOs jointly coordinating local DER power flows and those coming from the transmission grid, and hence managing the system closer to real-time.

It also will make a difference for adequate future regulation whether the respective DSO is subject to (voluntary) ownership unbundling as is the case in the Netherlands, or whether in contrast it is a small integrated operator being exempted from strict unbundling provisions. This for instance often is the case for small German ("Stadtwerke") or Spanish ("Cooperativas") utilities, which also engage in other-than-energy social activities within their territory. Insufficient unbundling biases the level-playing field against DER and in favor of conventional technologies especially when the incumbent retailer (that shares the parent firm with the DSO) mostly markets electricity from upstream sources, and, thus, poses one of the most serious obstacles to retail competition.

Key areas of DSO regulation and needed changes for DER integration

As demonstrated above, four key areas of DSO regulation have to be assessed on whether they – with massive DER penetration – still deliver the desired regulatory goals.

1 – Adequate regulated DSO remuneration

For high amounts of DER connected to distribution systems, the total costs of business-as-usual management of distribution networks (that is, a continued "fit-and-forget" grid management) will likely increase in most systems. Yet, increasing amounts of DER have a twofold impact on DSOs' cost structures: On the one hand, substantial future investments are required to connect all new resources, to enable the system to deal with increased volatility of net demand and peak demand fluctuations, and to set up ICT infrastructure that empowers DSOs to employ DER for their daily grid operations. On the other hand, DER at the same time offer a new set of instruments for grid operation and thereby a tool for DSOs to perform their tasks of ensuring a reliable, secure and efficient electricity distribution. Distributed energy resources allow for an active distribution system management and have the potential to decrease the total costs of DSOs compared to not relying on DER in local system management.

Therefore, incentive regulation for DSOs has to allow for overall higher compensation of DSOs, but at the same time set sufficient incentives to invest in ICT and grid infrastructure in order to exploit the full potentials that DER offer for system services and hence for active system management. Future regulation hence has to take account of i) changing OPEX and CAPEX structures of DSOs, ii) the optimal choice among both, and of iii) how to incentivize DSOs to deploy innovative solutions.

2 – Adequate distribution network tarification

The present design of network tariffs does not provide a level-playing field among all agents that use the distribution network. With an increasing penetration of DER, ill-designed distribution network charges, such as volumetric network charges combined with net-metering, will become even more problematic. Business models exploiting, for instance, inefficient arbitrage possibilities caused by differentiated treatments of different DER technologies, or of certain types of producers and consumers, might flourish in the absence of sound tarification procedures.

Moreover, grid users are becoming complex, sophisticated agents, which can have very diverse consumption and production patterns, being able (and willing) to react to price signals. The current paradigm, exclusively designed for pure consuming agents and where distributed generation was considered a minor exception, does not hold anymore. The power system of the future (of the present already in many countries) will be much more complex and the tariff design paradigm has to be changed before much efficiency distortion is created and many agents will acquire rights to ill-designed subsidies. A continuation of traditional tarification methodologies applying widely uniform charges over the whole distribution system and, thus, socializing network cost among all "consumers", would imply an increasing cross-subsidization. Such practice clearly is against the principles of cost-causality and economic efficiency.

Instead, grid tariffs, on top of guaranteeing full cost recovery, should be able to convey efficient economic signals to the entire diversity of agents that may connect to the distribution grid. Tariffs should reflect the true costs (or benefits) of different types of load and generation for the distribution system, which will depend on an agent's geographic location in the system as well as on the profile of injection/withdrawal from the connection point. A network reference model, as for example already applied in Spain or Sweden, can be very useful to evaluate the different components of distribution network charges. When distribution costs are allocated to those who cause them – admittedly not a simple task – distribution tariffs will induce a more efficient behavior of grid users. Network congestions and other operational problems should be dealt with separately. Any hidden subsidies should be removed and replaced by sufficient but direct subsidies that do not turn into inefficient signals. Guidelines for a fresh approach to network tariff design are proposed in the report.

3 – DSO activities vis-à-vis the market

There are a number of areas in the newly emerging market environment where there is no consensus about whether the respective tasks should be under the responsibility of the DSO or not. Such tasks in theory may be fulfilled by regulated agents (which could be the DSO or also a third regulated party) or by non-regulated ones. The regulatory challenge is to clearly define the roles, boundaries and responsibilities of DSOs, so that there is a stable level-playing field for all potential and valuable business models.

Different proposed (regulated as well as liberalized) models for (1) the ownership and management of metering equipment, (2) data handling and (3) EV charging infrastructure all have their advantages and disadvantages. These tasks may or may not be offered at lowest cost (due to sufficient synergies with grid operation) and/or in a more qualitative way by the DSOs as compared to other third regulated agents or commercial actors. The suitability of a certain model will depend on system-specific conditions. If a full rollout of advanced meters (including data management), and also EV charging infrastructure must be provided in a timely fashion, advantages lie in the domain of the DSO. Regulators, however, have to take care not to foreclose market structures through DSOs becoming incumbents once new technologies are deployed at scale and commercial actors want to enter the market.

For all new infrastructure services it holds that when regulators opt for implementing these new tasks via DSOs, possible repercussions on energy and power markets have to be ruled out. Retail market competition and, in particular, the current levels of unbundling are not fully satisfactory. With an increasing penetration of DER and the accompanying advent of new market actors and business relations, the negative effects of limited unbundling might become aggravated. When mandatory ownership unbundling is politically not enforceable, or is economically counterproductive for the customers' choice (through a drastic reduction of suppliers on the market) or for the customers' bill (through duplication of costs in separated entities or loss of synergy with other local utility functions), stricter implementation of unbundling requirements and market transparency measures should be mandated as more responsibilities are given to DSOs. At the same time it has to be noted that before investigating new forms of "Chinese walls", the implementation of, and the compliance with, existing unbundling requirements have to be reinforced.

Hence the existing unbundling rules place minimum requirements on DSOs, on top of which additional requirements can gradually be added as the role of respective DSOs changes with increasing penetration of DER. These additional requirements could mostly center around the use of customer data and transparency in procurement of services for DSO system operation. For instance, switching procedures should include clear mechanisms for accessing commercial information. An appropriate data management procedure should guarantee the availability of information for all interested market players (and especially retailers), to the extent allowed under data protection legislation. Strict supervision by regulatory agencies is necessary to prevent potential irregular practices and furnish advice on the appropriate package of measures to be finally adopted.

It has to be discussed if **small DSOs** that want to engage in additional tasks as introduced above, but which currently might be exempted from strict unbundling requirements, should also be exempted from additional "Chinese walls" that come with these new tasks. On this level, EU and national regulation will have a very high impact on local governance and municipal structures, in which often a part of the profits from distribution activities are also used for municipal social activities. Nonetheless, all problems arising from unbundling likewise apply to small DSOs. If general exemptions from unbundling for small DSOs prevail, other regulatory means gain in importance. Therefore, especially for small exempted DSOs, new ICT or EV infrastructure needs to be sufficiently standardized such that third party market entry is facilitated as far as possible despite the lack of unbundling. Furthermore, it should also hold for small DSOs that market data relevant to accessing ICT infrastructure and finally relevant for trading and retailing has to be made available such that barriers to market entry are further reduced.

4 – DSO activities vis-à-vis the TSO

When moving from "passive distribution networks" towards "active distribution system management", DSOs become more active system operators and the existing hosting capacity of the distribution network can be used more efficiently if an optimal use of DER is considered. Thus, DSOs become agents that manage local markets for network services or directly purchase services with commercial value from other agents, and their role and organization will have an important impact on (retail) market functioning. Thereby, the general responsibilities of network operators with respect to grid management do not change, but the set of tools available to perform their tasks is enriched by DER. DER can offer a range of products to manage short-term problems in the grid, to optimize the cost of maintaining the desired quality of service, to reduce grid losses and to reduce or postpone future grid investment needs.

Some of these products are relevant for either the TSO or the DSO, whereas other types of services might be of interest for both types of network operators. Hence, coordination and information exchange between TSOs and DSOs, from planning stage to operation, will play a particular role as the amount of DER increases and as DSOs become more active and exploit DER services closer to real-time delivery. Products that DSOs and TSOs use to ensure reliable grids (and often procure for this sake) should be clearly defined in terms of geography and timing. Wherever DSOs and TSOs in principle can procure the same service, a more clear coordination among DSOs and TSOs is needed the more this product relates to real-time trading. Furthermore, protocols have to be installed regarding which resource has sold products already, to whom, and for what time-frame.

Coordination needs will differ among systems. It will make a difference whether a distribution system contains only an insignificant amount of DER, whether in contrast there is a large penetration of distributed generation with installed capacities considerably exceeding peak demand, or whether it contains a whole portfolio of DER including also non-negligible volumes of local storage and demand response potential. Coordination needs will be higher in the latter system. Moreover, regulation or coordination efforts have to take account of which voltage levels are part of the distribution activity. Coordination needs probably will increase when DSOs also operate MV (or even HV) grids.

A role for the EU to encourage good regulatory practice

In the **European context**, regulation has to be in line with the three EU energy policy pillars and be kept at minimum level, respecting the principle of subsidiarity. Accordingly, we see neither the need nor a solid justification for an EU-wide comprehensive harmonization of the regulation of DSOs, although we recommend setting clear minimum requirements in a few key regulatory aspects, as well as the publication of EU guidelines to spread, encourage, and monitor good regulatory practices in some of the critical areas that have been identified in our report.

– National regulators can benefit from sharing experiences on bad and good practices. EU guidelines for a sound regulation and adequate remuneration of DSOs should be formulated, followed by regular monitoring and benchmarking to reveal shortcomings of national regulatory approaches. Similarly, although distribution grid tarification is – and should remain – a national issue, again, it is urgent that research is conducted to develop a set of EU guidelines that should be published, recommended and monitored to reveal shortcomings of national regulatory approaches and to improve tariff design practices.

– The performance of new business models and the functioning of retail market competition rely on comprehensive consumer data. The EU should provide a minimum level of support in that respect, mandating – provided that individual consumers give their authorization for the use of their personal profiles – that consumer data are made available to registered agents. The definition of the specific format of data provision (i.e. one of the three proposed data models, or a combination thereof) can then be left to the Member States.

- Depending on system complexity and the number of tasks to be accomplished by DSOs – stricter unbundling requirements should be mandated. As system complexity increases, an insufficiently unbundled DSO could either stay with a restricted set of tasks, or the DSO could expand its portfolio of activities, but accompanied with an increasing level of unbundling. Increasing levels of unbundling could be implemented by "higher Chinese walls" between DSOs and their subsidiary retailers that engage in trading of distributed sources. The EU should provide guidelines for measures to reinforce "Chinese walls" between any DSO and the DER-related businesses that may exist under the same holding that owns the DSO.

- If general exemptions from unbundling for small DSOs prevail, additional regulatory means gain in importance. Therefore, especially for small exempted DSOs, new ICT or EV infrastructure needs to be sufficiently standardized such that third party market entry is facilitated as far as possible despite the lack of unbundling. Furthermore, it should also hold for small DSOs that market data relevant to accessing this ICT infrastructure and finally relevant for trading and retailing has to be made available such that barriers to market entry are further reduced.

- Finally, procedures and principles of coordination between DSOs and TSOs also should be defined at a European level in order to avoid distortions in competition and barriers for market entry due to different rules and market designs in different Member States. The possible set of distribution company functions needs to be extended. Also the currently developed EU network codes should take account of the need for coordination and rules among system operators that rely on DER services.

Necessary regulatory actions must be developed in a timely manner in order to minimize regulatory risk and barriers and increase investment activities in distribution and retail market segments as soon as possible.

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Thomas B. Johansson. Dr. Techn. in Nuclear Physics from Lund Institute of Technology, Sweden. Professor Em. at Lund University, Commissioner, fossil free vehicle transport, Ministry of Enterprise, Sweden, Co-Chair of the Global Energy Assessment, published in 2012, and former Director of the International Institute for Industrial Environmental Economics (IIIEE) at Lund University. From 1994 through 2001 he was Director of the Energy and Atmosphere Programme at UNDP, where he initiated the use of energy as an instrument for socio-economic development and developed and launched the World Energy Assessment, published in 2000. He is Co-Chair, Global Network on Energy for Sustainable Development (GNESD) 2001-ongoing. He has chaired and has held memberships of a number of international and multilateral boards. He was Convening Lead Author of the IPCC Second Assessment Report from 1992 to 1996, and thus a co-recipient of the Nobel Peace Prize awarded to IPCC in 2007. He was awarded the Volvo Environment Prize in 2000. He is currently the Commissioner for fossil free vehicle transport, Ministry of Enterprise, Sweden.

Peter Kaderják

Péter Kaderják is the Director of the Regional Centre for Energy Policy Research at the Corvinus University of Budapest (www.rekk.eu). He received his MSc in Economics from the Budapest University of Economic Sciences in 1987. In 1998 he was appointed Chief of Cabinet of the Minister of Economic Affairs and started to work on the liberalisation of the electricity and gas sectors in Hungary. In January 2000 he became the President of the Hungarian Energy Office, the national energy regulator. Between 2000 and 2004 he also served as the Chairman of the Energy Regulators Regional Association (ERRA), an association of energy regulatory institutions of countries from Central and Eastern Europe, the CIS and South East Europe. Since 2004 he has been serving as Training Director for ERRA's in-house energy regulatory trainings. He has also been directing a postgraduate program in Energy Economics at Corvinus University since 2010. He is a research partner in the "European Energy Institute" at University of Leuven and a regular lecturer at the Florence School of Regulation. He has directed several recent research efforts with regional relevance. In 2011 he was appointed as alternate member of ACER's (Agency for the Cooperation of Energy Regulators) Board of Appeal.

François Lévêque

François Lévêque is Professor of Economics at Mines ParisTech. He is part-time professor at the Robert Schuman Center for Advanced Studies (European University Institute, Florence School of Regulation). His research and teaching interests are in the areas of antitrust, intellectual property rights and network regulation. He published several papers in academic journals, including Energy Policy, World Competition, Competition and Regulation in Network Industries, La Revue Lamy de la Concurrence, Concurrences, Electricity Journal, Review of Economic Research on Copyright Issues, Information Economics and Policy. He is the editor of an academic blog, Energypolicyblog.com.

Claude Mandil

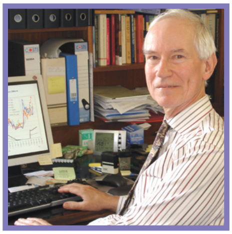
Mandil is Former Executive Director of the International Energy Agency. Claude Mandil served a four-year term from to 2003 to 2007 as Executive Director of the International Energy Agency, based in Paris. While serving as Director General for Energy and Raw Materials at the Ministry of Economy (1990-1998), he was instrumental in arranging for France to become a member of the IEA in 1991 and served as the IEA Governing Board Chairman from 1997 to 1998. During this time he also represented France at the Nuclear Safety Working Group of the G7 (1991-1998). Before joining the IEA in 2003, Claude Mandil was Chairman and CEO of the Institut Français du Pétrole and, previous to that, Managing Director of Gaz de France. Earlier posts have included Director General of Bureau of Mines and Geology (BGRM) 1988-1990; and Advisor in the French Prime Minister's office, 1981- 1982. Now retired, Claude Mandil is advising governments and companies in the domain of energy policy. He is a graduate of France's Ecole Polytechnique and Ecole des Mines. He has been awarded Honorary Doctor of the KULeuven in Belgium.

Władysław Mielczarski

Władysław Mielczarski is a Life Professor in Electric Power Engineering nominated by the President of Poland in 2002 for his achievements in liberalisation of the power supply industry, in particular the design of the Polish electricity market structure and rules for planning and operation of the balancing market. He has over 30 years of professional experience in Poland, Australia, Singapore and Canada. Between 1999-2000 and 2005-2007 he was an energy Advisor to the Polish government responsible for designing the electricity market and the new structure of the Polish power industry. As the European Energy Coordinator in 2007-2011, he was responsible for the development of cross border power connections between Lithuania, Poland and Germany. He has published 10 books and over 150 journal and conference papers including books published by prestigious publishing houses such as Springer Verlag–Heidelberg and Nova Science Publishers in New York (2007-2008).

Peter Mombaur

Peter Mombaur is honorary Professor of the University of Cologne. Until 2012 he was an associate lecturer on the Practice of European Law at the University of Cologne (2004-2012). He was Member of the ACER Administrative Board, Agency for the Cooperation of Energy Regulators, nominated 2010-2016, but stepped down 2011. He is a former Member of the European Parliament and also gained experience in the EU Convention on Fundamental Rights, and in a lengthy term as Deputy Member of the North Rhine-Westphalia Land Constitutional Court.



David Newbery

PhD, ScD, FBA, is an Emeritus Professor, Faculty of Economics, University of Cambridge and Director of the Cambridge Electricity Policy Research Group. Educated at Cambridge with degrees in Mathematics and Economics, President of the European Economic Association in 1996, President-elect for the IAEE 2012, to be President in 2013. Occasional economic Advisor to Ofgem, Ofwat, and ORR, former member of the Competition Commission, chairman of the Dutch Electricity Market Surveillance Committee, currently member of the academic panel of environmental economists, DEFRA. He has recently advised DECC and the House of Commons on Electricity Market Reform. Recent books include *A European Market for Electricity?* (co-author), and *Privatization, Restructuring and Regulation of Network Utilities*. Guest editor of *The Energy Journal* (2005) issue on European electricity liberalisation, and recently honoured in "Papers in Honor of David Newbery: The future of electricity" in *The Energy Journal* (2008).

Ignacio J. Pérez-Arriaga

Ignacio Pérez-Arriaga. MS, PhD (Electrical Engineering, MIT), Electrical Engineer (Comillas University). He is a professor and director of the BP Chair on Energy and Sustainability and founder and first director of the Institute of Research in Technology (Comillas University). Permanent visiting professor at the Massachusetts Institute of Technology (MIT, Engineering Systems Division). Previously a commissioner of the Spanish Electricity Regulatory Commission (1995-2000) and independent member of the Irish Single Electricity Market Committee (2007-2012). He is a member of the ACER Board of Appeal and review editor of the 5th Assessment Report of IPCC. He is a life member of the Spanish Royal Academy of Engineering and director of Energy Training at the Florence School of Regulation. He has been a consultant for firms and institutions in more than 30 countries and published several books and more than 200 papers on technical, economic and regulatory aspects of power systems. Ignacio acts as the director of Energy Training at the Florence School of Regulation.

Pippo Ranci

Pippo Ranci was the first president of the Italian Regulatory Authority for electricity and gas (1996-2003) and Co-founder and Vice-President of the CEER. Then he set up and directed the Florence School of Regulation at the European University Institute (EUI) in Florence (2004-2008) where he is now a part-time Professor. Trained as an economist at the Università Cattolica in Milan and at Oxford University, he also holds an MA from the University of Michigan. In 1971 he cofounded the Istituto per la Ricerca Sociale, Milan, a private cooperative research institute, where he was President until 1981 and then part-time Research Director until 1996. He was also an associate professor at the Università Cattolica (1973-1986), full professor of Economic Policy at the Università di Bergamo, and then at the Università Cattolica (1987-1996). He was often a consultant to the Italian Ministry of Industry (1970s and 1980s) and the President of the Council of Ministers (1992-93). Having retired, he still teaches at the Università Cattolica in Milan. He chairs the Board of Supervision of A2A, an Italian utility, and the Board of Appeal of ACER.

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Dr.-Ing. in Electrical Engineering, University of Erlangen-Nuremberg. Chairman of NEWES, New Energy Solutions. Consultant to several international organizations and national authorities. Member of the Harvard Environmental Economics Program Advisory Board. Invited Professor at the Technical University of Lisbon (MIT-Portugal Program). Member of the Administrative Board of ACER nominated by the European Parliament. Special Advisor to EU Commissioner Andris Piebalgs. First chairman of the Portuguese Energy Regulatory Authority (ERSE). Co-founder and first chairman of the Council of European Energy Regulators (CEER). First chairman of the European Regulators' Group for Electricity and Gas (ERGEG). Co-founder of the Ibero-American Association of Energy Regulatory Authorities (ARIAE). Founder and member of the Executive Committee of the Florence School of Regulation. Prior to the regulatory experience, he was deputy secretary-general of EURELECTRIC, worked for AEG in Frankfurt and at several universities in Europe.

People
Florence-based Research Team

Isabel Azevedo // Team Member

TOPIC 7 - TOPIC 10 - TOPIC 11

Isabel Azevedo is Research Assistant at the Florence School of Regulation since January 2011. Isabel has obtained a degree in Physics / Applied Mathematics (Astronomy) at the University of Porto, in Portugal. She spent one year of her studies at Lund University, in Sweden, under the Erasmus program. She has done post-graduation studies on sustainable development and energy systems, including the Sustainable Energy Systems Advanced Studies course within the MIT Portugal program, at the University of Porto. In 2010, she worked in the Faculty of Engineering from the University of Porto as a research assistant.

Xian He // Team Member

TOPIC 8 - TOPIC 10 - TOPIC 11

Xian He is Researcher at the Florence School of Regulation. She holds an MSc in Economics and Management of Network Industries from University of Pontificia Comillas of Madrid, Spain, and from University of Paris Sud XI, France, where she studied in the Erasmus Mundus Master program during 2006-2008. Xian did her PhD research on Electric Energy Storage between 2008-2011 in the framework of collaboration between University of Paris Sud XI and EDF R&D, where she also worked as a PhD engineer. She defended her thesis on "Designing the Market for Bulk Electric Energy Storage: Theoretical Perspectives and Empirical Analysis" in September 2011. Xian joined the Florence School of Regulation in October 2011. She holds a PhD in Economics from University Paris Sud XI.

Nico Keyaerts // Team Member

TOPIC 11

Nico Keyaerts is a Research Assistant at the Florence School of Regulation. His research interests include the organization of gas balancing and operational flexibility in liberalized European gas markets, and, in a wider context, European energy policy and regulation. Nico studied Commercial Engineering at the KU Leuven in Belgium. He then worked as a research assistant on gas markets at the department of Mechanical Engineering of the KU Leuven between 2007 and 2012. He published his work in international journals and presented it at international conferences. In 2012, he defended his Ph.D thesis on the topic of Gas Balancing and Line-Pack Flexibility. Nico joined the Florence School of Regulation in January 2013. Nico holds a PhD in Mechanical Engineering (2012) and a Degree in Commercial Engineering (2007), both from the KU Leuven in Belgium.

Peter Kotek // Visitor

TOPIC 7

Peter Kotek's research interests include energy efficiency policy and analysis of electricity markets. Peter studied Economics at the Corvinus University of Budapest, majored in industrial organisations. He spent a semester as an Erasmus student at the University of Groningen. He joined the THINK team in January 2012. Peter holds a Master's Degree in Economics, and had been working with the Regional Centre for Energy Policy Research as a research assistant since 2009.

Adeline Lassource // Team Member

TOPIC 9

Adeline Lassource is a Researcher at the Florence School of Regulation. Her research interests cover energy economics, policy and integration of a European Energy Market. Adeline studied Economics at the University of Franche-Comté, in France. She defended her PhD on the topic of "Auctions applied in Electricity Market" in September 2006. She joined the French Energy Regulatory Authority, the Commission de Régulation de l'Energie, in 2007. Within CRE, she was in charge of facilitating cross-border trade and was deeply involved in the Electricity Regional Initiatives' process. She mainly worked on harmonization of long-term capacity allocation on interconnection and market coupling implementation. At the EUI she works as a researcher for the THINK project. Adeline joined the Florence School of Regulation in June 2012.Adeline holds a PhD in Economics from the University of Franche-Comté, in Franc.

Leonardo Meeus // Scientific Coordinator, Team Leader

TOPIC 7 - TOPIC 10 - TOPIC 11

Leonardo Meeus is Associate Professor of Energy Markets at the Vlerick Business School in Brussels, Belgium. Leonardo is a Commercial Engineer with a PhD in Electrical Engineering, both from the KU Leuven. During his PhD, he was involved in setting up the first international electricity market on the European continent. Before joining Vlerick in 2012, he also worked in Ireland for an energy infrastructure project developer, and in Italy for the Florence School of Regulation at the European University Institute. At Vlerick, he is Director of the Future Power Grid Managers Programme. He is also a Part-time Professor of the Florence School of Regulation, and a Visiting Professor of the KU Leuven.

Sophia Ruester // Team Leader

TOPIC 8 - TOPIC 9 - TOPIC 12

Sophia Ruester joined the Florence School of Regulation in January 2010. She holds a PhD in Economics (2010) and Diploma in Industrial Engineering (2006), both from the Technical University of Dresden, Germany. She has published articles on various issues related to European energy policy and corporate strategies in (liquefied) natural gas markets in different academic journals, including the Journal of Institutional Economics, Utilities Policies, Energy Policy, and Energy. Since 2011, Sophia is also Managing Editor of the IAEE publication "Economics of Energy & Environmental Policy".

Sebastian Schwenen **//** Team Member
TOPIC 9 - TOPIC 12

Sebastian Schwenen is Researcher at the Florence School of Regulation. His research interests are in the areas of energy economics and industrial organisation, with most of his recent work focusing on the economics of supply security in electricity markets. Sebastian studied Economics at Humboldt University Berlin and at Charles University Prague. During his studies he interned at the German Antitrust Authority's energy division. After graduating in 2007, Sebastian worked as an Assistant Lecturer in Public Finance at Humboldt University Berlin. In 2008 he started his PhD at the Economics Department at Copenhagen Business School, where he joined a research program on energy markets. He also spent one academic year as a visiting PhD student at the London School of Economics. Sebastian joined the Florence School of Regulation in May 2012. Sebastian holds a PhD in economics from Copenhagen Business School and a Diploma in Economics from Humboldt University Berlin.

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