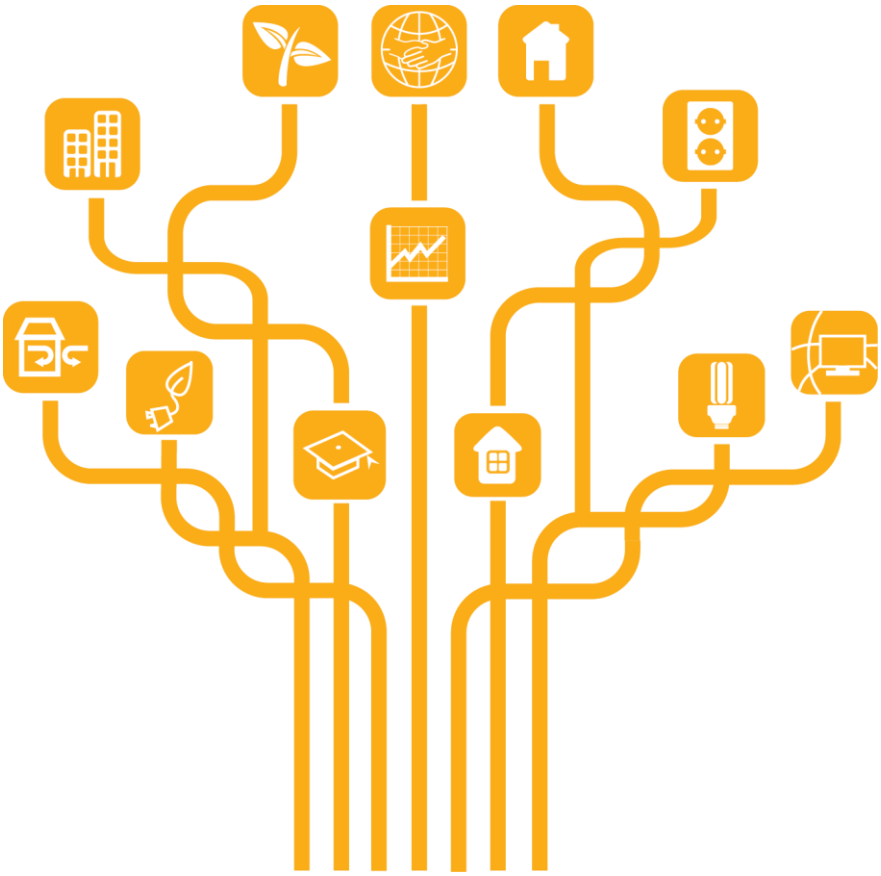
Strategic Energy Technology (SET) Plan

Towards an Integrated Roadmap: Research & Innovation Challenges and Needs of the EU Energy System

ANNEX IV: Research and innovation actions

PART IV – CROSS-CUTTING ASPECTS



Acknowledgements to Drafters and Contributors

in alphabetical order

European Energy Research Alliance (EERA): Joint Programme on Economic, Environmental and Social Impacts of Energy Policies and Technologies (EERA/e3s)

European Geothermal Energy Council (EGEC)

European Platform of Universities Engaged in Energy Research (EPUE)

European Platform of Universities Engaged in Energy Research (EPUE)

European Solar Thermal Electricity Association (STE)

European University Association (EUA)

The European Power Plant Suppliers Association (EPPSA)

The European Strategy Forum on Research Infrastructures (ESFRI)

The European Technology Platform on Renewable Heating & Cooling (RHC-Platform)

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HEADING 1: Analysis, modelling, and foresight

Challenge 1: Integrated analysis of the energy system and its components

KEY ISSUES

- Improvement of methods and tools is needed to assess the social, economic and environmental dimension of energy systems, considering costs and benefits for consumers and for society. **The economic viability, social acceptability and environmental sustainability of energy technology options** and system solutions should be systematically assessed ex ante and ex post. This could help reinforcing the dialogue with civil society on the future of the energy system.
- Existing European and national energy system assessment methodologies should be integrated into a **common assessment framework at the EU level**, including common sets of indicators to ensure comparability and harmonization in policy formulation and evaluation.
- This will help to address two basic problems encountered by socio-economic analyses:
  - Uncertainty about the future socio-economic, demographic and technological development.
  - Non-priced social values.

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

Action 1: Expand existing and develop new energy system assessment frameworks by including the dimension of sustainability

Energy scenarios are generally an accepted method to describe possible future developments of energy systems. In the past concerns were focused on energy demand, energy supply interruptions, pollution control, environmental conservation and climate protection. With the upcoming discussion on sustainable development, energy scenarios further addressed the overall concept of sustainable energy futures. However, a clear framework on how to assess sustainability of energy systems is missing. Further notions related to the concepts of 'sustainability, 'sustainability assessment' and 'sustainability measurement' need basic consideration.

Scope: The action aims at developing a frame to assess sustainability of future energy system. In particular, this calls for the further development of a common methodological understanding of sustainability assessments of energy systems, methods for sustainability measurement, indicators for transparent description of energy system and socio-economic impacts, methods to cope with target conflicts, and procedures to consolidate a set of indicators into a sustainability index.

Deliverables:

- Report on a proposed methodological frame for transparent and harmonized sustainability assessments of future energy systems.

Expected impact:

- The results provide a methodical basis for generating sustainable energy scenarios, for the structured comparison of different development paths and as procedure for including sustainability considerations in energy policy design and implementation.

KPIs:

- Final report reviewed and accepted by at least 10 MS energy agencies or similar bodies.

Costs: EUR 4-5 million.

Timeline: 2015-2018.

Modality of Implementation: EU level.

Action 2: Establish a European energy modelling forum

A number of models exist in Europe for assessing both the technological and socio-economic effects of the transition to a sustainable energy system. There is a need for making a collection of scenario studies based on the same assumptions regarding energy policy, climate policy, technology learning, costs, loads, fuel prices and more. This will create added value to collecting joint data for the energy system and enhance the value of scenario studies as a knowledge base for decision makers.

Scope: This action will establish a European energy modelling forum for studies of energy and climate policy scenarios. The forum will collect joint data sets in cooperation with stakeholders. Its main purpose is to make comparative studies between the available assessment models studying the transition to a sustainable European energy system.

Deliverables:

- A European energy and climate policy modelling forum.

Expected impacts:

- The expected impact is an open and transparent knowledge base for, energy modellers, policy makers and decision makers.

KPIs:

- European energy and climate policy modelling forum with representation from at least 10 MS modelling groups established.

Costs: EUR 2-4 million.

Timeline: 2015-2020.

Modality of implementation: EU.

Action 3: Expand existing impact assessment methodologies for investment programmes and projects in the energy field by including the dimension of sustainability

The assessment of the externalities associated to any given energy project are of utmost importance for policy makers as well as regulatory bodies. Besides the pure financial aspects, the effects that any energy technology deployment will have on the economy, environment as well as society must be equally considered in order to design effective sustainable energy policies.

There exist various methodologies and extensive literature aimed at estimating the environmental impacts (global and local emissions, water consumption, etc.) as well as socio-economic impacts (such as job creation and economic stimulation). However, the third sustainability pillar seems to be lagging behind.

In fact, several incomplete methodologies and reports co-exist that try to assess the social, economic and environmental impacts of energy systems, based on different assumptions (regarding discount rate, demand, economic value assigned to different externalities, etc.). The lack of a harmonised methodology can lead to fragmentation and in transparent funding decisions.

In this context, the aim of this action is to develop a methodology which, given the techno-economic characteristics of any given investment program or project, simultaneously estimates the economic, environmental as well as social impacts.

Developing a complete and unified methodology to be used for all available technologies in all countries would help policymakers to create a level playing field and transparent assessment of the social, economic and environmental impacts of different policies. One goal is to separate locally-varying assumptions on the social value (e.g. willingness to pay for alternatives, value assigned to different kinds of externalities) from physical facts (e.g. geologic and technical potential). These

assumptions can then be discussed at the citizen level, leading to different results for different societies and territories, with improved transparency. This would enable an efficient energy transition with the support of the citizens, while allowing for local differences.

Scope: The action should deliver a method or tool that is freely available, easy to use to simultaneously address the social, economic and environmental dimension of energy systems. This tool should capture the total environmental social and economic effects associated to energy investment projects or programmes. The tool should allow the estimation of both the gross as well as net impacts. The developed tool will strive to also include the socio-economic, environmental and social risks in the countries and/or regions where part of the required goods and services are imported from. The tool should be based on methodologies recognized by the scientific international community and the underlying data and assumptions should be updated regularly.

Deliverables:

- Open source and freely available tool comprising an externality calculation tool, a physical database, and a user manual, to assess the sustainability of energy investment projects or programmes in a simple but reliable way addressing simultaneously the three dimensions of sustainability.
- Assessment of the sustainability of a comprehensive set of energy investment projects/programmes using the developed tool.

Expected impact:

- Overall, more transparent national decisions for future energy mixes, faster implementation of appropriate investments, better cross-border cooperation, long-term savings at the society scale.
- In the short term, this action should provide a comprehensive view of the sustainability of investment projects/programmes and should provide insights on the differential sustainability impacts and the ways to reduce negative and foster positive impacts.
- In the medium term, this action should provide a way to evaluate the sustainability of any new energy technology breakthrough in an easy way.

KPIs:

- Agree on an exhaustive list of criteria relevant for energy assessment by 2016. Complete the methodology by 2018. At national level, evaluate current energy mixes and agree on social value for given criteria by 2020.
- Use of the tool to evaluate the sustainability of at least 15 investment projects/programmes in all Member States.
- Adoption of this tool by at least 10 organizations, energy agencies, consulting firms, project developers, industrial organizations dealing with energy in Europe and abroad.

Costs: EUR 25-30 million.

Timeline: Timing of the action: 5 years.

Modality of Implementation:

- Methodology design at EU level, methodology implementation at national level.
- EU level action open to relevant third countries with substantial exporting activities.

Action 4: Adapt the Life Cycle Analysis (LCA) methodology to assess energy systems, particularly regarding the use of resources and the trade-offs between different policy options

The use of resources in energy systems is not optimised, and the value of the assets that could be used to support sustainable growth is not capitalised. These inefficiencies can be addressed by taking an integrated approach to resource accounting and use across the supply chain, leading to an optimised and sustainable value chain. Along with other models, methods and tools, the LCA framework plays a fundamental role within and beyond the proposed action that provides strong alignment to EU policy.

As demonstrated by the CALCAS project (FP6), decision making on energy systems requires a coherent and robust assessment framework, capable of highlighting trade-offs and consequences at macro-meso level (policy definition) and micro level (technology implementation). Life cycle perspective is required for avoiding burden shifts, together with the ability to address future oriented scenarios.

Current LCA-based methodologies present weaknesses when applied to energy systems, as they lack explicit reference to relevant mechanisms (physical, technological, environmental, or socio-economic cause-effect relations), which affect input-output relations. Moreover, present LCA methods adopt linear models that represent oversimplification of the reality. Therefore there is a need of revisiting the current LCA-based methodologies and tools in order to make them suitable for and effective in supporting the decision-making process at all levels.

Scope: Development of a framework to include Life Cycle Thinking methodologies in support of energy policy design and implementation. Energy resource system optimisation and innovation for a sustainable value chain:

- Develop a dynamic energy resource system assessment tool in an open, consistent and integrated approach to support sustainable growth decision making.
- Build innovative modelling and optimisation tools and methods (beyond LCA) to represent the resource sustainability of supply chain.
- Inclusion of mechanisms into LC-based analysis, for the calculation of consistent indicators for social-economic and environmental sustainability, with an assessment of related uncertainties.
- Integrate tangible and intangible assets (machines, technologies, human capital and information) towards smart performance censoring and monitoring at all tiers within and across the value chain.
- Development of ICT-based tools supporting the new methodologies.
- Benchmark accelerated innovation and leadership for energy resource management and transformation.
- Propose a simple and standardised reporting protocol for all organisations in all supply chains on resource efficiency and sustainability decision making based on LCA-alike framework.
- Embed resource efficiency and sustainability skills and capabilities in training initiatives and jobs.
- Testing of the methodologies on real cases of policy option implementations, including ex-post validation.

Deliverables:

- Integrated resource model.
- Advanced assessment and decision methods and tools, integrating life cycle thinking.
- Standardised LCA based reporting routine.
- Training programmes at all levels including apprentice, high level skills for graduates such as R&D, executive and management.
- Operational methodologies for integrated LC-sustainability analysis.
- Well-documented open-source software tools implementing them.
- Methodology tested on real cases.

Expected impacts:

- Accelerate sustainable growth; promote job creation; stimulate R&D; support SMEs; develop future skills; reduce CO2; stimulate energy market and its industrial supply chain; strengthen capabilities; improve resource security; attract investment.
- Integration of life cycle thinking in energy policy design and implementation.

KPIs:

- Methodology tested on 5 real cases.
- Open-source software tool available on web-page.

Costs: EUR 6-8 million.

Timeline: 2015-2020.

Modality of implementation: Member State level.

Action 5: Modelling short term variations and the need of flexibility in the energy system in long term energy system models

A challenge in many of today's modelling frameworks for long term assessment of the energy system is that they do not include detailed enough information about how the energy system will be used. For example in the power system, the short term variations in load and intermittent energy generation have a major impact on the economic dispatch and on power flows between regions. Models that do not recognize this will underestimate the need for reserve capacities, storage and dispatchable energy.

Scope: The main focus is to develop models and assessment tools for the design of energy systems that include more detail of their operation under different situations for load, intermittent energy generation and other stochastic factors. The models should include technology details for example regarding flexibility options. They should also include markets for example for system services, energy exchange and capacities. In order to design a sustainable energy system, the interplay between technological capabilities, markets in order to handle short term uncertainty (variations over hours to weeks) when the system is in operation should be addressed.

Deliverables:

- Modelling frameworks for energy system design recognizing the need for flexibility in operation.

Expected impacts:

- The expected impact in terms of more efficient operation and thereby lower lifetime costs of the European energy system is billions of euros.
- By designing flexibility into the energy system, integration of more renewables will be possible contributing positively to the environment.

KPIs: At least 5 large long-term European energy system models have been adapted to include energy system flexibility requirements.

Costs: EUR 4-5 million.

Timeline: 2015-2020.

Modality of implementation: EU and national.

Action 6: Geopolitics: Governance in the EU's Neighbourhood and a methodology to assess the geopolitical and risk dimension of energy corridors

Scope:

- To develop a methodology to assess the geopolitical and risk dimension of energy corridors.
- European external energy governance in a fragmented international energy regime complex.

European external energy policy faces the challenge of integrating international energy-related externalities like energy security or good energy governance into the policy-making process. Energy-related externalities go beyond environmental or social aspects to include the provision of other global or regional public goods, like the security of energy supply and demand, adequate global energy infrastructures, and the fight against energy poverty or providing a global standard for the good governance of energy resources.

All these issues are at the core of external energy action (including not only EU and Member State's public policies, but also other actors like EU companies and NGOs). However, the lack of a systemic approach to deal with such global issue areas risks introducing inconsistencies in the EU's external energy action. The purpose of this action is to offer both a methodology to assess energy-related geopolitical risks and the development of a conceptual approach based upon the Europeanization of energy policies, that is, European energy external governance.

The action should deliver first a method to measure risk levels stemming from geopolitical realities that will offer an Index of Energy Security for each country and energy corridor supplying the EU. This

index may then be incorporated in other energy modelling exercises as an exogenous variable, or be part of detailed country-level energy policy analysis. By offering a methodology to measure 'energy security', this action allows for policy-makers to explore the impact of measures from the energy security perspective.

Second, the action will build upon the significant literature on energy-related outward Europeanization to assess the EU's role in global energy governance, which is characterised by its fragmentation in an increasingly inter-polar and polycentric energy regime complex. In particular, the Europeanization of energy policies in the EU Neighbourhood, the fight against energy poverty and efforts at both multi-stakeholder (EITI) and EU (transparency and accounting directives) levels to improve the governance of energy resources in developing producing countries.

Deliverables:

- Open source and freely available tool to construct an energy security index, both at a country and at a corridor (including all transit countries) level.
- Assessment of the outward Europeanization strategy followed by the EU in the field of energy policy, with the case studies of external governance in the EU's Neighbourhood, energy poverty and the governance of energy resources.

Expected impact:

- In the short run, the energy security index will provide an insight into the effects that involve certain energy policy decisions, for instance which energy corridors should be prioritised in terms of minimising energy risks.
- The conceptualisation of effective external energy governance will shed light on the results of EU's external action in areas more related with long-term energy security, like the good governance of energy resources and the institutionalisation of best practices in the EU Neighbourhood or in energy-producing developing countries.
- Use of the tool to evaluate the sustainability of renewable and efficient energy technologies in different countries during the implementation period of the action.
- Diffusion of this tool by the main EU and MS organizations, energy agencies, consulting firms, project developers, industrial organizations dealing with energy in Europe and abroad.

KPIs:

- Open-source software tool available on web-page.
- Adoption of this tool by relevant organizations in at least 10 MS.

Costs: EUR 3 million.

Timeline: 2014-2020.

Modality of Implementation: EU level action open to relevant third countries with substantial exporting activities.

Action 7: Investment models for Integrated Energy System Analysis

Scope: As energy systems become more integrated, the sources of uncertainties increase and the manner of interaction becomes more complex. This results in increased levels of risk and coupled with other uncertainties which are making investment decisions more and more difficult. One way to mitigate the risk is through detailed modelling of the energy system to allow the value of an investment to be assessed. Energy system models tend to be very specific e.g. electricity models can characterise the load flow through the transmission lines, while gas models can characterise the gas flow in the gas network. While integrated models are being developed they are not the norm, in particular for assessing investment decisions. In order to reduce computational time many investment models tend to be very coarse but with increasing operational complexity and uncertainty (driven in large part by stochastic energy sources such as wind) the need for higher fidelity models increases. Computational resources are becoming cheaper and the modelling techniques more sophisticated. This should allow developing tractable high fidelity investment models that represent the integrated nature

of the energy system at finer resolutions. However, this drive towards better energy system investment models requires corresponding data which is both scarce and of varying quality.

Deliverables:

- Developed high fidelity heat/cooling, gas, and electricity investment model.
- Provided robust data sets that form a basis for robust analysis.
- Quantified the "best" energy system investments in a number of test cases.
- Quantified the impacts of technology improvements and/or changing global circumstances (e.g. increased shale gas in Europe).

Expected Impact:

- Higher quality energy system investment models and corresponding data sets.
- Reduced energy system investment costs and more robust/efficient energy systems.

KPIs:

- Model available and filled with data for use in all MS.
- 10 test cases run with the model and documented in reports.

Cost: EUR 20 million.

Timeline: 2016-2019.

Implementation: National, European and International (particularly US).

Challenge 2: Integrated analysis of energy transition strategies:

KEY ISSUES

- Need to improve complex multi-level energy governance (European, national, subnational) to address the varied - and dynamic - societal concerns associated to energy production and consumption, and to ensure that the management of the energy transition receives the adequate institutional attention: reconversion and jobs creation.
- Consumer behaviour and firm behaviour must be assessed based on all business and economics aspects. Multi-criteria decision making methods can support policy making.
- Evaluations of energy (transition) strategies need to become more robust/mature: ensure a reliable energy supply.
- Legislative framework developments for energy transitions require integrated assessments: for both energy supply and demand for electricity, heating & cooling, and transport.

PROPOSED ACTIONS

Action 1: Assess the role of strategy formulation by European, Member State and sub-national actors in guiding current energy transition across the EU

Energy systems across the European Union are an important pre-requisite for vibrant economies and societies. However, they face a range of challenges: the need to reduce their environmental impacts (particularly on climate change); to be resilient to energy security risks; and to deliver affordable energy for citizens and businesses. Meeting these challenges will require transitions in many of these energy systems that go beyond 'business as usual' or incremental change. These transitions are very unlikely to be uniform across the EU: Member States have diverse energy systems and a range of different priorities. Market and industry structures vary between Member States, and so do the transitions that are being implemented by governments and other actors. There is also a need to better understand the relative roles of transitions at the local, national (Member State) and EU levels. Within this, there are tensions between the desire for integrated, harmonized approaches at the EU

level and the need for Member States and sub-national authorities to have significant autonomy over their energy policies.

Scope: This action will analyse energy transitions across the EU, and the relative roles of European, Member State and sub-national strategies to realise these transitions. It will take into account the wider international energy context (e.g. international climate negotiations and geopolitical energy developments). Its scope includes both current transitions and potential future transitions. It would not only focus on the deliberate planning of transitions by Member State governments, it would also focus on the governance of more emergent 'bottom-up' energy transitions that are shaped by a wide range of actors (including households, firms and civil society). Many energy systems are becoming more complex with, for example, a greater variety of energy generators and suppliers, greater temporal variation in electricity grids, and more scope for the application of communication and control technologies.

Deliverables:

- Studies on the interactions between energy transitions at EU, Member State and sub-national levels - and the strategies for implementing them by different actors.
- Studies on the relative roles of 'top down' planning and more 'bottom up' action in shaping transitions in Member States, with a particular focus on contrasting market structures and regulatory frameworks.
- Studies on the relative importance of technological, economic, behavioural, institutional and political dimensions of transition strategies and the relationships between them.
- Training programme for decision makers at all levels (EU, MS, regional) established with best practice examples for efficient design and implementation of energy transition.

Expected impact:

- A better understanding of the relative roles of EU, Member State and sub-national energy policies.
- The identification of transitions and strategies for their implementation that have the broad support of European society.
- A strengthened evidence base for a plural approach to energy policy across the EU that helps to identify opportunities for EU-wide strategies and policies.

KPIs:

- Number of studies analysing strategy formulation by European, Member State and sub-national actors.
- Pilot training performed with 40 participants from all relevant levels.

Costs: This Action would require a substantial new research programme that builds on the significant body of research that has been conducted in recent years on energy system transitions, energy policy and the political economy of energy system (and energy system change) in various Member States and at EU level. A rough estimated cost is EUR 5-10 million, but further scoping would be needed to confirm this.

Timeline: A major programme of research would require 3-5 years to complete.

Modality of Implementation: EU funding for a research programme that complements (and, if where possible, integrates with) relevant research in several Member States.

Action 2: Develop an integrated conceptual and methodological framework to develop low-carbon transition strategies; establish a platform for their implementation

Multidisciplinary framework(s) and platforms need to be established to formulate and analyse sustainable low carbon visions and strategies. The framework should integrate techno-economic and socio-economic analysis taking into account the industrial dimension (i.e. technological characteristics of the energy system), human behaviour (i.e. values, acceptance, resources), and institutional factors (i.e. policy, regulation, market). Platform(s) are also needed to facilitate common understanding, acceptance, and thereby the implementation of sustainable low carbon strategies on a regional, national, and EU level.

The platform is also needed for systematic integration of parts I, II, and III of the SET-Plan IR, and also for the various sections of Part IV.

Scope: Design, analysis and implementation of sustainable energy strategies with multi-level and multidisciplinary perspectives. Sustainable low carbon platform(s) offers a common framework for analysis of low carbon strategies and supports communication and implementation of effective policies and strategies.

Deliverables:

- Multidisciplinary framework for analysis of effective energy system transition. Platform to facilitate implementation of sustainable low carbon strategies.

Expected impact:

- Increased efficiency of policies and actions through better commitment and understanding between all stakeholder, technology developers, policy makers, investors, financiers, private customers, industries, etc. Better integration of the energy policies and strategies to industrial, agricultural and forestry, innovation, climate, environment, education, policies, etc.

KPIs:

- Increased cost-efficiency of sustainable GHG mitigation, i.e. taking into account socio-economic and environment dimensions as well as effective use of natural resources. The well-targeted strategies will also facilitate clean-tech development and export outside the EU region.
- Platform established with at least participation from energy agencies or equivalent from 10 different MS.

Costs: EUR 4-5 million.

Timeline: 2014-2020.

Modality of Implementation: Regional, national, and EU levels.

Challenge 3: Collecting energy data and facilitating access to the knowledge base

KEY ISSUES

Collaboration between stakeholder communities to ensure the collection of energy–relevant data at the local/regional level, including on energy use and low carbon energy supply, to feed into targeted local transition policies and measures: address lack of data from the non-ETS sector and in particular the small scale heat installations (need methodology for data collection, may need additional efforts in statistical offices):

- Collection, assessment and benchmarking of energy best practices at regional, national, European and international level: create regional model for energy supply.
- Open access to energy data and information: smart electricity and thermal grids.
- Insufficient (in quality and quantity) data on the building sector.

PROPOSED ACTIONS

Action 1: Develop ICT tools to visualise energy data in pursuit of EU 20-20-20 targets, to aid decision making by policymakers particularly at the local level

The Covenant of Mayors addressed the local level in taking action to help realize the ambitious 20-20-20 targets. In order to build tangible Strategic Energy Action Plans, reliable energy data are needed on energy consumption and, more importantly, on the potential of heating and cooling exchange, on

renewable energy technologies, energy efficiency measures, as well as data on energy poverty. These data should be visualized in a Geographical Information System (GIS), so the authorities at a local level have a tool that helps them to make an energy roadmap that is realistic, tangible and socially oriented. There are currently examples of GIS tools depicting the potential of a particular renewable energy technology in a particular region, but they tend to focus on one particular technology.

Scope: This action looks at existing tools, how they are built and what data sources they use and process. Based on this knowledge, best practices can be presented and guidelines can be drafted for tool developers. Data should be shared between EU Member States and/or regions in order to help local authorities to fill the data gaps.

- There is a need to integrate various layers looking at a particular technology into a comprehensive energy atlas at the local level, enabling local authorities to prioritize particular pathways.
- These tools should facilitate the selection of appropriate options for new or refurbishment areas.
- There is also a need of instructing local officers on how to use such an energy atlas to make an energy policy for the local level that is in line with the urban planning.

Deliverables:

- Specific ICT tools for EU 2020 targets monitoring at local level.

Expected impacts:

- A bottom-up implementation of the EU 2020 targets.

KPIs:

- Newly developed ICT tools in use in at least 20 different relevant organisations.
- Training programme for ne ICT tools established and tested in pilot programme with at least 40 participants from relevant organisations.

Costs: EUR 3-4 million.

Timeline: 2015-2020.

Modality of implementation: EU.

HEADING 2: Societal impacts of the energy transition

Challenge 1: Understanding the behaviour of social and political actors

KEY ISSUES

- Awareness, attitudes and values of groups shaping the energy system, including policy makers, consumers, regulators, innovators, technicians, financers, etc. needs to be better understood and addressed in the decision making process and initiatives.

PROPOSED ACTIONS

Action 1: Carry out public opinion surveys regarding the transition to a more sustainable energy regime

The transition to more environmentally sound energy solutions has proven not to be straightforward. Political and economic interests diverge, some policy instruments have not worked as expected, and questions have been raised regarding the level of public support for the kind of change required to meet goals with respect to sustainability and reduced emissions of CO_2.

Scope: The action shall carry out and synthesise a large number of studies of a diversity of forms of studying how publics engage (or not) with a wide range of new sustainable energy technologies and how this engagement is understood by involved groups of stakeholders. This focus also includes energy efficiency measures and new energy consumption practices. The goal is to provide useful knowledge about these issues to policy-makers, industry, relevant R&D communities and the public. The action surveys attitudes and practices related to relevant sustainable energy technologies, mobility, energy efficiency, energy demand/use and global warming. The purpose is to assess public perceptions of different energy related technologies and initiatives. It will also draw on survey data of individual households to understand how people in selected communities think about energy efficiency, energy installations in the landscape (such as wind farms) and geothermal power production, to mention but a few. Included in the work are comparative case-studies of deployment of relevant technologies in society: for example CO_2 capture and storage, transmission infrastructure extensions, wind, photovoltaic and district heating projects. Important concerns include how localization may interact with the opinions about the technology in question and behavioural change as a response to changes in the energy system.

An aim of this action is to enable a better understanding of the diverse features of public engagement, including the role of media, public beliefs and trust (in for instance climate science) as well as the sources of diversity with respect to attitudes and engagement.

Deliverables:

- Surveys of public perceptions for sustainable energy and energy efficiency.

Expected impacts:

- The impact will be increased support for transition strategies in European households enabling energy efficiency and sustainable energy.

KPIs:

- Survey results on various energy related technologies and measures available with complete MS coverage and appropriate sample size.

Costs: EUR 6-10 million.

Timeline: 2015-2020.

Modality of implementation: EU and national.

Action 2: Compare perceptions and assess the role of underlying social dynamics of different stakeholder groups across Europe, in view of more effective policymaking with regard to the energy transition.

Scope: Effective energy and environmental policy formulation and/or implementation depend on policy acceptance by stakeholders including individuals, groups, communities and organizations. Assessing the degree of policy acceptance of the energy transition calls for socio-economic analyses, dealing with some limitations such as uncertainty about future and non-priced social values. Special attention will have to be paid to preventing energy poverty and ensuring full access to energy for low/no income citizens. Thus, a set of indicators including perceptions and preferences of each stakeholder need to be developed and tested across all European countries. These measures can then be used to carry out comparative assessments of alternative policy options to understand how, on average, each society will respond to a given policy measure.

Deliverables:

- Analysis of factors influencing individual behaviour/decision making with regard to energy policies.
- Identification of a set of common socio-economic indicators.
- Construction of a common dataset related to the identified common indicators for EU.
- Improving methods and tools based on the indicators and related dataset.

Expected Impact:

- Developing effective energy and environmental policies that can be accepted by stakeholders in EU.
- A cost and time effective policy implementation rolled out across the EU.

KPIs:

- Set of common socio-economic indicators defined and peer-reviewed by 10 internationally renowned socio-economic researchers.
- Database established with full MS coverage.

Costs: EUR 2-4 million.

Timeline: 2015-2020.

Modality of the Implementation: EU-Level.

Challenge 2: Facilitating and enabling public participation in the energy transition

KEY ISSUES

- Innovative strategies need to be developed to raise awareness of consumers and stakeholders, engage local communities, reinforce and build capacities to enable and support the energy transition.
- Strategies and methods need to be elaborated with the aim of increasing public engagement in energy policy debate and stimulating social innovation initiatives of end-users to contribute to a low carbon energy system.
- Preventing energy poverty and ensuring full access to energy, including electricity but especially heating and cooling is essential (80% of the energy consumption in a house is for heating + DHW)
- Green partnerships.

PROPOSED ACTIONS

Action 1: Build a framework for understanding and enabling public engagement in the energy transition

Public engagement is closely related to – but not the same as – socialisation of technology. New technologies – including new practices – need to be made social in order to work. Such socialisation processes includes public engagement practices but also regulatory frameworks, media coverage, information regimes, and institutions providing advice (e.g., consumer agencies, public advisory services and consulting companies). This brings forward not only a focus on risks and benefits associated with new energy technologies but also issues like entrepreneurship, energy literacy, social innovations, and sense-making with respect to post or low carbon technologies.

A transition to a more sustainable and climate friendly energy system requires successful development and use of a broad set of new energy technologies, but to achieve this goal there is also need for a constructive public engagement. Political support for a transition to a post carbon society is needed, but just as important is a willingness to host area-demanding renewable energy production as well as uptake and adaption of new energy practices. To build trust and constructive engagement, transition strategies need to be made more transparent, inclusive and perceived by a broader set of stakeholders as being politically, economically, socially and environmentally viable.

Scope:

Consumers respond in at least two ways to the changing energy environment:

- As societal voters/citizens, related to public acceptance, whereby they influence public decision making, and enable, delay or block new investments in infrastructure (wind turbines, power plants, transmission lines, etc.).
- As active customers 'voting' with their wallet, and taking action themselves by creating co-ops, installing private batteries and/or back-up generators, etc. The dynamics and especially the reaction on the system's behaviour, clearly leading to non-linear and hence unexpected outcomes must be studied thoroughly. Customers react to prices, policy and regulatory signals, but often in unforeseen ways. The scope of this action is trying to identify boundaries of the playing field for policy and regulatory changes, and to help design an efficient energy system via robust policies:
  - The action targets the governance framework that will influence public engagement. The focus will be on economic instruments such as support schemes, green procurement etc., and social accords such as the formal framework for targeting public engagement in energy production, distribution and consumption as well as environmental laws and directives protecting for instance landscapes of particular ecological aspects related to public engagement.
  - The aim is to provide a better knowledge base for developing more effective instruments and ways of governing and engaging relevant stakeholders in the development of environmentally friendly energy. The action also target the roles of different stakeholders like engineers, architects, suppliers, retailers, etc., studying their ability and willingness to manage technology portfolios, e.g. to inform, educate and engage with relevant publics in socially acceptable deployment of sustainable technologies. In addition the aim is to provide a better knowledge base of developing more effective instruments and ways of governing and engaging relevant stakeholders in the development of environmentally friendly energy.

Deliverables:

- A framework for understanding public engagement.
- Make inventory of MS and international (outside EU) lessons learnt of policy/regulatory and customer reaction.
- Analysis of possible customer-behavioural impact onto the energy system.
- Develop solutions for negative impacts and promote positive impacts.

Expected impacts:

- The impact will be increased support for transition strategies in European households enabling energy efficiency and sustainable energy.

- Improved understanding of the energy consumer/citizen.
- Increase the regulatory and market understanding of consumer/citizens potential response through the development of 'off-the-shelves' tools for consumer response assessment.
- Establish supply-side and demand-side models allowing to delineate appropriate (i.e., non-conflicting) policy goals.

KPIs:

- Guide for best practice in public engagement in the energy transition established and used by relevant organisations in at least 10 MS.

Costs: EUR 20-25 million.

Timeline: 2015-2020.

Modality of implementation: EU, national, International (particularly US).

Action 2: Develop methods and tools to encourage citizens to adopt more sustainable consumption patterns

Encouraging people to adopt more sustainable patterns of consumption in the context of energy in households is a key step in addressing some of the biggest societal challenges that the EU faces. A kind of paradox exists or, at least, there is apparently an inconsistent pro-environmental attitude held by individuals, as that expressed on the one hand e.g. in surveys, while on the other not reflected consequently in significant shifts in voluntary behaviour. In addition, there is little evidence to suggest that more information, and/or information campaigns alone, can successfully promote voluntary behaviour changes in order to protect the environment, i.e. to persuade people in order to make long-term behavioural changes. As our behaviour is governed by a kind of a dual system (2 types of processes: 1. Reflective and conscious; 2. Automatic and unconscious) the role of the context is key.

Scope: Individual consumption attitudes and behaviours are complex. Physical, social, cultural and institutional contexts shape and constrain people's choices/options, and those influences should be understood in a systematic and consistent way underlining the crucial role of the contexts, the information flows, communication and feedback, the framing of the choices and the subsequent design of the choice contexts.

Deliverables:

- Methodology for context oriented analyses of information provision and of choice architecture facilitating desirable consumer choices.
- Case studies.
- Policy recommendations.

Expected impacts:

- Contribute to the reduction of the 'intension-action' gap.
- Improve the mix of factors for an effective adoption of attitudes and behaviour towards low-carbon energy options.
- Influence the technical infrastructures and social norms to effectively interact in order to affect more sustainable behaviour over time.
- Stimulate energy engineers to integrate such concerns in the design and innovation processes.
- Stimulate discussion with different stakeholder groups including the communication media and advertising.

KPIs:

- Reports published on at least 10 case studies regarding the implementation of more sustainable consumption patterns.

Costs: EUR 4-5 million.

Time line: 2015-2020.

Modality of implementation: Member State level.

HEADING 3: Improved innovation processes for the transition to sustainable energy

KEY ISSUES:

- Increase the number of innovations coming out of research on sustainable energy technologies.
- Increase stakeholder's ability to take research results into use.
- Reduce the time to market for energy innovation.
- Improve cooperation between public authorities, companies, end users and research institutions.

PROPOSED ACTIONS

Action 1: Study the interactions between public policy and firm level innovation in the sustainable energy sector

This action is needed to understand how public policy affects the innovation actions of firms and their cooperation with other stakeholders in the innovation chain, like research institutions and end-users. In order to reach ambitious environmental and economic objectives beyond 2030 one of the more efficient actions would be to increase the number of innovations coming out of research and reduce the time they need to reach the market.

Scope: The factors that influence the commercialization of research are insufficiently understood and more multi-level and process studies of the university spin-off and technology transfer phenomenon are needed. Specific technology projects with commercial potential will be identified, and their paths towards actual commercialization (spin-offs, transfer to existing firms, etc.) will be studied. The action focus is on knowledge transfer processes and possibilities of "open innovation" practices between R&D-institutions and companies. It includes the study of how ICT-based social may be used for knowledge sharing and interaction in innovation processes. The aim of this action is to increase the understanding of technology transfer and value creation related to the energy sector from public research institutions. It therefore also includes the study of company level strategies and decisions processes influencing production, distribution and consumption of energy. Emphasis will be on the influence of public policy and regulations on firm level processes and on how innovative and responsible firms interact with research institutions, government, other firms and the general public to find new solutions to the climate challenges.

Deliverables:

- Study of the relationship between public policy, firm innovation and research.

Expected impacts:

- Better understanding of how public policy, research and education can be used to increase the innovation rate in the transition to a sustainable energy system.

KPIs:

- Report published with wide EU and company coverage describing best practices for knowledge transfer.

Costs: EUR 2-4 million.

Time line: 2015-2020.

Modality of implementation: EU and national.

Action 2: New Policy instruments to stimulate low-carbon technologies along the innovation chain and improve industrial competitiveness through a multilevel energy governance assessment model

Recent industrial and energy policies to carry out the 20/20/20 energy and climate European Directives are having an impact on industry development, energy costs and the economy in general. EU Member States have implemented a multitude of policy instruments to respond to the various energy-related directives on energy efficiency (ecodesign, labelling,) and renewable energy (renewable power, heat,).

Some of these policies have already been assessed, however only on an ad-hoc basis so far and not in a systematic way. The lack of a model or tool that enables assessing the impact of multi-level governance and energy policies on industrial development (including both new business opportunities and the decline of incumbent technologies) does not allow making the most of earlier experiences or designing better policies to carry out energy transition technologies. As a result of this lack within the EU, inadequate policies are not corrected or are even copied by other Member States.

The enhanced understanding of shortcomings and best-practice examples of innovation or deployment policies in the EU Member States will be very valuable for stimulating the transfer of research results to the market, as well as for enhancing policies and measures that have a favourable impact on the industrial competitiveness of the sector in Europe. It will help to establish a more harmonized and systematic approach for ex-ante and ex-post evaluation of low-carbon policies and strategies.

Scope: This action analyses the policy instruments the EU Member States (or other competent authorities) have put in place to stimulate low carbon technologies. The action focuses on the following main aspects:

- How does the effect of the policies/measures in terms of bringing additional technologies to the market compare to the associated costs (effectiveness versus cost-efficiency, robustness and maturity of assessment tools)?
- Each step in the innovation chain, from RD&D to market uptake, demands a specific policy support. What is the impact of different policies and measures on innovation chain developments? To what extent is there a good balance between the various policy instruments the EU Member States have put in place to stimulate these low-carbon technologies along the innovation chain?
- What is the most appropriate level for taking action under the principle of subsidiarity: what policies should be set at the European level, at the member state level, at local level?
- What is the impact of different policies and measures on industrial competitiveness developments in Europe? How can research and innovation policy measures support better the development of industrial supply chains in Europe?
- The action should develop a model of multi-level energy governance that takes into account implemented energy policies and instruments to enable assessing its impact on the industrial competitiveness, the development of the energy policies and technologies. This model should allow gaining a deeper insight and reaching conclusions valuable for designing more efficient policies towards the deployment of energy transition strategies.

Deliverables:

- Analysis of factors influencing decision making of industrial companies with regard to energy and innovation policies.
- A model that integrates the multi-level governance and the energy policies framework, assessing impacts on innovation, industrial developments, and the energy sector as a whole.
- A description of the methodology used to build the model.

Expected Impact:

- Evaluation results of the policy instruments implemented in each EU Member State.
- Design more efficient energy policies that enhance industrial competitiveness and the development of the industry related to energy technologies.

KPIs:

- Model established and in use at relevant organisations in at least 10 different MS.

Costs: rough estimate EUR 7-11 million.
Timeline: 2015-2020.
Modality of the Implementation: EU-Level.

THEME 2: EDUCATION

The actions covered under Theme 'Education' address three major areas as defined in the SET-Plan Roadmap on Education and Training[1]:

- Filling the knowledge skills and competences gap.
- Fostering involvement of business and research, access and uptake by the labour market.
- Planning and enabling skills development, transfer and recognition.

The lack of sector or technology specific skills is partly addressed by relevant actions in Parts I, II and III, mainly focusing on vocational education and training. Theme 3 'Education' puts forward education and training actions at a higher level which aim to advance the provision of adequate human capital and assist the development of the necessary cooperation networks among education and training providers, research institutes and businesses. The actions can be developed for individual technologies/solutions and/or address several fields together.

HEADING 4: Advancing higher education and lifelong learning and fostering the link between education and training institutions, business and research institutes

KEY ISSUES

- Not updated or unavailable curricula for emerging/evolving energy related competence profiles at bachelor and master level, as well as for lifelong learning.
- Need to ensure adequate interdisciplinary integration of knowledge from relevant fields, and adequate integration of higher education with industrial research and innovation.
- Insufficient interaction among higher education and training institutions, business and research institutes in terms of curricula development, mobility programmes and access to facilities.
- Lack of professors/instructors who possess the required knowledge in new technology/research areas.
- Need to attract quality students to follow STEM and other related programmes in the energy field.
- Need to provide awareness and insight for decision makers and policy makers in the public and private sector.
- Difficulty in quality assurance of the energy education, national and cross border. Need for accreditation and certification of education programmes for the energy sector, including defining Intended Learning Outcomes.

PROPOSED ACTIONS

Action 1: Develop networks of higher education institutions with links to business and research

Scope: The overall goal of the networks of higher education institutions with links to business and research is to address knowledge, skills and competences needs and gaps via building networks, pooling capacities and allowing quick and wide replication. As such, they have the following guiding objectives:

[1] http://setis.ec.europa.eu/setis-deliverables/education-training-roadmap.

- To establish a flexible framework for developing new and upgrade of existing curricula in the respective evolving technology field, including blue-sky research, and involving of a broad range of experts from academia, research organisations and business.
- To speed up the process of implementing such curricula within and outside the networks by helping higher education institutions to structure their studies along the developed programmes.
- To facilitate the development of joint degree programmes among different universities via the envisaged streamlining and integration of curricula, teaching materials, teaching and learning methods at EU level.
- To create links to relevant research and industrial infrastructure(s) in order to provide access for training of students and staff.
- To encourage skill-led strategies for education, providing students and professionals with the latest technology trends.
- To develop a new generation of professorships and trainers in fields where expertise is lacking.
- To create a forum for relevant stakeholders from research, higher education institutions, industry and the public sector to exchange information on educational needs and share knowledge and experience.

The networks should gather stakeholders along the technology value chains, including a core network of universities and other higher education institutions, relevant research institutes, industry/business associations, and companies in the field. They should contribute to mobility and practice exchange across the EU. Furthermore, they should seek to have a global approach, and create links to relevant universities and quality organisations also outside the EU.

The new or updated educational programmes at the three levels of higher education, bachelor, master and doctorate, will be developed to support education and training on emerging or cutting-edge energy-related specialised areas (e.g. bio-refineries, advanced materials in energy storage, bio-resource value chain management, concentrating solar power, smart electricity grids, integrated renewable energy power market management, fuel cells and hydrogen, geothermal energy, nuclear technologies, fusion, photovoltaic, wind and ocean energy, smart thermal grids). The programmes should ensure suitable integration of several disciplines (e.g. technology, economics, public policy, business management, law, society), and will incorporate elements of entrepreneurship and developments of industrial-based research.

The development of such cooperation networks will enable industry to identify skilled partners from universities and other research institutions and, at the same time, provide academic support to students and researchers (e.g. doctoral candidates working in industry). Career development services offered by universities should include promotion of career opportunities in the energy sector. Excellence, ethical values and long-term vision should be at the heart of this activity.

Deliverables:

- The creation of Networks among higher education institutions with links to business and research, ensuring collaboration in terms of curricula development, mobility and cooperation programmes and access to facilities.
- The implementation of innovative educational programmes curricula at all levels (bachelor, master and doctorate) enabling cutting-edge energy-related research and development outcomes to support the implementation of the SET-Plan. A solid and long-lasting integration of education with industrial research, innovation and entrepreneurship.
- A well-educated pool of professors and instructors with the required knowledge in new developments spanning both technology and sustainable market visions.
- More qualified students attracted to follow energy-related studies by the visibility and opportunities provided by the networks.

Expected impact:

- The development of networks among higher education institutions, businesses and research will facilitate the development of innovative bachelor, master and doctoral programmes, enhance knowledge transfer and networking between industries and researchers at universities across

Europe. It will ensure adequate Multidisciplinary integration of knowledge from relevant knowledge fields. This activity shall enable alumni and industry to develop and use effectively and ethically advanced energy knowledge, research and innovation in the framework and according to the objectives of the SET-Plan.

KPIs: -

Costs: -

Timeline:

- New networks developed for at least two fields: 06/2016.
- Updated bachelor/master/doctoral programmes: 06/2016.

Modality of Implementation: -

Action 2: Develop networks among training institutions, business and research institutes for lifelong learning

Scope: The overall goal of the lifelong learning education and training networks is to provide education and training in domains with potential shortages/domains needing new or upgrade of existing competences. As such, they have the following guiding objectives:

- To establish a flexible framework for developing new and upgrade of existing vocational education or training course modules, involving relevant experts from education and training bodies, research organisations and business.
- To speed up the process of implementing such modules via joint programme development and sharing of experience within the network.
- To promote the incorporation of a strong practice element within the education and training schemes, including hands-on training in business/research settings.
- To develop a new generation of trainers in fields where expertise is lacking.
- To provide a framework to harmonise vocational education and training, strengthen the mutual recognition of qualifications, and monitor vocational education and training efforts.

The networks should involve technical training centres, vocational institutes and technical schools, universities and continuing professional education institutes, companies from related industries, business and research organisations, as well as other relevant actors such as vocational orientation/career guidance bodies, bodies responsible for accreditation, qualification or certification. The course modules should be developed in cooperation between the sectorial industrial associations and relevant academia/innovation partnerships.

The networks should focus on the skills development and upgrade of staff from key stakeholders along the technology value chains such as industries, related services, research organisations, public authorities, and professional end users while supporting lifelong learning and facilitating mobility across the EU.

New technology-oriented master courses or learning modules reflecting the latest technology developments and up-to-date knowledge on markets on a broad range of energy-related areas of specialisations will be developed (e.g. bio-refineries, advanced materials in energy storage, bio-resource value chain management, concentrating solar power, smart electricity grids, and integrated renewable energy power market management). Courses and learning modules will include other relevant topics and disciplines (e.g. economics, society, market foresights and visions, business management, public policy, law). The content should be prepared in such a way that could be easily assimilated by the existing labour force or by educated people wishing to change their professional careers. The content should be developed jointly by industry, research organisations and universities within the networks, in order to incorporate the knowledge and newest industrial developments in the curricula and teaching processes. The development of this action will enable continuous knowledge upgrade of the labour force and will ensure that the industrial sector finds qualified and up-to-date workforce, better prepared to tackle the emerging technological, social and economic challenges faced in the energy sector.

Deliverables:

- The creation of Networks among education and training institutions, business and research, ensuring collaboration in terms of curricula development, mobility and cooperation programmes and access to facilities.
- The development and implementation of innovative courses or learning modules, which will allow the continuous update of the workforce on cutting-edge energy-related research and developments, supporting the implementation of the SET-Plan.
- A solid and long-lasting integration of education with industrial research, innovation and entrepreneurship.

Expected Impact:

- The development of networks among education and training institutions, businesses and research will facilitate the development of innovative courses and learning modules, facilitate knowledge transfer and include elements of entrepreneurship and networking between companies and researchers at universities across Europe. It shall enable the existing workforce to develop and use effectively and ethically available knowledge in the energy sector in the framework and according to the objectives of the SET-Plan.

KPIs: -

Costs: -

Timeline:

- New networks developed for at least two fields: 06/2016.
- First new Lifelong Learning Programmes: 08/2017.

Modality of Implementation: -

Action 3: Establish a human resources and skills observatory for low-carbon technologies

Scope: This action will aim to adapt educational programmes to the expected large increase of well-educated employees and entrepreneurs in this field. It will seek to better understand and qualify the future workforce related to low-carbon technologies. In particular, it will seek to identify the profiles, competences and skills currently needed, but also in a timeframe of 5 to 10-15 years ahead, as higher-education programmes are 3-7 years long. The Observatory will carry out strategic analyses of skills gaps and shortages on a regular basis. It will also aim at improving training supply by indicating needs for new learning outcomes and paths to improve flexibility of specific sector workforces. It should cover all levels of higher education and lifelong learning. The observatory should be based on the clustering of existing innovation and foresight networks in Europe but should also be open to new initiatives. It should be oriented along the low-carbon technology supply chains and their actors in a comprehensive way. It should take regional differences in the skill-profile of different actors into account. The observatory has to include a representative sample of stakeholders and decision-makers (e.g. industry, policy makers) and cover all levels of education, in particular higher education and lifelong learning. The more future-oriented studies are risky because of their foresight nature and, consequently, sound methodology needs to be developed first to ensure reasonable outcomes of the studies. Excellence and encouragement of new developments should be at the heart of this activity.

Deliverables:

- Regularly updated and quality-assured database on the short-, medium- and long-term needs of human resources in the different low-carbon technology fields, based on sound methodology.
- Periodical surveys of business and research organisations' skills requirements which help education and training institutions to adapt curricula and educational programmes.
- A common reference system for education and training in the field via ECTS and defined learning outcomes, supporting cooperation as well as harmonisation of European efforts to strengthen the skill base of the workforce.

Expected Impact:

- The human resources and skills observatories for low-carbon technologies will provide comprehensive educational and training knowledge about current and future needs of the workforce related to low-carbon technologies. They will also monitor and provide periodical assessments of the Roadmap's implemented educational and training activities.

KPIs: -

Costs: -

Timeline:

- First survey of business and research organisations' skills requirements: 12/2015.
- Establishing a quality-assured database on energy human resources: 12/2016.
- Provision of first assessment of SET-Plan education and training activities: 12/2018.

Modality of Implementation: -

Action 4: Develop a quality assurance framework for higher education and lifelong learning programmes on energy

Scope: The Ministers for higher education of the 47 countries that conform to the European Higher Education Area (EHEA) have, in the context of Bologna Process, adopted the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG), a common framework for quality assurance in Europe. The structure of regulations and practices for educational programmes in Europe is complex. Regulations and practices exist at three levels: European, national and institutional. Many regulations originate from old practices and cultural differences between higher education institutions and nations. The Bologna process in Europe has for the last 15 years slowly but steadily moved European universities and member states towards a higher degree of interconnectivity in terms of accepting grades, merit, courses and programmes. However, barriers still exist.

The external quality assurance normally is performed at two levels in European countries: Programme and institutional external quality assurance (whether it takes the form of accreditation, evaluation or audit). It is important to point out that not all EU countries practice accreditation (one of the types of Quality Assurance) but use evaluations and audits instead. Furthermore, the autonomy of the establishments may vary in the accreditation process. The Programme accreditation based on e.g. national accreditation committees for each study programme seems to be relatively stiff for innovation, but higher education providers such as universities are usually free to change the set of courses and their content, e.g. in the range 10 to 30%. The Institutional accreditation/evaluation/audit can give a possibility to create new study programmes in a general accredited area rather freely, but requires an internal quality assurance system. A majority of European countries have Programme accreditation but the university reforms in many countries show a trend towards the Institutional accreditation, evaluation or audit. Another emerging trend is also on Double degrees or Joint degrees that may improve quality and cost efficiency of education. Double degree programmes are simpler for the accreditation process, while Joint degree programmes represent a more advanced form of cooperation.

In the low-carbon technology field these processes need, among various elements, the development of solid quality assurance systems (national and cross-border) for the energy sector, including the definition of Intended Learning Outcomes (ILOs) for master programmes, addressing both higher education and lifelong learning.

Within this context, there is a need to encourage Member States to work through their national agencies towards flexible accreditation systems and to undertake necessary reforms, in particular for the energy field and SET-Plan purposes.

Deliverables:

Improvement in Accreditation and Certification procedures are considered of utmost importance to recognise appropriately high-quality European-wide energy education and training in Europe. Such recognition requires the involvement of the Member States as they are legally responsible for the

national accreditation procedures. However, this issue does not relate solely to the energy sector and the approach should be systemic. Therefore, deliverables should be:

- Analysis of the accreditation processes in European countries necessary for the internationalisation and harmonisation of educational processes in the field of energy.
- Accreditation procedures and criteria in EU Member States evolving towards more flexible structures facilitating the accreditation of Pan-European educational programmes.
- Defined ILOs for master programmes for all formal occupational profiles at relevant levels of the European Qualifications Framework (EQF), including adequate Multidisciplinary integration. (To complement the already applied European Standard and Guidelines and European Credit Transfer Systems (ECTS).)

Expected Impact:

- This action will develop and provide trust between higher education providers across borders through a common understanding of quality in education and training. It will provide confidence in the safe and secure development of a low-carbon energy system through the use of defined and assessed ILOs in the related educational and training programmes. This action will facilitate workforce mobility and retention of suitably qualified and experienced personnel across Europe. It will increase services related to job qualifications that are based on portfolios of ILOs (knowledge, skills and competences) in view of their recognition across the EU.

KPIs: -

Costs: -

Timeline:

- Definition and harmonisation of ILOs: 12/2016.

Modality of Implementation: -

Action 5: Development of energy-related education programmes for decision-makers

Scope: Under this action, a wide range of education and training programmes will be developed addressed specifically to policy/decision-makers and other key actors involved in promoting and implementing energy solutions in the public arena, businesses and in specific communities. This education and training need is very specific because it concerns the implementation of energy solutions and policies affecting the daily life of all of us, the end users. The content of these programmes, which shall be updated regularly (e.g. every two years), will aim at the development of energy-related competences across various disciplines (e.g. economics, engineering, political science, architecture, law, industrial design). As a result of this action, the level of awareness and knowledge on energy topics of the decision/policy-making community will increase. Furthermore, the capacity of local/regional governments to assess and better implement energy solutions and energy policies in cities and communities will be enhanced.

Education and training programmes developed under the actions described above should be the basis for the programmes developed under this action. The action on e-infrastructures, Action 2 in Heading 3.2, should be also linked to this one to make the content of these programmes and courses available online.

Deliverables:

- Programmes aiming at mobilising and updating, expanding and creating educational capacity and curricula for low-carbon energy systems at master and doctorate level, covering a diverse range of disciplines, including e.g. behavioural economics, policy evaluation, engineering and law. Programmes addressing global energy transition scenarios.
- Energy-related education and training programmes targeting new knowledge and/or skills upgrade for specific groups of consultants.
- Education and training programmes for city policy evaluators and managers, as well as urban planners, for example, 'City-level Energy Planning', 'Energy Policy Evaluation and Management'.

- E-platforms for knowledge and best practices exchange and dissemination, targeted to local/regional governments. E-tools allowing system simulations.

Expected Impact:

- This action will provide a solid baseline to enhance the qualifications, knowledge and competences of key actors in the energy sector. The education and training courses will cover appropriate mixture of knowledge areas relevant to the energy sector and will be specifically tailored for policy/decision makers. The programmes will provide also elements for proper assessment of energy technology options: their opportunities, challenges and consequences of the implementation for the end users in cities, villages and communities located far from the main poles of population.

KPIs: -

Costs: -

Timeline:

- Flexible and Multidisciplinary European energy-related programmes: (12/2016).
- E-platforms for knowledge and best practices exchange and dissemination, targeted to local/regional governments: (12/2015).

Modality of Implementation: -

HEADING 5: Infrastructure support to higher education and lifelong learning

KEY ISSUES:

- Lack of quality European Open Educational resources in the field of low carbon energy, which can be used for educational programmes adapted to regional and local needs.
- Providing access to research and industrial infrastructure such as laboratory, pilot projects and test facilities for practical training in real environment.
- Providing access to educational infrastructure such as laboratory and test facilities, and databases containing case/experience data that can form the basis for analytical studies.

PROPOSED ACTIONS

Action 1: Ensuring access to research infrastructures, pilot and demonstration facilities to support education and professional training

Scope: This action will facilitate, for education and training purposes, access to large or small local, national and international research infrastructures, industrial and research technology pilot and demonstration facilities, and research institutes' laboratories. These infrastructures will adhere to high-quality education and training principles by engaging the necessary range of experts from education and training bodies, research and industry. A close link will be established with the education and training observatory which will act as an e-repository to the education platforms. These infrastructures should adhere to the principles and recommendations of the Charter for Access to Research Infrastructures, currently under development by the European Commission.

Deliverables:

- Energy-related education and training programmes or modules, projects and exchange programmes with the participation of education and training providers, research infrastructures and/or industrial installations, and relevant industry.
- Platforms for practice-oriented education and training and sharing of experience (e.g. on bio-refineries, concentrated solar power, hydrogen, ocean energy, CO_2 capture and storage, system integration and complexity management). They could assist entrepreneurs and 'entrepreneurs' (as in 'entrepreneurship', the practice of some businesses that integrate risk-management as part of their innovation strategy).

Expected Impact:

- Energy-related infrastructures will support education and training, from fresh students to experienced employees such as engineers, project developers, managers and researchers. The platforms for practice-oriented education and training will welcome these professionals and can also offer career opportunities. As a consequence, either by educating and training professionals on new developments in the field, and/or through the implementation of joint research and innovation projects, the supportive infrastructures will contribute to accelerate technology development, market uptake and market replication.
- Energy-related infrastructures will adopt good practices as indicated in the EC Charter for Access to Research Infrastructures.

KPIs: -

Costs: -

Timeline:

- Education and training development programmes (minimum two): 12/2015.
- Platform for practice-oriented education and training from fresh students to experienced employees: 06/2016.

Modality of Implementation: -

Action 2: Develop and make available e-tools (e-Infrastructures) for energy education

Scope: In order to foster talent development anywhere, it is important to establish a well-functioning educational e-infrastructure in Europe, including e-repositories, to enable students and professionals to access the teaching material even if they are not physically present in a university campus.

This action will facilitate access to education and training through national and international research electronic infrastructures (e-Infrastructures). The supportive e-infrastructures will adhere to high-quality education and training and distance learning principles. Teaching materials will be developed by education providers through engaging a broad range of experts from education and training bodies, research and industry. Since this action will develop courses that are widely available, this will require a substantial development effort towards e-learning tools (e.g. Massive Open On-line Courses). The participant infrastructures should adhere to the principles and recommendations of the Charter for Access to Research Infrastructures, currently under development by the European Commission.

Deliverables:

- Energy-related education and training programmes, available through e-learning platforms, including MOOCs.
- Access to relevant and updated energy-related knowledge through e-repositories. Practical training via e-infrastructures.

Expected Impact:

- The e-Infrastructures will support ubiquitous education and training. Actions under Heading 3.1 (new and updated energy education and training programmes; skills observatory) and action 1 under Heading 3.2 can be part of this Action, by promoting and linking the educational programmes into a consolidated set of e-infrastructures. The supportive e-infrastructures will accelerate the process of technology development, market uptake and market replication via educating and training students and professionals about new developments in the field.
- Energy-related e-infrastructures will adopt good practices as indicated in the EC Charter for Access to Research Infrastructures.

KPIs: -

Costs: -

Timeline:

- Electronic education and training development programmes (minimum two): 12/2015.
- Electronic platform for practice-oriented education and training from fresh students to experienced employees: 06/2016.

Modality of Implementation: -

HEADING 6: Raising awareness, developing behaviour and enhancing knowledge, skills and competences among citizens and the young generation

KEY ISSUES:

- Need to better inform the public towards the energy transition, to implement and make use of innovative energy systems in Europe to their full extent.
- Need to develop behaviour and skills amongst the young generation to support the energy transition as smart consumers of tomorrow in and outside the school curricula.
- Need to stimulate interest in low-carbon technologies and solutions amongst students to feed future workforces in the energy sector.
- Lack of systematic integration of successful educational methodologies into national curricula that foster energy competencies in students.
- Lack of capacity and skills amongst teaching staff to engage their students in relevant low-carbon fields.

PROPOSED ACTIONS

Action 1: Energy Citizens Campaigns

Scope: Information to the public is a key factor towards the energy transition, to implement and make use of innovative energy systems in Europe to their full extent and to mobilise the workforce necessary to operate them. Given the strategic importance of the SET-Plan for Europe and the strong link of energy-related issues to the urban contexts as well as to other policy fields, this Energy Public Information Campaign Action should be coordinated at European level but brought to citizens in their local contexts. The action therefore involves meetings at 'town hall' level, including live-streams of expert lectures via internet to local outlets. The sessions will provide proven, clear and balanced information on the opportunities, requirements and consequences of the implementation of the new energy systems. It will provide technical, environmental, social and economic knowledge about key issues of energy systems understandable to the general public, as well as moderated discussions in different regional settings addressing local issues of innovative energy system implementation. The Public Information Campaigns will include the research community, industry, energy companies, consumer associations, governmental bodies, etc. and will aim at creating the understanding of the needs for action, the opportunities created by new technologies, the inevitable consequences and necessary change of habits, the policy options and their consequences.

Deliverables:

- Scripts for local events within the Public Information Campaign.
- Live streams of expert lectures.
- Archives of streamed lectures.

Expected Impact:

- The Public Information Campaigns will bring high quality information about innovative energy systems to the general public and in particular to actors on the ground. It will initiate a discourse on the grass roots level about the challenges and opportunities of innovative energy systems.
- This campaigns will serve two objectives:
  - Increase awareness of the general European public about the opportunities, requirements and consequences of the implementation of innovative energy systems in their local context.
  - Increase awareness, particularly among the existing workforce and young people entering the job market about:

- The societal need to evolve towards more clean and efficient energy systems and, in consequence.
- The greater than ever need and demand of well-educated workers and entrepreneurs in the low-carbon energy sector.

KPIs: -

Costs: -

Timeline:

- Development of campaigns framework and tendering for national contact points: 06/2015.
- Implementation of campaigns: 2016 - 2018.

Modality of Implementation: -

Action 2: Developing behaviour and enhancing knowledge, skills and competences among the young generation

Scope: This action will support the integration of successful and innovative methodologies and lessons into national curricula in order to foster behaviour, build competences and skills for the energy transition among the young generation. It will enhance collaboration among actors (e.g. education authorities, teaching staff, teaching academies, relevant businesses) for the full integration of appropriate methodologies into curricula. In addition, it will provide professional training for teaching staff, fully accredited and in-line with national education policies. Collaboration with professional training bodies, businesses and social partners will be encouraged. Relevant skills and behaviour outside the school environment will be fostered.

Deliverables:

- Pedagogic approaches integrated into curricula that foster smart energy behaviour and build necessary competences and skills for the energy transition. These pedagogic methodologies should go beyond awareness rising and should consider possible collaboration with local businesses and the public sector.
- Programmes to encourage school students' interest in STEM and other relevant studies, at the same time showing developments and growth prospects in the field of energy, including also practical courses for students in businesses.
- Accredited professional trainings for teaching staff delivered by recognised professional training institutions and in line with professional training standards.
- Attractive edutainment solutions that can foster interest in the energy field, as well as encourage responsible behaviour outside the school environment, e.g. social media campaigns and serious games.
- Competitions and innovative supporting schemes rewarding young scientists, knowledge in STEM and related energy fields, smart behaviour and mainstreaming a low-carbon lifestyle (e.g. addressing split incentives between school building user and owner).

Expected impact:

- Higher affinity of young people towards low-carbon lifestyles, technologies and solutions and recognising them as main pillar of a secure, affordable and clean energy supply.
- Higher number of students pursuing education and career pathways in the low carbon energy fields.
- Higher sales of energy efficient products and increasing demand of renewable energy through choices made by consumers.
- Increased capacity of teaching staff to foster smart energy behaviour and build necessary competences and skills for the energy transition.

KPI's: -

Costs: EUR 50 million.

Timeline: 2014-2020; foresight 2025 and beyond.

Modality of implementation: Requires European and Member State support coordinated at EU level. MS support must provide the backbone of this activity together with European incentives.

HEADING 7: International Cooperation for Capacity Building

PROPOSED ACTIONS

Action 1: Capacity Building in renewable energy for southern Mediterranean (North African) states

Scope: The rapid growth in energy demand in the coming decades and the decision on what technology portfolio this shall be based leads based on will have essential impact on the economic and social development as well as on the level of greenhouse gas emission in neighbouring Mediterranean countries. Existing technical expertise in the field of renewable energy in Europe shall be used in joint project in order to support the national renewable energy strategies for North African partner countries. It shall be based on the proper assessment of technology options in order to focus on the right products and develop a competitive industrial sector. In particular, mechanisms shall be supported that create capacities in research and industry that help to build up assessment competence in the field of all renewable energy A technology centre capable to asses and benchmark products and support the national industry in the development of their own products and provide training is needed.

Deliverable:

- Creation of a research / industrial cooperation infrastructure.

Expected impact:

- The use of renewable energy will have impact on the greenhouse gas emission, on the economic and social development of the neighbouring countries.

KPIs:

- Local share of renewable installations raised.

Costs: Around EUR 10 million per centre out of which 30% is provided by EU grant (5 centres for the region).

Timeline: Implementation until 2020.

Modality of implementation: EU and North African Member States.