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Multidimensional Impact of the Low-carbon European Strategy on Energy Security, and Socio-Economic Dimension up to 2050 Perspective

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Report on drivers of societal processes of energy transition

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Abstract: This report on drivers of the societal processes of the low-carbon energy transition present an analysis of drivers and barriers of energy transition, examining Factors in three domains: *Market, External and Governance Factors (E), Social, Political Movement and Grassroots Factors (S) and Personal, Cultural and Site-specific Factors (P)*. The analysis combines qualitative and quantitative information from literature, focus groups and expert interviews on local Anticipatory Experiences into an assessment model to study the relevance of Factors, the interconnectedness of Factors and the temporal fluctuation in relevance of the Factors. Results point toward *Social, Political Movement and Grassroots Factors* as being the most relevant drivers for the energy transition. This information is meant for policy makers and academics alike.

Disclaimer

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Abbreviations:

EC	European Commission
EU	European Union
GHG	Greenhouse gas emissions
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
MILESECURE-2050	Multidimensional Impact of the Low-carbon European Strategy on Energy Security, and Socio-Economic Dimension up to 2050 perspective
NGO	Non-governmental Organisation
PCA	Principal Component Analysis

Jargon / defintions:

Anticipatory Experience	European locales where a low-carbon transition has taken place on a local scale
Assessment Matrix	A grid of quantitative values based on a qualitative ranking of Anticipatory Experiences; the first step in the Quantitative Evaluation
Domain	Regime or category to which Factors belong
Factor	Significant influencer on energy transition. Can encapsulate either transition drivers or transition barriers within its scope, depending on context.
Final Framework	Organisational and framing structure of key drivers and barriers in energy transition, based on synthesis of entire research proccess
Preliminary Framework	Initial hypothesis of comprehensive organisation and structure for Factors in energy transition
Quantitative Evaluation	Statistical analysis conducted on Anticipatory Experiences after they had been scored according to the Preliminary Framework

Executive summary

This report is a result of MILESECURE-2050, a collaborative and multi-disciplinary project seeking to identify the modes through which energy security is defined at the European, national and local scales with a focus on energy transition towards a low carbon society.

This report on drivers of the societal processes of the low-carbon energy transition focuses on the analysis of drivers and barriers of energy transition, the Factors in the three domains: *Market, External and Governance Factors (E), Social, Political Movement, and Grassroots Factors (S) and Personal, Cultural and Site-specific Factors (P)*. This report goes beyond the "social and technological dichotomy" and considers in equal or perhaps greater weight the human factor in energy transition. The analysis uses elements of "post-normal science" to reduce the complexity of the involved systems to be manageable for environmental policy making. It combines qualitative and quantitative information from literature, focus groups and expert interviews, as well as local Anticipatory Experiences into an assessment model to study the relevance of Factors, the interconnectedness of factors and the temporal fluctuation in relevance of Factors. Research results point toward *Social, Political Movement and Grassroots Factors* as being the most relevant drivers for the energy transition.

Overview of key insights from qualitative and quantitative research on energy transition

- The *"Social, Political Movement and Grassroots Factors"* dimension (Citizens' orientation to change, engagement in movements and projects at the local level, willingness to pay in part for initiatives) is a foundation for smooth energy transition.
- External governance and financial instruments help bottom-up initiatives scale to a regional or national level.
- Behaviour change and transformation in the personal dimension are prerequisites for the measurable success of transition.

Although further research with more data points is required to substantiate these insights, the findings from literature and supplementary experimental research informed the following framing of key energy transition drivers as well as their relationship with one another.

Pre-conditions (leverage points in the system)	**Triggers** (change of flows in system)	**Impact** (behaviour or systemic change)
Openness of individuals to social change and change processes (S)	Engagement of individuals in local projects, existence of change agents (S)	New socio-cultural power structures (S)
Political leadership (covering various levels of governance) (S)	Legal framework, incentives, regulation (E)	New political power structures (S)
Human capital (E)	Effective implementation (project management, technical training, information) (P)	New interaction of individuals with technology, society (P)
Positive economic impact of the project / measure (P)	Funding models (S)	Evolution of new business models (S)
Market signals (E)	Massive shocks, external disruptions to system (E)	New financial and economic power structures (S)

The information in this report supports policy makers in improving the design of policies and measures to support the energy transition. At the same time, academics can take up the methodologies developed here and advance them further.

1. Introduction

This report is a result of MILESECURE-2050, a collaborative and multi-disciplinary project seeking to identify the modes through which energy security is defined at the European, national and local scales with a focus on energy transition towards a low carbon society.

The goal of the following analysis is to synthesise key drivers and barriers in energy transition. The identification of these key elements can inform policy making, support interests in the private sector and enhance broader academic and educational investigation of the energy transition towards low-carbon energy security.

The research conducted not only identified important factors in energy transition processes but considered how these elements could be influenced. In essence, **this report considers leverage points for change in the system** and therefore goes beyond the mere identification of factors.

The research undertaken was an iterative process. After a preliminary literature review of key elements in the desired secure, low-carbon and inclusive society as well as of energy transition literature (drawing upon previous publications in the MILESECURE project including D1.3, D1.4, D2.1 and D2.2[4] as well as external publications), a preliminary framework for categorising and structuring the key factors in energy transitions was developed (Chapter 3.1). This framework was then tested (or "prototyped") within the MILESECURE-2050 consortium via an assessment process (Chapter 3.2) as well as among experts during focus groups and interviews (Chapter 3.3). The feedback then informed a collection of key insights (Chapter 4) and the development of the final framework for the key drivers and barriers in energy transition (Chapter 0).

The information in this report supports policy makers in improving the design of policies and measures to support the energy transition. At the same time, academics can take up the methodologies developed here and advance them further.

[4] All MILESECURE-2050 deliverables are freely available at http://www.milesecure2050.eu/en/public-deliverables

2. Current perspectives on a secure, low-carbon, inclusive energy system

2.1 Background

In this chapter, an overview of the key components of a secure, low-carbon and inclusive energy system are presented as identified in Work Packages 1 and 2 of the MILESECURE-2050 project.

Energy has been at the heart of the European Union (EU) since its inception (European Coal and Steel Community 1951, European Atomic Energy Community, 1957). In particular, EU energy policy has developed around a common objective of ensuring safe, secure, affordable and sustainable energy supplies for its economy and citizens (EC 2011).

Over the past few years, Europe's energy system has been encouraged to move towards a low-carbon, competitive and secure energy system with the pace towards this new energy system expected to be drastically intensified (COM (2011) 112). This will be achieved mostly through EU legislation, relevant subsidies and investment strategies which aim to combat a multitude of issues which range from climate change to the expected depletion of fossil fuels, from issues of energy poverty to security of energy supply and from highly volatile energy prices to the new energy-related geopolitical realities. In other words, the overall target is to drastically transform Europe's energy system over the next few decades.

Europe's energy policy is based on three complementary pillars of security of supply, sustainability and competitiveness (COM(2006) 105 final). These three pillars have also been re-confirmed in the EU's 2020 to 2030 transition framework for climate and energy policies (COM(2014) 15 final).[5] Throughout the official texts of the EU, it is clearly stated that any energy system must also be inclusive. In particular, the EU concept of *sustainability* refers to three interconnected components, i.e. environmental, economic and social (COM(2006) 105 final). In this chapter, we examine the targets set-forth by the European Union for this new energy system and examine issues regarding the transitional period.

2.2 Key components of a secure, low-carbon and inclusive energy system

It is important to first establish what the key components of the desired energy system are, that is, what are the individual strategies and targets in reference to the three dimensions: secure, low-carbon and inclusive. For this task, we mostly rely on the official communications of the European Union, especially those of the European Commission.

[5] Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: A policy framework for climate and energy in the period from 2020 to 2030. COM(2014) 15 final.

a. A secure energy system

A secure energy system can be defined as one "*evolving over time with an adequate capacity to absorb adverse uncertain events, so that it is able to continue satisfying the energy service needs of its intended users with 'acceptable' changes in their amount and prices*" (Gracceva and Zeniewski 2012). This definition builds upon the IEA's definition of energy security as "*the uninterrupted availability of energy sources at an affordable price*"[6] by shifting attention to the actual capacity of the energy supply chain to cope with adverse events. An extended survey regarding the conceptualisation of the term "energy security" is presented in Deliverable 1.1 of MILESECURE-2050 (D.1.1).

From the above definition it is evident that, amongst other characteristics, a secure energy system is one that can tolerate disturbances with respect to different threats. Such threats can arise from high and volatile energy prices and costs (from conventional, unconventional and renewable sources), abrupt changes in policies (e.g. tensions between countries) and social resistance to energy investments (e.g. for transmission lines) etc.

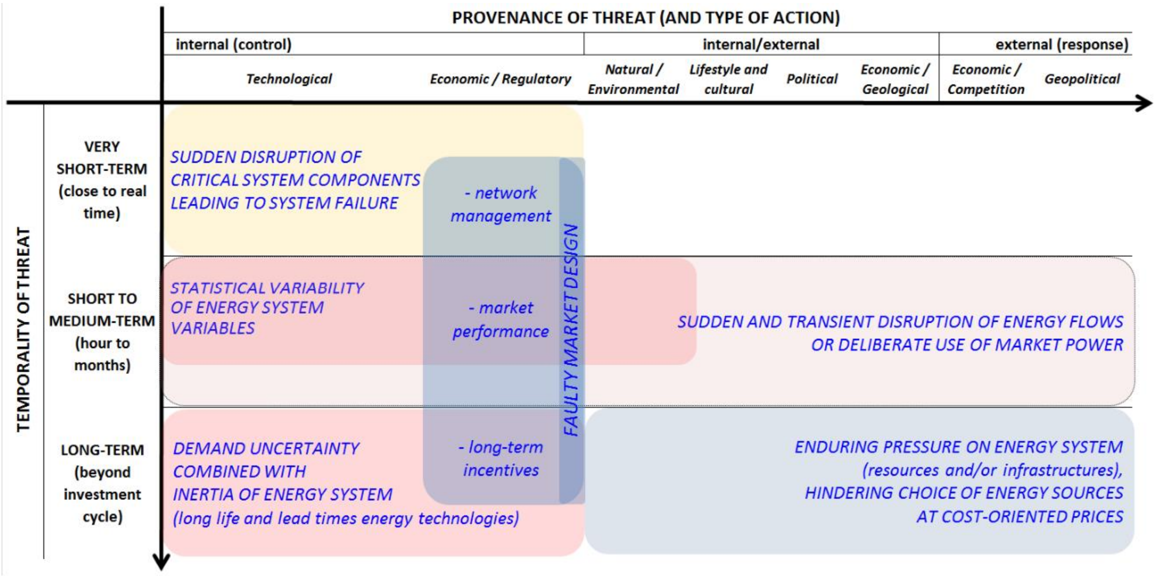
In its simplest form, the security of an energy system can be evaluated on the basis of two dimensions: temporality and provenance of threats. In effect, the system must be able to cope with both short-term disruptions (i.e. shocks) and medium and long-term stresses (e.g. enduring pressures). Short-term disruptions may include strikes, sabotages, transmission network failures, temporary export restrictions etc. Medium and long-term risks may include export cartel issues, resource shocks, "real climate policy" shocks (Mitchell 2002), war and civil conflicts, political instability, regime change, revolutions, long-term export restrictions, closure of trade routes, sanctions etc. (Fattouh 2007).These threats to energy security can also be visualized as in the figure below. In particular,

Figure 2-1. A map of potential threats to the energy system in terms of temporality (Source: D.1.1)

links the temporality with the provenance of a particular threat. An analytical discussion is provided in MILESECURE-2050 (D1.1, ch. 2.4).

[6] Source: IEA website: http://www.iea.org/topics/energysecurity/

Figure 2-1. A map of potential threats to the energy system in terms of temporality (Source: D.1.1)



Furthermore, the energy system must have the characteristics of stability, adequacy, resilience and robustness, where the first two are related to internal threats and the remaining two concern threats which are mainly external (Stirling 2009). An analytical discussion on this subject is provided in MILESECURE-2050 (D1.1, ch. 2.4).

The European Commission seeks to increase the security of the current EU energy system. It often cites the fact that the EU external energy bill exceeded €400 billion in 2013, representing more than a fifth of total EU imports. Most notably, EU imports of crude oil and oil products account for more than €300 billion, a third of which is imported from Russia. Currently, the EU imports 53 percent of the energy it consumes with a 90 percent import dependency for crude oil. Furthermore, six Member States depend on a single external supplier (Russia) for their entire gas imports and three of them use natural gas for more than a quarter of their total energy needs (COM(2014) 330 final). To decrease EU energy dependence, the European Commission has proposed a wide range of actions which are being simultaneously pursued such as strengthening emergency/solidarity mechanisms, protecting strategic infrastructure, building a fully integrated internal market and further developing energy technologies.

b. A low-carbon society

According to the European Commission (DG CLIMA), "*In a low-carbon society we will live and work in low-energy, low-emission buildings with intelligent heating and cooling systems. We will drive electric and hybrid cars and live in cleaner cities with less air pollution and better public transport*."[7]

Transforming Europe's energy system to a low-carbon one has been deemed necessary to address a wide range of existing and expected issues such as combating climate change and the expected depletion of fossil fuels. Regarding climate change, the EU intends to play its part in a broader worldwide effort to keep the average global temperature increase to below two degrees Celsius compared to pre-industrial levels (e.g. UN Climate Change Summits in Cancun 2010 and Copenhagen 2009). Further benefits of a low-carbon society include a general improvement in health due to decreased airborne emissions and waste, new job potentials, decreased energy import dependencies (again, of high priority for Europe) and reduced energy costs.

The European Commission has created a "Roadmap for moving to a competitive low-carbon economy in 2050" (COM (2011) 112) which involves a cut in the EU greenhouse emissions by 80 percent by 2050 (compared with 1990 levels) entirely through measures taken within Europe. To achieve this, intermediate GHG cuts of 25 percent by 2020, 40 percent by 2030 and 60 percent by 2040 would be needed. This essentially means that the carbon-based society of today which took 200 years to develop would need to radically transform to a new low-carbon society in less than 40 years.[8] According to the European Commission, the low-carbon economy target(s) will be (mostly) achieved through the mobilisation of investments in energy, transport, industry and information and communication technologies and through policies that promote increased energy efficiency (COM (2011) 112).

The European Commission's Roadmap further predicts a decrease in energy consumption by almost 30 percent, mostly due to improved energy efficiencies, which in turn would reduce dependencies through decreased price volatilities and energy imports as well as reduce air pollution and provide additional health benefits. Furthermore, during the transition period there could be up to 1.5 million new jobs, mostly in the construction sector as residential and commercial structures would have to be renovated and constructed to achieve the desired energy efficiencies. Currently, buildings use 40 percent of total EU energy consumption and generate 36 percent of greenhouse gases, showing a great potential for energy efficiencies to be gained in this sector.[9]

[7] Source: European Commission (2012): Roadmap for moving to a low carbon economy in 2050 (webpage). Available on http://ec.europa.eu/clima/policies/roadmap/index_en.htm. Accessed July 2013.

[8] In particular, the goal is for annual emissions to be lowered in such a manner so that the increase in global temperature is below 2 degrees Celsius against pre-industrial temperature levels (the industrial revolution occurred between 1750 and 1850).

[9] Source: Directive 2010/31/EU of the European Parliament and of The Council of 19 May 2010 on the energy performance of buildings (recast).

Harmonizing climate goals and policies internationally is essential for a low-carbon global economy. As the EU is responsible for just around 10 percent of global emissions (a figure that is shrinking), it is clear that the EU cannot solve the problem through unilateral initiatives (COM (2011) 112). Furthermore, the transition to a low-carbon economy involves increased costs to certain sectors (e.g. manufacturing) and thus any unilateral actions may have a negative effect on the competitiveness of the local region.

c. An inclusive energy system

The issues of defining and describing secure and low-carbon energy systems have received much more attention by both academics and policy makers than the cultural and social dimensions, which have been highlighted in the revisited 2005 Lisbon Agenda. In particular, a specific vision was set for the promotion of growth and jobs for sustainable development. Furthermore, in 2006 the European Commission published the "A European Strategy for Sustainable, Competitive and Secure Energy" Green Paper (COM(2006), 105). Finally, the EU has funded various projects which highlight the human factor as central to the energy system, especially when dealing with energy system(s) transition. Such projects included Paradigm shifts modelling innovative approach (PASHMINA), Sustainable lifestyles 2050 (SPREAD) and Challenges for Europe in the world 2030 (AUGUR).

An inclusive energy system may also enhance the quality of life of citizens in ways that may be less measurable. Cultural richness, stronger connectivity and an active community can reside in an inclusive energy system and even though these are qualitative descriptions rather than statistical thresholds, we should not underestimated their value.[10]

Along with sustainable growth and job creation, another driver for an inclusive energy system is its affordability. Households evaluate energy affordability directly through their (monthly) energy budget and indirectly through prices of goods, especially those that are energy intensive. The issue of affordability is explicitly highlighted in almost every overall strategy for energy policy (e.g. EC,[11] IEA[12]) as decarbonising the economy could lead to significant costs for households, especially if fuel and/or technology switching are required.

d. Common, yet different visions across Member States

It is important to note that while the main characteristics of a desired energy system may be similar across Europe, the exact desired (and achieved) energy system(s) will be different due to technological, political, economic, environmental, lifestyle and cultural differences as well as the societies' needs and desires which are furthermore influenced by these factors. For the same reasons, the transformation process from the current energy system to a secure, low-carbon, inclusive one will also drastically

[10] For further explorations of key societal aspects in a post-carbon energy system, see D2.1 and D2.2.
[11] For examples, see EC (2011, 2013 and 2014).
[12] The IEA's motto is "Working together to ensure reliable, affordable and clean energy" (source: IEA website).

differ amongst EU Member States and even regions due to different lifestyle and cultural perspectives (social norms, societal priorities, customs, cultural needs, etc.).

2.3 Three components, one policy

The previous section identified some characteristics regarding each of the three main desired components of an energy system, i.e. secure, low-carbon and inclusive energy. However, it is evident that due to their interdependencies and externalities, both positive and negative, these three components cannot, and should not, be evaluated or pursued independently.

In particular, governmental initiatives (e.g.) aimed at reducing greenhouse gas emissions can affect other energy policy objectives and (e.g.) bring about additional costs within the energy system. The European Commission warns that *"If not properly designed, policies aimed at the reduction of greenhouse gases emission may affect the resilience of the energy system and its ability to tolerate disturbance and deliver stable and affordable energy services to consumers" (EC 2013).*

For example, an effort to increase the security of energy supply through the construction of storage facilities which would be used infrequently, e.g. only in case of a crisis, may increase the total cost of the energy system. This would in turn hurt consumers along the social dimension. Similar arguments can be made regarding actions that would lead to lower-carbon solutions, e.g. an increased presence of biomass fuels in the total energy mix, i.e. electricity production from biofuels may need to be funded through subsidies, thus increasing the overall cost of the system.

Therefore, (public) policies must simultaneously take into account all three components and their interdependencies. They must not aim at improving any of the three individual components but at improving the overall energy system performance along these three dimensions. Initiatives must be designed and evaluated with a holistic view.

In the past, energy and climate policies in the European Union were mostly implemented by addressing single issues or initiatives (a "Directive-by-Directive" approach).[13] However, in 2014 the European Commission (DG ENER) proposed a New Governance System that would oblige Member States to draft and submit for approval, plans that encompass overall energy and climate policies (COM(2014) 15 final). These so-called "National Action Plans" incorporate the issues of energy competitiveness, security and sustainability into a single plan. In particular, these plans will have to simultaneously address issues of achieving domestic objectives regarding greenhouse gas emissions, renewable energy, energy savings, energy security, research and innovation, nuclear energy, shale gas and carbon capture and storage as well as European Union level climate and energy objectives etc. Furthermore, coordination with neighbouring Member States, as well as regional effects, will also have to be taken into consideration. In particular, these National Plans will have to ensure "*that EU policy objectives for climate and energy are delivered, provide greater coherence of Member States' approach, promote further market integration and competition and provide certainty to investors for the period after 2020" (COM(2014) 15 final).*

[13] For example, while the 2004 Directive on the promotion of cogeneration (Directive 2004/8/EC) explicitly mentions combating climate change and job creation as objectives (positive externalities), no actual calculations as to the impact of the Directive on these objectives are required.

Previously, policies to achieve EU climate goals used to be examined in isolation, especially detached from energy security. For example, one of the main targets of the EC's strategy for transport ("Transport 2050") is to eliminate conventionally-fuelled cars in European cities by 2050[14] but there do not seem to be any assessments of how this would affect energy markets and the overall fuel supply. In contrast, the assessment of co-benefits and externalities of climate policies are now being integrated into a larger context, e.g. the assessment of co-benefits have become a key challenge of the debates in the Working Group III of the IPCC report released in 2014. An overview of the macro-regional energy scenarios proposed in the scientific literature can be found in MILESECURE-2050 (D.1.2).

2.4 The transition to the desired energy system

As seen in the previous section, the European Union has set forth ambitious medium and long-term goals regarding the transformation of the current European energy system. The achievement (or not) of these goals highly depends on the transition process. Thus, it is equally important to the targets themselves, if not more, to acknowledge the importance of the transformation (transition) process.

a. Key insights on energy transition drivers and barriers, based on national energy policies

Energy transition societal considerations can also be drawn from **national decarbonisation experiences** in the EU thus far. Previous research in the MILESECURE-2050 project has investigated energy policy and security topics in-depth for three Member States: Germany, Italy and Poland. These three case studies were chosen based on the geographic diversity, cultural differences and different economic development situations in each EU Member State. Key insights can be arranged as follows:

Table 2-1. Energy transition insights from EU experiences at the national level (Source: D.1.3)

Germany	***Italy***	***Poland***
Overall Energy Transition profile (since 2005)		
Positioning a green economy: Germany's economy has reduced energy usage per output while continuing to grow. Federal and private sector efforts have created a business environment supportive of green industries.	**Achieving GHG emissions reductions:** Italy has already surpassed its 2020 target of reducing CO_2 emissions by 13% and plans to push further with its National Energy Strategy.	**Reducing carbon intensity of the economy**: The growth of Poland's economy has been energy efficient. GDP has increased faster than energy consumption, reducing emissions per GDP in the country.
Key considerations influencing energy transition		

[14] See European Commission - IP/11/372 (28/03/2011).

Germany	*Italy*	*Poland*
Public support for renewables through financial opportunity: Through citizen cooperatives and investments, over 51% of renewable energy capacity is owned by private citizens and only 6.5% by the "Big Four" energy companies. To support public awareness, the German Energy Transition website also communicates *Energiewende* lessons learned to the broader international community. **Public response to disasters (**aversion to nuclear): Chernobyl (1986) and a complex grassroots history against nuclear has created conditions for scepticism of large, centralised generators. In Germany it is politically easier to pass ambitious distributed generation or clean energy legislation.	**Appetite in local government**: With the most signatories of the European Covenant of Mayors initiative, Italian municipalities are successfully implementing sustainable energy policies aimed toward reducing transportation emissions through congestion fees while improving the efficiency of buildings with strategic audits and analyses. **Public response to disasters (**aversion to nuclear): Public consultations following Chernobyl (1986) and Fukushima (2010) in Italy definitively ruled out the role of nuclear as a generation fuel domestically and the Italian economy has oriented around natural gas. **Geographic positioning is advantageous for supply:** Its geographical position at the centre of the Mediterranean basin allows it to intercept the main North-South and East-West energy flows across Europe and to North Africa. Italy is geographically a part of five energy (gas and electricity) corridors whose development is being supported by the European Union's infrastructure outlay via Projects of Common Interest (PCI).	**Energy security fears drive resistance to fuel switching**: Polish society is hesitant to shift from coal to gas in heating homes when the country already imports 80% of its gas from Russia. Furthermore, some Poles worry that EU fracking regulations prevent the MS from achieving its energy independence. Thus geopolitics (and historical political relationships) strongly influence public opinion on energy. **Energy poverty and information.** Energy costs cause resistance to policy on renewable. As a fraction of median income, energy costs are higher in Poland than most of the EU. Residents fear that switching to renewables will only increase these costs. **Cost of energy strongly linked to availability of jobs:** The public ties energy security and energy cost to the success of the economy (in industry) and therefore to the availability of jobs. Historical economic conditions may lead Polish citizens to value economic growth and prosperity more than other western MS so any affront to that may build doubt in citizens. **Market fluctuations build uncertainty:** Quota systems and tradable certificates (property rights) created good conditions for renewable energy

Germany	Italy	Poland
		development in Poland but the prices of green certificates have fallen quite dramatically in secondary market transactions. This led, on the one hand, to 'the purification' of the market from excess certificates' speculations but on the other hand resulted in quite a large number of bankruptcies and mergers, particularly small producers, and suppliers of biomass.

b. Challenges for the transition process

As mentioned previously, a secure and low-carbon society would be significantly different from the one today as drastic changes in areas such as the primary energy mix, consumer behaviour and technologies used would be required. Furthermore, intermediate goals need to be set. For example, in order to reach the target of decreased emissions of 80 percent by 2050, the European Commission has targeted emission cuts of 25 percent by 2020, 40 percent by 2030 and 60 percent by 2040 (compared to the 1990 levels).

The transition will be lengthy and there are many uncertainties as to its evolution. What follows is a non-exhaustive list of challenges:

- **Lack of combating climate change through international coordination.** Until today, there has not been an international treaty or agreement on emissions reductions that covers all countries. Therefore, international and regional strategies and goals have yet to be defined, and even when they are, they will be subject to constant change for reasons that will be political, technical, economic etc. Thus, any decarbonisation strategies and plans must be flexible enough to cope with constant changes without threatening the overall long-term strategies. In other words, fluctuations in short and medium-term goals should not disrupt long-term planning (for example, upgrades to infrastructure should not be subject to myopic political changes).
- **Significant infrastructure investments are needed.** On the issue of infrastructure, the IPCC has reported additional investments required in the energy supply sector by 2050 to be around $190 billion to $900 billion per

year to limit the global average temperature increase to below two degrees Celsius (2°C).[15]

Regarding Europe, to achieve the desired low-carbon energy system transition, investments in the region would need to increase by an additional €270 billion or 1.5 percent of EU's GDP annually, on average, over the next four decades.[16] The extra investments would bring Europe to the investment levels seen before the current economic crisis and would spur growth within a wide range of manufacturing sectors and environmental services.

However, in many cases, market-clearing prices for electric energy are too low to recover the total costs of power production, e.g. in some places in Germany and in the USA. This phenomenon, coupled with uncertainties regarding future (e.g. climate) policies and technological developments, may result in under-investments in all aspects of the energy sector (construction of new power plants, transmission grids, storage facilities etc.). In particular, the European Commission estimates that the market can currently deliver only half of the necessary investments (COM(2014) 330 final). Thus policies promoting investments in infrastructure are necessary.

- **Different starting points for Member States.** In respect to infrastructure, the transition to the desired energy system will differ between EU Member States as energy supply characteristics, energy efficiency of the economy, environmental sustainability etc. are currently quite different across Member States and in some cases, significantly different across internal regions. That is, the current economic and technical differences create different paths to the desired energy system. For example, some Member States have made improvements along the lines of energy efficiency but still have high levels of energy consumption per capita (i.e., Germany and Belgium). On the other hand, northern and western European countries (Denmark, Sweden and the UK) have significant energy resources and relatively low levels of greenhouse gas emissions per unit of GDP due to less dependency on imported fossil fuels. Eastern and southern Member States need to focus on decreasing their energy security exposure while Poland has a relatively secure energy supply but a significant ecological footprint due to coal use.

  Therefore, the unbalanced energy sectors and the high and geographically uneven energy dependencies, coupled with the unbalanced geography of suppliers across Member States create different transition paths towards the (common) goals. These transitions must be coordinated and harmonized as they have strong interdependencies.

- **Emissions in the inflexible transportation sector.** In recent years, many EU states (PL, DE, etc) have increased emissions in the transportation sector. Decarbonising and reducing energy use in the transportation sector is key to transformation. Thus, transport infrastructure, promoting a modal shift,

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[15] Source: http://www.rtcc.org/2014/04/14/ipcc-report-bet-your-house-on-low-carbon-energy-growth/#sthash.wXkG5J5a.dpuf

[16] Source: http://ec.europa.eu/clima/policies/roadmap/

alternative mobility and electro-mobility programmes, tax incentive restructurings and increased funding for mass transit would be mutually shared goals for all Member States.

- **The energy system transformation as a societal process.** At times, researchers and policy makers tend to forget that an energy system transformation is also a "societal process" which is the product of the interaction of multiple actors and intended and unintended elements. The World Health Organization has eloquently captured the importance and characteristics of the societal process of an energy system transformation*: "People are at the centre of successful transition to a world of far-reaching and balanced global reduction of emission and enhanced resilience. The goals of this transition must include fulfilment of basic needs, enjoyment of human rights, health, equity, social perception, decent work, equal participation and good governance" (WHO, 2011).*

Initiatives that would lead to a low-carbon society tend to be generally accepted, and even encouraged, by the general public. However, local stakeholders focus on their local and specific problems which sometimes bring about social resistance for key energy investments (e.g. construction of new wind turbines, transmission lines). Thus, there are often gaps between the general support of energy policies and their local, specific implementation. An analytical discussion on this issue is presented in MILESECURE-2050 (D.1.1, as well as in a more peripheral manner in D.2.1 and D.2.2).

It is also important to recognise that the priorities of societies and subsequently their cultural attentiveness for various initiatives differ within the EU. This could be considered as another practical example of the EU's official motto *"United in diversity."*[17] According to the European Commission's website, the motto signifies how Europeans have come together in the form of the EU to work for peace and prosperity, while at the same time being enriched by the continent's many different cultures, traditions and languages. Therefore, it is important to acknowledge these differences as an opportunity to learn and collaborate in a productive manner.

In other words, there is a need to consider the techno-economic and socio-cultural requirements in order to develop a secure energy system and this is one of the main goals of the MILESECURE-2050 project. In the following chapters of this report, the barriers and drivers of societal processes of energy transitions are thoroughly analysed.

c. Opportunities in the transition process

The previous sub-section referenced some of the challenges for the transition process towards a secure, low-carbon and inclusive society. However, as already mentioned throughout this chapter, there are also many opportunities, some of which are in brief listed below:

[17] Source: http://europa.eu/about-eu/basic-information/symbols/motto/index_en.htm

- **Societies coming together.** As mentioned at the end of the previous sub-section, there are many differences between EU Member States such as techno-economic, cultural, regulatory and priorities.[18] These differences produce challenges but, in true EU spirit, also opportunities for closer collaboration and harmonization of policies and energy systems as well as externalities for further collaborations in other sectors. These benefits extend on an international scale as this transition must be achieved through an unprecedented level of international collaboration.[19]
- **Build off renewable energy and efficiency progress**. Previous research in the MILESECURE-2050 project has shown that EU Member States in Central, Eastern and Southern Europe all have made significant strides toward 2020 targets in renewable energy and energy efficiency, building off of governmental plans like the “Energy Concept” (DE), “National Energy Strategy” (IT) and “National Action Plan for RES” (PL) (D.1.3). For example, countries like Germany and Italy are driving down the EU average energy intensity per unit GDP while Poland is quickly improving its position on this metric.
- **Increased intra-EU trade.** One of the European Commissions’ key strategies for increasing the EU's security of energy supply is the creation of an internal energy market, especially through building interconnections between energy regions (COM(2014) 15 final). This will create opportunities for job creation and cost efficiencies through competition as well as diverse sources of energy supply. Other opportunities for job creation will arise from other necessary infrastructure projects, increasing the energy efficiency of buildings, research and development activities, etc.
- **Increased health**. A gradual reduction of fossil fuel dependence will increase quality of life, e.g. through decreased air and noise pollution. For example, Machol and Rizk (2013) estimate that the economic value of health impacts from fossil fuel electricity in the United States is between 2.5 percent and 6.0 percent of the national GDP.

  Over the years, the integration of low-carbon or zero carbon alternative energy technologies (such as renewables, hydropower, nuclear, etc) have likely already saved millions of lives through avoided airborne soot, particulate and other emissions (Pushker and Hansen 2013).
- **Research and development.** Significant funding will be provided for research and development for activities related to the transformation process. For example, the EU is allocating over 10 billion Euros to energy related

[18] For example, while current energy strategies in Belgium, Germany and Switzerland include phasing-out nuclear power for energy production, Sweden and the UK are investing in new nuclear power plants.
[19] We are reminded that the EU evolved from the European Coal and Steel Community which was established to promote coorporation and to "make war not merely unthinkable, but materially impossible" ("The Schuman Declaration", 9 May 1950).

research, mostly linked to energy efficiency and low-carbon solutions.[20] Research and development activities are known to provide positive externalities as they stimulate economic growth, produce knowledge (which contributes to other discoveries) and so on (Bilbao-Osorio and Rodríguez-Pose, 2004).

Box 2-1 An opportunity of the transition process: Natural gas as a transition fuel?

An example of the complexities regarding Europe's energy transition concerns the potential increased usage of natural gas (e.g. exploration of shale gas in Europe, increased imports). In particular, while presenting the summary for policy makers of the IPCC's Fifth Assessment Report (AR5) in April 2014, Professor Ottmar Edenhofer, co-chairman of the IPCC authors, stated to reporters that *"The shale gas revolution can be very consistent with low-carbon development - that is quite clear. It can be very helpful as a bridge technology".*[21]

The potential for increased exploration of natural gas in Europe and allowing it to have a prominent role in the energy mix is one of the counter-intuitive proposals for the transition process towards a low-carbon society, given that natural gas is a fossil fuel. Natural gas is sometimes discussed as a "bridging" fossil fuel since the average air emissions could be theoretically less than half for a coal-fired generator.[22] Furthermore, burning natural gas does not generate substantial amounts of solid waste.

However, some environmentalist critics oppose policies that support natural gas extraction or consumption from the perspective that it reinforces a fossil fuel consumption lifestyle – one that may need to change in accordance with deep decarbonisation. There are additional environmental concerns such as the required water for cooling natural gas-fired boilers and combined cycle systems and the environmental impact from the extraction, operational lifecycle and consumption of natural gas.[23]

One projection for European electricity production can be found within the MILESECURE-2050 project (D.1.4, ch. 4). The results of a low-carbon scenario show that natural gas, mostly unconventional (shale), is the only remaining fossil fuel for electricity production in the 2050 energy mix. Furthermore, it is the most dominant fuel with a share of 27 percent of the EU energy mix, just above nuclear power (25 percent). For comparison, the gross inland consumption in the EU in 2012 was 33.8 percent from petroleum and products, 23.3 percent from gases, 17.5 percent from solid fuels (e.g. coal), 13.5 from nuclear and 11 percent from renewables (Eurostat, 2014).

[20] Within "HORIZON 2020 The EU Framework Programme for Research & Innovation" (2014-2020), €5.931 billion has been allocated for sustainable (non-nuclear) energy research, €6.339 billion for green, integrated mobility, €3.081 billion fir climate action, environment, resource efficiency and raw materials and €1.603 billion for nuclear research (COM/2011/0808 final).

[21] Source: "Shale gas can help to prevent global warming – IPCC", The Times, April 13 2014.

[22] The degree to which methane leakage at hydraulic fracturing wells contributes to accelerating warming is debated and variable. It is possible that per unit electricity, natural gas withdrawn from "fracked" wells emits more GHG per unit energy than coal. For more perspectives on the debate please see, Howarth (2014) (http://onlinelibrary.wiley.com/doi/10.1002/ese3.35/full), Davis and Socolow (2014), and Heath et al (2014) (http://www.pnas.org/content/early/2014/07/16/1309334111/suppl/DCSupplemental).

[23] Source: US Environmental Protection Agency website http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html

Although this is just one of many scenarios, it is indicative of how natural gas could replace other (fossil) fuels. However, it should be noted that this techno-economic scenario and analysis does not take into account the inclusivity (or not) of the computed new energy system, nor the geopolitics and energy trade patterns of today. Insights based on a quantitative modelling architecture (IMACLIM) to assess the multi-dimensionality of energy security and interactions with other policies areas will be presented in later stages of the MILESUCRE-2050 project.

This example shows that the transition process will not be instantaneous but rather step-wise. In other words, during the long transition to the desired energy system, societies will have to adapt and re-adapt multiple times (eg. use of "bridge fuels"). These multiple transformations create additional challenges for transition management and call for a more active focus of public policy on societal aspects of transition (see for example Kemp *et al.,* 2001).

2.5 Summary

For many years, the EU has aimed at transforming Europe's energy system through legislation, subsidies, investment strategies and other policies. In particular, this on-going transformation addresses a multitude of issues from combating climate change to the expected depletion of fossil fuels and from issues of energy poverty to security of energy supply. Given the Europe 2020, 2030 and 2050 goals, the pace of this transformation is expected to be drastically intensified over the next years as the overall target is to drastically overhaul Europe's energy system over the next few decades.

In particular, the EU desires an energy system that is secure, low-carbon and inclusive. Such a system would have to be adequate, stable, resilient and robust in order to tolerate threats, whether they be internal or external, short or long lived etc. Furthermore, the goal of a low-carbon energy system would entail meeting the ambitious target of reducing EU greenhouse gas emissions by 80 percent by 2050 (compared with 1990 levels). Finally, a culturally inclusive system is one that would satisfy its users' energy needs with acceptable changes in their amount and prices as well as while enhancing their lives (e.g. quality of services, low environmental impacts, sustainable growth and job creation).

The transition to the desired energy system is a very challenging task. For example, any relevant policies must simultaneously take into consideration the three individual components due to their interdependencies and externalities, both positive and negative. Furthermore, there is a lack of harmonization for the national energy policies of the EU Member States. For example, some Member States have made improvements along the lines of energy efficiency but still have high levels of energy consumption (per capita). This lack of harmonization is not limited to current policies but is also expressed in the different priorities of societies and subsequently, differences regarding their cultural attentiveness for various initiatives. These cultural differences create conflicts even for issues regarding which technologies should be promoted as intermediate replacements for petroleum imports (biofuels, nuclear, shale gas etc).

Other barriers are the significant investments needed in the energy sector, especially for large-scale infrastructure, as well as the current lack of international coordination for mitigating climate change.

The transition process also offers many opportunities. In particular, collaboration and harmonization of policies and addressing externalities provide opportunities for European societies to come closer. Furthermore, strengthening the EU's security of energy supply entails the creation of a true internal energy market, providing opportunities for intra-EU trade and incentives for promoting efficiencies. Finally, a gradual reduction of fossil fuel dependence will increase quality of life, e.g. through decreased air and noise pollution as well as provide many job opportunities.

This chapter presented a brief overview of the key components of a secure, low-carbon and culturally attentive energy system as viewed by the EU. Furthermore, some challenges regarding setting particular goals as well as the transformation process to the desired energy system were briefly discussed. In the next chapter, the societal barriers and drivers are explored in-depth.

3. Methodology: an iterative process

The goal of the following analysis was to synthesise key drivers and barriers in energy transition. The experimental research process applied here may be described as “post-normal science”. The complex, interlinked nature of related topics in energy transition involves deep uncertainties and a variety of different, value-loaded perspectives. The process described below was not seeking one or several fundamental underlying truths but instead to draw more general conclusions based on an inherently imperfect and incompletely representative round of framing key factors in energy transition.

The research exploring key drivers and barriers in energy transition was an iterative process. Beginning with a literature review, the authors developed a hypothesis framework that would encapsulate the most relevant factors in energy transition processes (each of these “Factors” was defined in such a way that each Factor could be either a driver or barrier, depending on context)[24]. The research team agreed from an early stage that the framework should cover the complexity of the transition process while at the same time being manageable for policy makers. Fifteen Factors across 3 “Domains” ended up as a resulting Preliminary Framework of the investigative process (see section 3.1).

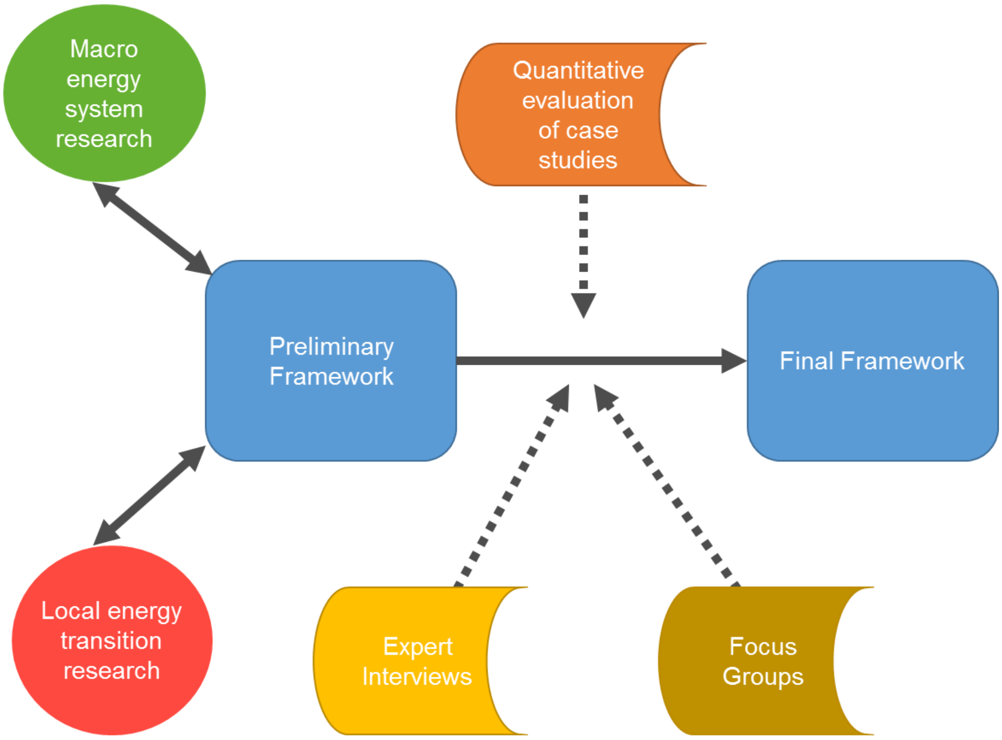
A quantitative evaluation of the Factors in the Preliminary Framework, based on real local energy transition case studies (known as “Anticipatory Experiences” (Caiati et al. 2013)), was carried out which formed the basis of an explorative statistical analysis to examine the interrelatedness of the Factors. The “Preliminary Framework” was also discussed and tested with experts and stakeholders in the form of interviews and focus groups to receive input on:

a) the significance of individual Factors within the framework;
b) how Factors may have a sequential role in transition processes; and
c) what relevant aspects of energy transition were lacking in the Preliminary Framework.

Following this analysis, the researchers developed a series of conclusions and a final framework that is presented in Chapter 6.

[24] In this report, the term “Factor” will be used to represent what could be a driver or barrier, depending on context. A driver of transition is certainly a “Factor” of transition, as is a barrier. But a “Factor” does not specify – it merely highlights that an aspect is significant.

Figure 3-1. Visual representation of the iterative research process deployed to identify key factors (drivers and barriers) in energy transition.



3.1 The Prelimary Framework

a. Integrating macro energy system and local energy transition research

As an abstract and boundary-less suite of related topics, it is useful to initially consider how to frame and present the different aspects of transition to a post-carbon energy system in the form of a framework. Another important step in understanding the topics is to draw on existing research on the issue. Thus, background knowledge would fill in the content components of such a preliminary framework.

Considering the key insights, vocabulary and framing from previous work in the MILESECURE-2050 project (see Chapter 2, Caiati et al. 2013 and Caiati et al. 2014) as well as external research and related research projects, a total of 15 key drivers and barriers ("Factors") of transition to a post-carbon energy system were identified, developed and detailed according to the domains and structure laid out above. The authors, therefore, **hypothesised that this grouping of 15 Factors would comprehensively cover and capture the most relevant drivers and barriers**.

The first step of the process was generative during which the authors collected as many common aspects in energy transitions as possible from previous research, specifically PACT (Caiati et al. 2010), "Report on Integrated analysis of Local anticipatory Experiences" (Caiati et al. 2013) and "Report On Comparative analysis" (Caiati et al. 2014). The authors then began structuring the framework. The second step was to consider whether the identified Factors were applicable at the EU-level and not just the local-level. The third step was to determine which aspects of energy transition were missing from the evolving framework based on qualitative energy transition research and input from the MILESECURE-2050 consortium. Next, the authors identified factors that may have been redundant within the draft framework.

Finally, descriptions and sub-indicators were developed to further describe the 15 factors.

This five-step process, as further outlined below:

A. **Generating**: locating factors from existing research
B. **Narrowing**: imposing an international and supranational constraint on factors
C. **Generating**: adding input from expert sources
D. **Narrowing**: considering redundancies among factors
E. **Elaborating**: introducing sub-indicators that illustrate how the factors perform

b. Preliminary draft of framework

It is worth discussing the division of the Factors across regimes. Inspired by the theoretical framing of different types of *“Human energies”,* or “social systems in transition” in the “Report on Integrated analysis of Local anticipatory Experiences” (Caiati et al. 2013)[25], the authors built off this framing and introduced new “Domains” (or regimes, categories) below to which the Factors belong. Each Domain in the Preliminary Framework contains five of the 15 Factors.

Table 3-1. The three Domains of the Preliminary Framework of “Key Factors in Energy Transition”

E	S	P
Market, External, and Governance Factors	*Social, Political Movement, and Grassroots Factors*	*Personal, Cultural, and Site-specific Factors*

The concept behind the **E Domain** is to group the related **Market, External and Governance Factors**. These Factors are largely beyond the scope of what an individual might be able to influence in his or her day-to-day life (i.e., market economic forces, energy security as a planning consideration, technology trends or support schemes etc.). Inevitably certain elements of energy transition come from and are influenced by external factors.

Similarly the **Social, Political Movement and Grassroots Factors** are represented in the **S Domain**. The S regime groups all related local, community and participatory forces of an energy transition process. This covers a wide range of influence, including for example, cultural values, priorities and the political system (representative democracy vs. other).

Third, the **P Domain** covers the **Personal, Cultural and Site-specific Factors**. The P Domain is all about the individual’s interaction with the change in reality – whether the transition was a new service or new energy generation technology. Hence the P

[25] Human energy is defined by Caiati et al. as a three dimensional phenomenon where:
a) social energy includes different forms of social activism that brings together, coordinates and orients toward social actors’ energy transition goal;
b) endosomatic (or personal) energy originates directly from the body and can be assimilated to the capacity of effecting profound changes at the personal level in one’s daily actions and convictions in view of a more sustainable lifestyle;
c) extrasomatic energy is characterized by the use of natural resources through the adoption of all kinds of equipment, technology or machinery (using all energy sources, whether carbon or low carbon).

Domain has aspects related to: a) local embrace or reaction to low-carbon initiatives, b) whether the transition changed quality of life and c) how the people on the ground are included in the initiative.

After the series of divergence and convergence (described as "generating," "narrowing" and "elaborating" in 3.1b above) steps, the authors developed the Framework below (Table 3-2), including Factor names, Factor descriptions and representations of the Factors ("sub-indicators" as guidance for the assessment).

Table 3-2. Preliminary Framework: "Key Factors In Energy Transition" (starting point for experimental research)

Factor	Factor Description	Important representations of the factor
FACTOR **E1**: Competency and training of technical professionals	Varying staff responsible for the maintenance and implementation of the new energy technologies may bring different attitudes and received variable training.	1. (positive) Outlook (interest and confidence, or resistance and scepticism) of eco-project actors and technicians toward the introduction of new technologies. 2. Quality of communication between actors involved in implementing eco-sustainable projects. 3. The availability and competency of professionals linked to the new technologies introduced. 4. Presence of local trainings for relevant technical professionals.
FACTOR **E2**: Learning and dissemination beyond the region	To what extent project developers and government disseminate successes and exchange with other relevant professionals.	1. Accumulation and share of knowledge from eco-sustainable initiatives at local level. 2. Transfer of knowledge and technologies of eco-sustainable initiatives in the national context (copycat initiatives in other cities, prominence of AE at national level, etc). 3. Disseminating success stories through the Internet and other global platforms. 4. Establishing new operational procedures or standards based on implementation or innovative experiences.
FACTOR **E3**: Legal and incentives framework for project implementation	How structures in place between government and economic interests facilitate project development.	1. Similar tax rates of post-carbon and traditional technologies (or advantageous rates for eco-technology). 2. Public service provider investments (based on their mission) aligned with (or opposed to) eco- sustainable technologies. 3. Low consumer costs of eco-technology (or lack of market price fluctuation). 4. Support addressing upfront and maintenance costs of eco-sustainable technology plants and production. 5. Predictable (and/or decreasing) costs to sustain energy efficiency or other eco-initiatives over time.
FACTOR **E4**: Market and technological trends	Cost trends and macroeconomic factors influence governance and project development structures.	1. Gross National Product trends at the national level create supportive environment for investment. 2. Geopolitical relationships (trade, tariffs, etc) make technology accessible/affordable, if importing is necessary. 3. Industry of eco-technology is supported at federal/national level (research funding, political priority, etc). 4. Long-term certainty in national or private support of eco-sustainable technology.
FACTOR **E5**: New independences caused by new technology, effects on security of supply	Legal, trade or technological characteristics of the low-carbon project creates local independence from or dependence on external processes.	1. Eliminating fuel, technological or other consumption dependence from abroad. 2. Guarantees and assurance offered locally in the adoption of eco-initiatives. 3. Quality and availability of local supplies for eco-initiative. 4. Long-term financial or contractual self-sustaining path for eco-initiative operations. 5. Appropriate local services in place for facilitating the maintenance or consumption of new eco-technology/service.

Factor	Factor Description	Important representations of the factor
FACTOR **S1**: Funding and Ownership	How diverse funding sources and fundraising methods, including local ownership models, are.	1. Certainty, reliability and consistency in access to relevant funds. 2. Adopting a mix of funding sources (local, regional, corporate, European, consumer stakeholders, etc) 3. Aiming technology subsidies or credits, when present, to consumers with the greatest need. 4. Diversifying funding outlay locally to include innovation or other research opportunities in addition to capital costs. 5. Leveraging new opportunities in deregulated energy or other markets.
FACTOR **S2**: Citizens' engagement in the energy transition	Active civilian campaigns and organising can catalyse political processes, contribute to economic conditions and even affect maintenance / management processes of low-carbon technology. Bottom-up characteristics.	1. Citizens' active participation in decision-making and planning of eco-initiative. 2. Private sector and/or key civil groups actively championing and supporting the initiative. 3. Financial commitment by civilians toward project, which may include co-financing, volunteering, fundraising, etc. 4. Connecting multiple stakeholders to support project (ie, inviting schools and hospitals for pilot project site, inviting the public to training sessions, using the media to further the project, etc).
FACTOR **S3**: Orientation to change	Environmentally-minded worldview, value system and community identity of human capital at the local level.	1. Established environmental (or related) orientation of the political forces of local administration. 2. Citizens attentive to the economic and other advantages of post-carbon societies. 3. High sense of ownership by, and motivation of, citizens and firms of initiatives aimed at the post-carbon society. 4. Creating a common vision for the various local actors involved in the energy transition. 5. Strong, historic grassroots and bottom-up activity in political processes.
FACTOR **S4**: Political programming, leadership, and regulation	To what extent the local political structure explores transparent, new funding / regulation options and a proactive approach to facilitating low-carbon technology. Top-down characteristics.	1. High technical competence, awareness (research) of environmental topics and positive outlook of political leaders. 2. Reforming administrative processes related to, or creating specific institutions supporting eco-sustainable projects. 3. Adopting a progressive taxation, quota or other system for encouraging uptake of eco-initiative. 4. Ideological stability or predictability (to an extent) of political parties in power. 5. Politicians' openness to participatory approaches from civil society.
FACTOR **S5**: Local informational and educational outreach	Presence and effectiveness of campaign efforts to inform community of technical and other aspects of low-carbon technology.	1. Communication activities on eco-projects (norms and standards, technological options, use of technologies). 2. Establishment of new disciplinary specialisation pertaining to eco-sustainable experiences. 3. Use of appropriate language and vocabulary for the affected populations. 4. Promoting general awareness-raising activities for eco-initiatives (expositions on technologies, guided visits). 5. Creation of institutions dealing with public communication.

Factor	Factor Description	Important representations of the factor
FACTOR **P1**: Regional and cultural considerations in design	Technology design in local context can be suitably adapted to sociocultural comfort, considerations or lifestyles.	1. Adopting technologies that can make use of local environmental & cultural factors, built aspects, resources, etc. 2. Holistic and multi-stakeholder project design process attentive to consumer needs, behaviours and preferences. 3. Project design reflects awareness and sensitivity to different lifestyles and social classes. 4. Technology overcomes consumer biases for comfort, automobiles, privacy, high energy consumption and certain lifestyle choices. 5. Minimisation of the "rebound effect" or phenomenon of increased consumption with efficient technology.
FACTOR **P2**: Project management	Operational structures evaluate and respond to technology, system and user performance in different ways.	1. Presence of holistic and statistically-driven monitoring and evaluation systems for eco-sustainable project. 2. Designing, scaling and planning project appropriately (from a technical perspective - ie, energy output). 3. Introducing or utilising (carefully considered) benchmarking systems in measuring performance. 4. Methodical project implementation with flexibility to change technical and maintenance aspects, if necessary.
FACTOR **P3**: Potential social and cultural impact	Low-carbon technology can transform recreational and cultural opportunities, influencing quality of life (aesthetic impacts) and community more broadly.	1. Broadening the social classes benefiting from technology, reduction of fuel poverty. 2. Project impact on the disabled and the elderly. 3. Increased social cohesion. 4. Increased appeal of the neighbourhood as a recreational place for citizens. 5. Improvement in cultural life and quality of life.
FACTOR **P4**: Potential economic impact	Low-carbon technology can create or inhibit new local economic and financial opportunities.	1. Broadening the market in sectors directly or indirectly connected to eco-sustainable technologies. 2. Profits or capital generated by project reinvested into the (local) economy at the benefit of project consumers/users. 3. Active role of private sector investing into project or related services. 4. Job creation.
FACTOR **P5**: Potential environmental impact	Low-carbon technology can have documented, clear and visible immediate result on local water, biodiversity, air quality or other environmental aspect.	1. Measured (or serious expected) reduction in pollution, emissions, toxicity or other key metrics from date of project implementation. 2. Documented (or expected) environmental improvements known among consuming/relevant population that might not be easy to measure.

3.2 Quantitative Evaluation of Anticipatory Experiences

In order to test the accuracy and relevance of the first grouping of Factors, the Preliminary Framework was applied to 23 energy transition case studies, so called Anticipatory Experiences (see "Report on Integrated Analysis of Local Anticipatory Experiences" (Caiati et al. 2013).[26] The researchers carried out quantitative and qualitative assessments of these Anticipatory Experiences. The output, a grid of values based on the rankings, is referred to as the Assessment Matrix.

All of these 23 Anticipatory Experiences at this point were considered "successful." For the purposes of this analysis, the authors did not compare how "successful" the Anticipatory Experiences performed but rather evaluated **how instrumental certain drivers and barriers were in the transition process.** The assessment was therefore measuring the importance of each of the separate 15 Factors in the Preliminary Framework.

Following this first step of ranking Factors in the Anticipatory Experiences in the Assessment Matrix, the research team collaborated on a statistical analysis of the Assessment Matrix.

a. Assessment Matrix

The intention of creating an Assessment Matrix was twofold: 1) to uncover problems or difficulties with using the Preliminary Framework for wider applications and 2) to gain early insights on the importance of certain Factors within the Framework and on the interrelation of Factors.

Each Anticipatory Experience in the Assessment Matrix was scored across the 15-Factor Framework from -3 (major barrier) to 0 (neutral) to 3 (strong driver). Numeric scores provided the opportunity to conduct quantitative analyses at the completion of the Assessment Matrix. The scores were assigned based on guidance questions (see column three, important representations). To ensure consistency in the scoring approach and to elaborate on the justifications of numerical scoring for fuzzy and abstract concepts, a short written explanation (2-4 sentences) accompanied each score of each factor for each Anticipatory Experience. The written sections explain in words why the numerical ranking was appropriate and draws from specific examples, anecdotes and facts from the Anticipatory Experiences.

The assessment work was conducted and shared across the research team. The assessors were given a sample assessment (on the Anticipatory Experience of Vauban, Germany), the Preliminary Framework (along with their descriptions and "sub-indicators") and a more detailed version of the instructions outlined above.

It is understood that the relatively limited number of Anticipatory Experiences included in the Assessment Matrix implies that the findings can only be explorative and serve to direct further research rather than to derive general and final findings.

A simplified version of the Anticipatory Experiences Assessment Matrix (for the sake of brevity, without the qualitative explanations) can be found in Table 7-1 in the Annex.

[26] A total of 23 were chosen since the researchers had previously analysed in-depth 23 of the 90 AEs in MILESECURE D2.2.

b. Statistical Analysis

Fully aware of the fact that the sheer number of 23 Anticipatory Experiences would not suffice to derive robust statistical findings, the emphasis of the statistical analysis was on developing a methodology that would allow the exploration of certain interconnections for further research but also to test the proposed methodology for later application to a larger sample size in follow-up research activities.

A two-part statistical analysis of the scores from the Assessment Matrix was conducted. The first one examined general correlations between the Factors based on the linear regression and a Principal Components Analysis (PCA).

The second part investigated how dependent the scores of certain Factors were on other Factors by translating the Factor scores for each Anticipatory Experience into a simplified binary form to test potential dependences with binary logistic regression for two types of models. The “Key driver” perspective modelled the probability of getting a high score within a given Factor, i.e. a score of 2 or 3. The “Obstacle” perspective modelled the probability of getting a score of 0 and below. The explanatory factors remained within the original range of scores of -3 to +3.

All parts of the analysis relied on univariate models (i.e. used just one explanatory factor at a time) as the small sample size discarded the possibility of a multivariate approach. Furthermore, we retained only the results significant at the level of at least 95%, which was assessed with the standard t-test for the linear regression, and Wald-test and drop-in-deviance test for the logistic regression. For the latter, we also tested the overall fit and stability of received models. A more detailed description of the applied procedure can be found in the Annex. Results from the analysis are available in Chapter 4 and the Annex.

3.3 Focus Groups and Expert Interviews

The next step in the iterative approach was to follow-up on first results and to fill in remaining knowledge gaps by consulting with experts in the form of focus groups and expert interviews. These activities were chosen to facilitate free expression, open-ended responses and collaborative contributions. Participants were chosen to cover the national and regional level as well as a range of stakeholder groups. The final group of 38 external expert participants represented a diverse and interdisciplinary sample group with different perspectives on energy processes – be it from a consumer behavioural or energy security point of view. Moreover, participants were chosen to represent a geographically diverse sample. The participant diversity ensured the research team was not limiting its findings to the consensus from one discipline or geographical origin. Stakeholder groups were defined as follows:

- Policy makers and government, i.e. experts employed by government bodies as well as decision makers from various levels of government;
- Local activists, civil society;
- Utilities, energy companies and for-profit consultancies; and
- Academic and other research.

The following tables describe the participants of the focus groups and expert interviews along stakeholder group and geographic location.

Table 3-3. Breakdown of Focus Groups and Expert Interviews by stakeholder type

Stakeholder	Expert Interviews	Focus Groups	**Total**
Policy makers and government	**7**	**3**	**10**
NGOs and unions	**3**	**3**	**6**
For-profit consultancies, energy companies, utilities	**1**	**1**	**2**
Researchers and academia	**12**	**8**	**20**
Total	**23**	**15**	**38**

Table 3-4. Breakdown of Focus Groups and Expert Interviews by nationality

Country	Expert Interviews	Focus Groups	Total
Albania	**1**	**1**	**2**
Argentina	**0**	**1**	**1**
Croatia	**1**	**0**	**1**
Czech Republic	**1**	**0**	**1**
Denmark	**0**	**1**	**1**
France	**0**	**1**	**1**
Germany	**3**	**4**	**7**
Greece	**1**	**0**	**1**
Ireland	**0**	**1**	**1**
Italy	**6**	**0**	**6**
The Netherlands	**2**	**2**	**4**
Poland	**5**	**0**	**5**
Switzerland	**1**	**0**	**1**
U.K.	**1**	**3**	**4**
Ukraine	**1**	**0**	**1**
U.S.A	**0**	**1**	**1**
Total	**23**	**15**	**38**

In the early stages of the project, before the focus groups and expert interviews were conducted, the target audience for the focus groups was a balance of stakeholders, whereas the expert interviews were to be expert-oriented. This changed to include a greater presence of researchers and local project implementers (often from "Policy makers and government") in the focus groups for several reasons:

The Preliminary Framework was assembled based on more desk research than anticipated. This was before the focus groups, which meant the type of feedback that was sought from the participants was different. The participants were not simply going to help create the Framework; they were going to respond to the first iteration. Hence, since feedback was sought from those who understood energy transition well, researchers and local project implementers were also targeted in the focus groups. This approach was supported by the MILESECURE-2050 consortium.

The general target audience did not change during the expert interviews since the iterative process brought up new questions and offered a great statistical sample size to provide feedback on the Preliminary Framework. Thus the expert interviews filled in the gaps through responses to new questions that emerged in the focus groups (see questions 4 - 9 in the expert interview template, Table 8.2 in the Annex), as well as responded in similar ways to the activities that were conducted in the focus groups.

Both the focus groups and the expert interviews were filmed or recorded to ensure that the results could be reviewed in detail. Summaries with key insights and analysis from each session and interview were developed according to a template.

a. Focus Groups

One online focus group and two in-person focus groups (one in Brussels and one in Berlin) were conducted to gather insights on the "Key Drivers and Barriers in Energy Transition." A total of 15 experts primarily from research and civil society participated in the focus groups with a heavier Western European presence (however, the Eastern perspective was well-represented in the expert interviews). The goal was to confirm preliminary insights and develop new components in the Framework. The focus groups were composed of broader sessions:

1. Brainstorm of drivers and barriers (*What are the relevant drivers and barriers? How can they be ranked in terms of relevance?)*
2. A case study perspective *(How truly strong were certain drivers and barriers in sample/relevant case studies?)*
3. Solutions and lessons *(How might we apply ideas from successful transitions to other locations? What are the take-home messages? How might we scale energy transitions to a larger process?)*

A mixture of group discussions, individual questionnaires, focussed brainstorming and experimental methods were utilized during the focus groups, many of which were selected to take advantage of a group dynamic. An effort was made to provide intuitive graphics and visual presentation to explain the Preliminary Framework in the focus groups as well as the expert interviews[27].

Each focus group session came at a different stage in the iterative research process, making the aims of each varied. At the same time, the content of all three focus groups centred on:

a. How important individual Factors are,
b. To what extent energy transition is a sequential process and
c. Which relevant aspects were left out of the Preliminary Framework.

b. Expert Interviews

Twenty-three semi-structured expert interviews were carried out to provide additional information on drivers and barriers and the developed Framework. While the focus groups aimed at creating a dynamic group process, the focus of the expert interviews was in-depth one-on-one interaction. Detailed instructions were provided to all the interviewers to ensure consistency in approach.

The purpose of these was to test the initial hypotheses and gather a larger sample of input on the 15-factor framework developed across the three regimes, including themes such as

- The most important factors,
- The interconnectedness of the factors and the degree to which factors influence other factors (or if the factors follow a "sequence"),
- Whether the factors are relevant and applicable at all political hierarchies of the energy transition (local, national, international) and

[27] For example, Table 3-2 was presented to participants in several ways – broken down into separate colorful figures by Domain (E, S, P) and as Table 3-2.

- The crucial (most important) regimes or Domains of influence *("Market, External and Governance Factors" "Social, Political Movement and Grassroots Factors" and "Personal, Cultural and Site-specific Factors").*

For every numerical judgment, ranking or scoring, experts were asked to provide a qualitative basis or anecdotal response as to why a ranking or score was given the value that it was given (also see Table 8.2 in the annex). These results were then cross-checked for consistency by the research team. Scores and rankings were not normalised in the data analysis – some participants, for example, gave more than five scores of 10 and zero scores less than 5. Some participants had no scores of 10, on the other hand.

The expert interviews also gave participants a chance to provide direct feedback on the strengths and weaknesses of the Preliminary Framework. Participants were encouraged to provide suggestions on influential aspects not contained within the framework. Free-flowing conversation also encouraged the discussion of anecdotal and other recent research evidence on the topics.

4. Results

Box 4-1 Everything is an engineering problem.

"If you have the will to change, everything is an engineering problem" – Anonymous expert, September 16, 2014, Berlin

The goal of the present analysis is to synthesise key drivers and barriers in energy transition. This section depicts the results of the iterative evaluation and examination of the preliminary framework introduced in section 3.1. Based on these results, a final framework will be developed in section 6.

The following insights have been shaped based on interactions with experts and additional analysis conducted by the research team, as explained in section 3. Methods included literature review, a mixture of a qualitative and quantitative assessment of 23 energy transition case studies (Anticipatory Experiences), a statistical appraisal of the assessment and furthermore, focus groups and expert interviews.

4.1 While the initial Assessment Matrix was valuable for testing the deriving quantified drivers and barriers based on the Preliminary that this Assessment Matrix was populated by the researchers severe risk of bias with it. Therefore, the Assessment Matrix results the annex (Strengths of Drivers and Barriers in Anticipatory Experiences – Assessment Matrix

Table 8-3), but are not essential findings of the research.

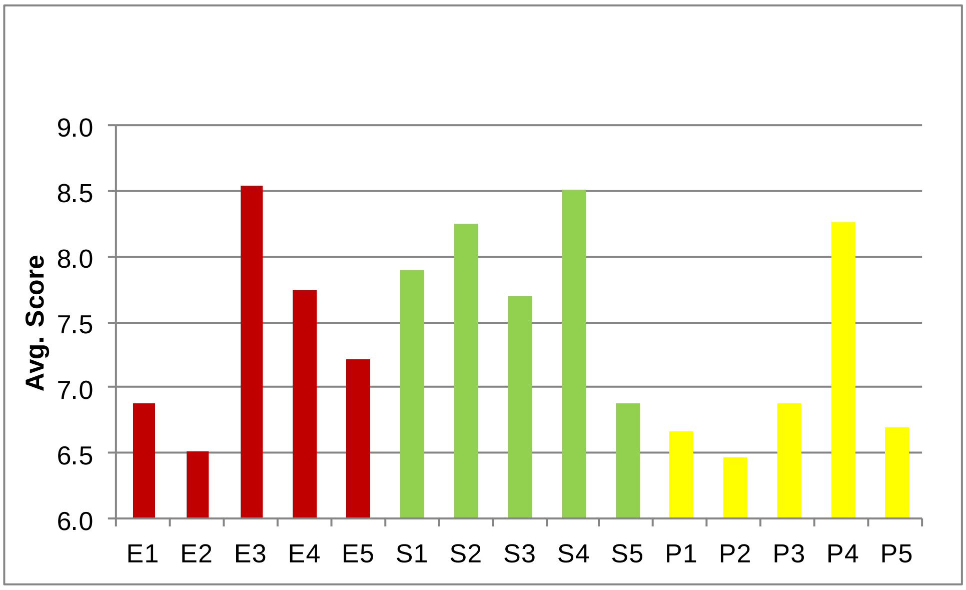
The results of the research give evidence on the likely significance of specific Factors of the Preliminary Framework, the possible interconnectedness of the Factors and a possible sequence of Factors within energy transitions and point to further research needs. Moreover, the results of the exercise help refine the applied methodologies for future use to investigate further drivers and barriers in the energy transition.

4.2 Significance of specific Factors

During the focus groups and expert interviews, experts were asked to assign each of the 15 Factors from the preliminary matrix a value according to their relevance in an energy transition process on a scale from 0 to 10. A key outcome of this assessment was that no Factor scored less than 6.5 on average, while seven Factors scored higher than 7.5 on average (based on 27 expert assessments, see Figure 4-1 below[28]). This suggests that all experts agreed that each of the 15 Factors plays an important part in energy transition processes. Highest scores were given to the Factors 'Legal and incentives framework for project implementation' (E3), 'Citizens' engagement in the energy transition' (S2), 'Political programming, leadership and regulation' (S4) and 'Potential economic impact' (P4). Even though there are differences in scores assigned, the differences seem rather small. The average score was 7.4.

[28] N=27 instead of n=38, since several participants did not respond completely to the scoring exercise, and since two of the focus groups did not incorporate the scoring activity.

Figure 4-1. Importance of factors in energy transition (scores 1-10, n=27)



Going further in the analysis, assessments for the different factors show differences in terms of standard deviation and range.

Table 4-1 Factors with very low standard deviations.

Factor	standard deviation	range	average
E3: Legal and incentives framework for project implementation	1.248	(6;10)	8.5
S1: Funding and Ownership	1.507	(5;10)	7.9
P4: Potential economic impact	1.663	(5;10)	8.3

It can be derived that the expert opinion regarding the relevance of the Factors presented in Table 4-1 was relatively homogeneous. Therefore, the relevance of these factors seems less shaky. Taken together, one could argue that 'Funding and Ownership' (S1) is to be considered as very relevant. Factors S2: *'Citizens' engagement in the energy transition'* and S4: '*Political programming, leadership, and regulation'*, although among the highest average scores, exhibit slightly higher standard deviations and ranges than S1.

Highest standard deviations and ranges were observed for the Factors P1: *'Regional and cultural considerations in design'*, P3: *'Potential social and cultural impact'* and E2: *'Learning and dissemination beyond the region'* (see Table 4-2).

Table 4-2 Factors with high standard deviations.

Factor	standard deviation	range	average
P1: Regional and cultural considerations in design	2.481	(1;10)	6.7
P3: Potential social and cultural impact	2.286	(2;10)	6.9
E2: Learning and dissemination beyond the region	2.225	(2;10)	6.5

For sake of completeness, we can also compare the standard deviations and ranges for the entire sample as well as for the three domains E, S and P, as displayed in Table 4-3.

Table 4-3 Standard deviations in the sample and by domain.

Item	standard deviation	range	average
Entire sample	2.068	(1;10)	7.4
E: Market, External, and Governance Factors	2.027	(2;10)	7.4
S: Social, Political Movement, and Grassroots Factors	1.840	(2;10)	7.9
P: Personal, Cultural, and Site-specific Factors	2.245	(1;10)	7.0

A number of conclusions can be derived from this data:

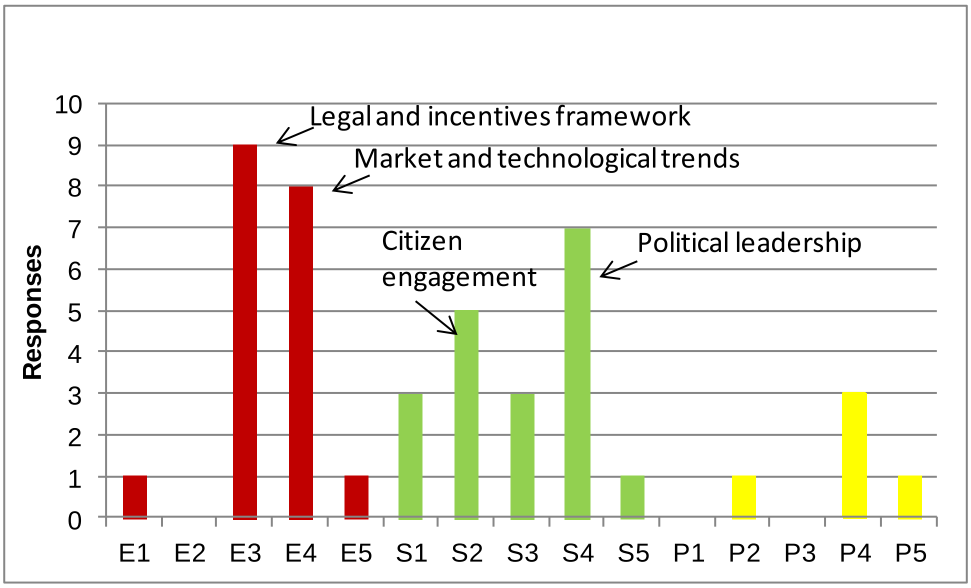
- Expert opinion was most in agreement regarding **S:** *Social, Political Movement and Grassroots* Factors (also with highest average score)
- Expert opinion was least in agreement regarding **P:** *Personal, Cultural and Site-specific* Factors (with lowest average score)
- Ranges were very high for all three domains and for all factors (the lowest range was for Factor E3: 'Legal and incentives framework for project implementation')

It can be concluded that expert opinion was far from unanimous and that the sample size and sample composition therefore has a significant impact on the ranking of the Factors. The breadth in scores for the different Factors can also be the result of different interpretations of the Factor descriptions.

These findings instruct us to restrict all conclusions from our analysis to anecdotal evidence and discussion of the methodology. An increase of sample size could very well improve the quality of the data. A larger sample size would also enable a sound normalisation of sample scores by criteria such as stakeholder type and thereby yield more robust findings.

Apart from the scoring, further information was derived from the focus groups and expert interviews. When the experts were asked to name the two Factors that were, according to their assessment, the most important of the 15 Factors in an energy transition process, results differed somewhat from the previous (n is below 27*2 as some experts did not answer or only named one most important Factor). As **Errore. L'origine riferimento non è stata trovata.** shows, Factors **E3**: 'Legal and incentives framework for project implementation,' **E4**: 'Market and technological trends,' **S4**: 'Political programming, leadership and regulation' and **S2**: 'Citizens' engagement in the energy transition' have the highest number of responses.

Figure 4-2. Most relevant Factors (2 allowed answers, n=24 respondents)



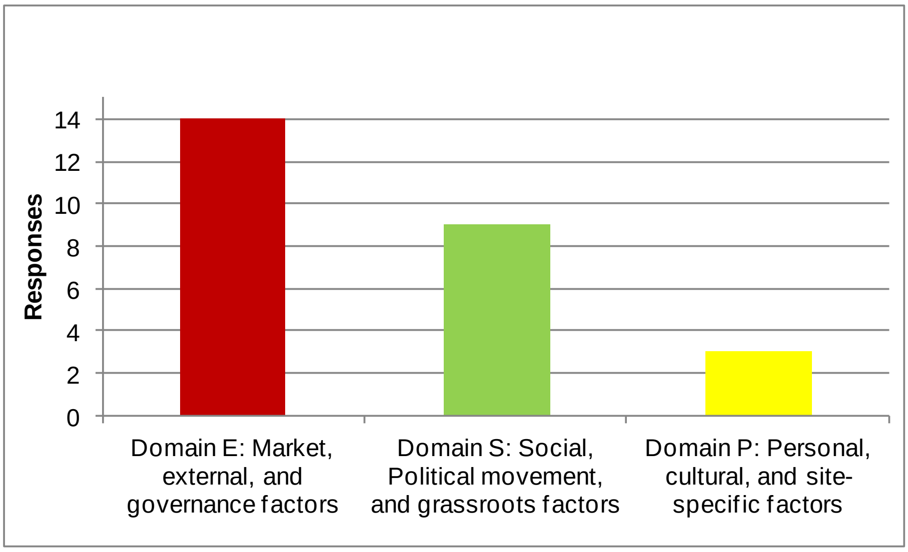
Again, given the lessons learned in the scoring exercise, caution needs to be applied to the interpretation of the results.

Even though the opinion was considerably more pronounced, the highest scoring Factor (**E3**: 'Legal and incentives framework for project implementation') scored only 9 out of 24 possible points, i.e. an average of 0.375. The responses are still fairly heterogeneous and show mostly which factors should not to be considered as the most relevant two factors. The aggregation of "most relevant factor" scores per domain yields the following results:

- E-Domain *Market, External and Governance* Factors – *19*
- S-Domain *Social, Political Movement and Grassroots* Factors – *19*
- P-Domain *Personal, Cultural and Site-specific* Factors – *5*

When asked to rank the Factor Domains according to their importance, most experts named the E-Domain as the most important in an energy transition process; second was the S-Domain and third the P-Domain (see **Errore. L'origine riferimento non è stata trovata.**).

Figure 4-3. Respondents ranking the domains as most important (n=26)

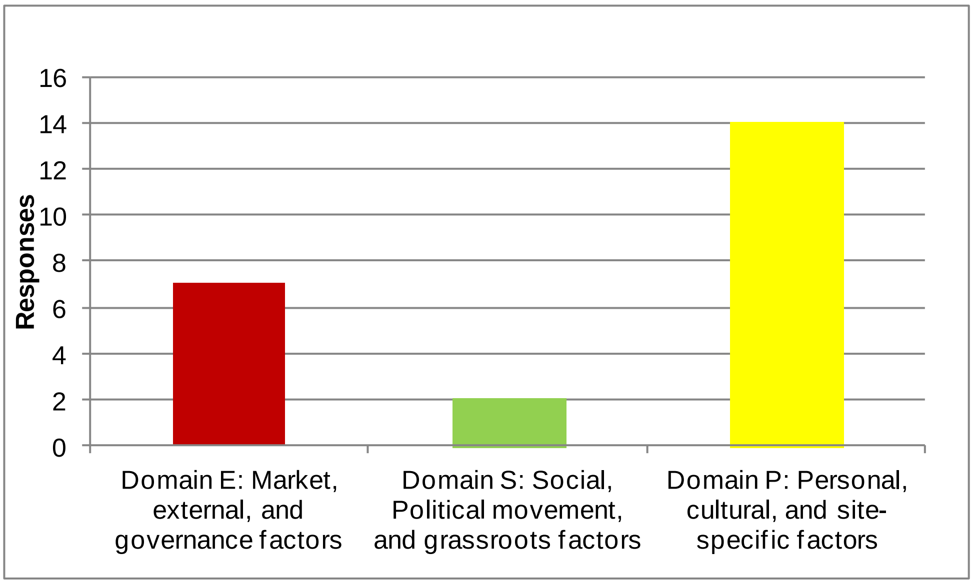


However, when calculating average scores for each Domain using the data from the numerical assessment (see **Errore. L'origine riferimento non è stata trovata.**1), E-Domain *Market, External and Governance Factors* scored 7.4 and thus lower results than the S-Domain *Social, Political Movement and Grassroots Factors* with 7.9. P-Domain *Personal, Cultural and Site-specific Factors* scored 7.0. The results are therefore not conclusive. The low prominence of the P-Domain could indeed either indicate a lower relevance of that domain or a bias in the sample or a miscommunication regarding the description of the specific factors. The inconsistency between Figure 4-1 and the other two Figures might also be due to the formulation of the questions.

It seems that **E3** ('Legal and incentives framework…') and **E4** ('Market and technological trends') are very crucial to the energy transition process according to the experts while the other Factors are given slightly less importance. Domain E ranks highest in the question of the most important domain as well as Factors **E3** and **E4** on the question of the most important two factors. In the numerical assessment, the S-Factors have a higher average score in total since the experts assigned high importance values (>7.5) to nearly the whole range of S-Factors while only two of five E-Factors received high scores. Especially **S4** ('Political programming, leadership and regulation) was ranked very high in importance by the experts.

As a last question, the experts were asked to name the Factor Domain that they would deem as least important for an energy transition (Figure 4-4). The P-Domain is the one considered as least important by the experts which also ties in with the answers of the aforementioned questions.

Figure 4-4. Respondents ranking the least important Factors (n=23)



In addition to the numerical evaluation of the Factors and the specific questions on Factor significance assessed above, the experts were also asked to give a more qualitative and broad appraisal of the 15 Factors of the preliminary framework and the relevance of specific Factors. Table 4-4 captures quotations from focus group and expert interview participants who commented on the significance of certain factors. The comments somewhat mirror the categorisation (along the lines of importance) introduced above.

Table 4-4 Dismissal and support of Factors.

Factor	Dismissal or Support
E1: **Competency and training of technical professionals**	"The market acts as a driver; in a few months the interest in training professionals in the field emerges." – expert interview, Italy
E2: **Learning and dissemination beyond the region**	"There is a general difficulty in making information available to decision makers who are "too busy to make sense of information". E2 is important but may not be such a key factor when "information is being drowned out." – Brussels focus group "Who can tell that a given experience done in a given place can be transferred also to a big city like Rome? Favourable conditions in a place are important for the success of a project, but it cannot be said that the same conditions will be beneficial to the project also in other places." – expert interview, Italy
E3: **Legal and incentives framework for project implementation**	"This requires the existence of a clear agreement with industry and market actors since beautiful ideas need the market to be ready otherwise the risk of failure is extremely high." – expert interview, Italy
E4: **Market and technological trends**	"Market and technological trends are important, since there is interdependence between market trends, economic and social impact, and job creation." – expert interview, Croatia
E5: **New independences caused by new technology, effects on security of supply**	"The weight of this factor depends on the scale of the fuel imports and on the national energy security philosophy (policy) and how national-centric vs. European-centric the security approach is." – expert interview, Czech Republic
S1: **Funding and Ownership**	"For me, you're not going to get anything done without money and funding – that's the prime mover." – expert interview, United Kingdom
S2: **Citizens' engagement in the energy transition**	"Without the support of the population, policy changes as well as technology developments are difficult to implement." – expert interview, Germany
S3: **Orientation to change**	"A public discourse around quality of life in light of energy transitions is necessary. Perhaps this is orientation to change" – expert interview, Switzerland "A social consensus can only come to existence if enthusiasm is present." – expert interview, Germany
S4: **Political programming, leadership, and regulation**	"Without political programming nothing will happen. It is necessary to achieve some critical mass and 'get the snowball rolling'. Deep political involvement is necessary." – e-focus group "Political leadership in buildings & energy and in broader sustainability can lever funding – the relationship of politics to money. In terms of shaping cities, politics is incredibly important for implementation" – expert interview, United Kingdom
S5: **Local informational and educational outreach**	
P1: **Regional and cultural considerations in design**	Anecdote on the importance: "In Edinburg an energy efficient building was designed by a Mediterranean architect – with extremely small windows. For Scotts this was disgusting." – expert interview, Poland
P2: **Project management**	"Getting the project management right helps bring what is at the beginning just an interesting technology to a feasible project. This can then be replicated and scaled." – e-focus group
P3: **Potential social and cultural impact**	
P4: **Potential economic impact**	"Basically I think economic benefits may be the main driver for change." – expert interview, Italy
P5: **Potential environmental impact**	

Based on the analyses conducted in this chapter, the Factors are grouped into two segments – one segment with Factors that show evidence of being relatively more important and one segment with Factors that seem to be rather less important. All findings are to be taken with considerable caution given the limited sample size of experts. It is of utmost importance to bear in mind that these results show the perception of the experts in the focus groups and expert interviews and are not in any way representative.

Potentially more important Factors:

- E3: Legal and incentives framework for project implementation
- E4: Market and technological trends
- S4: Political programming, leadership, and regulation
- S1: Funding and Ownership
- S2: Citizen's engagement in the energy transition
- S3: Orientation to Change
- P4: Potential economic impact

Potentially less important Factors:

- E1: Competency and training of technical professionals
- E2: Learning and dissemination beyond the region
- E5: New independences caused by new technology, effects on security of supply
- S5: Local informational and educational outreach
- P1: Regional and cultural considerations in design
- P2: Project management
- P3: Potential social and cultural impact
- P5: Potential environmental impact

According to this interim result, the S-Domain dominates the factors ranked as potentially more important while there are also some factors from the E-Domain that received high ranking from the experts. Some results may be contradicting intuition. For example, *Personal, Cultural and Site-specific* Factors *(P-Domain*) seem to be considered less relevant. On the other hand, some results seem to be in line with other evidence. The importance of *Citizen's engagement in the energy transition* and *Orientation to change* can be confirmed from the experience of the transition process in renewable electricity in Germany, which started as a bottom-up and very decentralised movement that was supported and enhanced by the early introduction of a feed-in tariff (*Funding and Ownership*). The lesser relevance of environmental, social and cultural impacts compared to economic impacts also mirrors the hierarchy of policy goals in times of indebted communities, substantial unemployment rates and ongoing economic crisis in Europe.

4.3 Interconnectedness of Factors – Synergies in Drivers and Barriers

Box 4-2 Mutual reciprocity between Factors.

"They appear to be a chain – all of them are interdependent (and so difficult to rank as a hierarchy). There is mutual reciprocity between them – each one influences others and we could find relationships between every pairing."
– Expert, July, 2014, Greece

The focus groups and expert interviews revealed very early that some Factors might be interconnected with other Factors.

The statistical analysis revealed only a relatively low correlation of Factors in the Assessment Matrix (for further information on the statistical methodology, please see section 8.4 in the Annex).

The analysis of statistical dependencies showed certain linkages for drivers and barriers:

- Factors gathered in the **S-domain** of ‘Social, political movement and grassroots factors’ are the most prone to depend on one another, as well as to interact with the factors from P- and E- domains.
- Strongest dependence for drivers was observed between **(S2)** ‘Funding and Ownership’ and **(S1)** ‘Citizens’ engagement in energy transition’
- Low levels of **(S3)** ‘Orientation to change’ are likely to turn into an obstacle in terms of **(S2) ‘**Citizen’s engagement…’
- High scores in the **(S4)** ‘Political programming, leadership and regulations’ Factor were found to depend on the positive scoring of **(P5)** ‘Potential environmental impact'
- Low levels of **(P1)** ‘Regional and cultural considerations in design*’* tend to go hand in hand with low levels of **(S2)** ‘Citizens’ engagement*…’* and (E2) ‘Learning and dissemination beyond the region’
- Factors **E1** ’Competency and training of technical professionals’ and **E4** ‘Market and technological trends’ seem to act independently from the rest of the 15 factors

While statistical analysis can provide additional signals for further examination, the limited number of Anticipatory Experiences and of experts involved, again, precludes any hard findings from coming out of this step. However, developing methods and methodologies for a further, broader application to a larger number of cases also provides significant benefits.

At this point, the authors hypothesised that if some Factors can influence other Factors, perhaps some Factors could directly drive other Factors. That is, perhaps a sequential relationship exists within the Preliminary Framework and certain Factors trigger others.

4.4 Leverage in a sequence

One of the most common pieces of feedback expert participants had in the focus group and expert interview activities was that the Preliminary Framework presented factors that are relevant at varying time horizons in the energy transition process. For example, it was very hard for experts to compare a factor such as **(P4)** ‘Potential environmental impact’ with a factor like **(S3)** ‘Orientation to change,’ as the former is an aspect that can only be tangibly measured at the end of a project lifetime while the latter is an element that cannot be quantified at all and is perhaps most important well-before the physical aspects of a post-carbon initiative take hold.

Box 4-3 Irrelevance of economic impact after implementation.

“It is absolutely irrelevant to talk about [Factor P4] ‘economic impact’ at the end of the project.”

– Expert, September 16, 2014, Berlin

Participants in one of the focus groups were asked if there was a way to present a sequence in drivers or an order in which Factors were triggered. The responses were diverse but most participants that responded believed that the S-domain *Social, Political Movement and Grassroots Factors* would trigger the other domains.

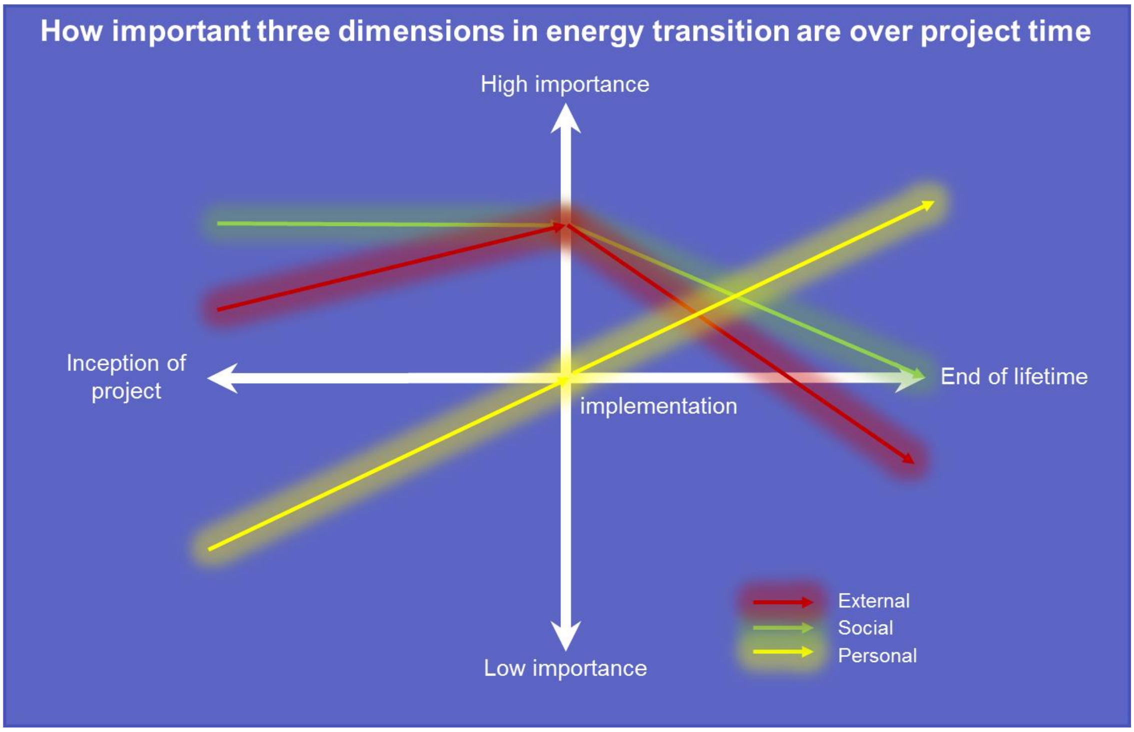
One of the experts proposed that the E-domain *Market, External and Governance Factors* would follow and become the force that allows the transition to “scale” at a broader, national or even international level. This reading of the role of the E-domain suggests that some E-Factors may indeed be triggers in the energy transition proliferation.

Box 4-4 Innovation and external support.

"Innovation does not require external support. External aspects came later. External factors are key in the scaling of energy transition"
– Expert, June 19, 2014, online focus group

This concept was tested in a later focus group through a participatory mapping exercise during which participants plotted the importance of Factors from different domains over the course of a project lifetime. The Figure below presents a hybrid result from the average points plotted by participants, and later, the author team.

Figure 4-5. Relevance of External-, Social- and Personal Factors over time[29]



Errore. L'origine riferimento non è stata trovata. shows that the different dimensions have varying roles in different phases of energy transition projects. The S-domain of *"Social, Political Movement and Grassroots Factors"* dominates in terms of importance during project inception and implementation. The participants of the Berlin focus group were nearly unanimous in ranking the different drivers in the social dimension (i.e., *"Orientation to Change," "Citizen's Engagement in Energy Transition," "[diversified] Funding and Ownership")* of having the highest importance during the planning stages of a project.[30] A proactive driving force in the community is more important than the existence of funding incentives and legal mechanisms to bring the project to fruition. This aspect takes on greater importance during the implementation stages. Finally, it seems that behaviour change and the relationship between the individual and the energy transition service, technology or lifestyle (the *"P"* dimension) is most important once the initiative has been launched.
It is desirable, of course, for enabling conditions across the three dimensions to remain strong throughout the project lifetime. For example, during the lifetime of an

[29] This figure draws on the expert opinion from the Berlin focus group, mapping the average placement of points on the y-axis at three different time intervals. The participants placed dots for different E, S, and P factors, providing enough information to plot a visual trend
[30] If considered the starting point or prerequisite in energy transition, this finding reinforces the assessment in Chapter 4.2 that the S domain is the most important in energy transition.

energy transition initiative, if the financial and legal scheme at the time of implementation persists, then the initiators can rely on a safe financing environment and don't risk financial failure. Likewise, it is ideal that social movements do not change public opinion dramatically (in a confrontational direction) on the initiative during its lifetime. Moreover, if the initiative fails to connect with individuals, the tangible impacts of the project cannot be achieved and the project may achieve merely success in terms of deployment rather than transformation.

The research conducted provides an intuitive guide for policy makers: **the social dimension is critical before policy. The external aspects can drive the tangible development and the behavioural elements unlock the doors to measured success.**

Any energy transition "sequence" is recursive and non-linear. The interdependent nature of the Factors from the Preliminary Framework (both within the same Domain as well as across Domains) suggests that there is a "rough" or "loose" S-E-P sequence, as outlined above.

Box 4-5 Key Messages on the role of sequence in energy transition

Key Messages

1. The *"Social, Political Movement and Grassroots Factors"* dimension (Citizens' orientation to change, engagement in movements and projects at the local level, willingness to pay in part for initiatives) is a foundation for smooth energy transition.
2. External governance and financial instruments help the bottom-up initiatives scale to a regional or national level.
3. Behaviour change and transformation in the personal dimension are key to measurable success of transition.

At the same time, the findings are still based on a very small sample of Anticipatory Experiences and few expert opinions. It is therefore quite possible that other sample compositions will yield other results.

Nevertheless, the developed methodology seems to elicit rational results in line with research expectations.

5. Discussion

5.1 Further research needs

This section discusses Factors which are not or not sufficiently covered by the Preliminary Framework.

a. Brainstorm of drivers and barriers

Participants in the Brussels focus group proposed 19 Factors in energy transition before seeing the Preliminary Framework by the authors. The participants of the Berlin focus group completed a similar exercise. Participants in the e-focus group were also given an opportunity to craft their own Factors individually and then in a group. The list below includes some of the popular ideas – those with high levels of agreement and those that dominated the conversation.

- The presence of financing models (local banks, government banks and risk capital) for **capital to drive innovation**
- Whether **business models** are in place that can be replicated easily
- **Information flow** on energy transition to all stakeholders in society (broad and wide vs. narrow and stifled)
- The current **socioeconomic growth model** of development
- **Male decision making**
- **Sectoral thinking**
- Large **fossil fuel interests** (or other lobby power)

b. Insufficiently represented topics

The Preliminary Framework could not include all relevant elements in a low-carbon, secure, inclusive energy transition. Focus group participants offered the following insights on topics that should be better integrated into the Final Framework.

- The presence of **agents of change** in the process as catalysts for the transition.
- Identifying and **taking advantage of leverage points in the political system**. Things cannot scale without political force and every system is different, offering new opportunities to accelerate the energy transition process.
- **External shocks to the system** through supply and extraordinary events are not completely represented by the framework. Their impacts could greatly impact many aspects in the process. (Or alternatively, the system resilience).
- In their current form, factors remain rather abstract which means that it is largely meaningless to put them into rank order. Also, the factors overly represent techno-scientific aspects and focus much less on the socio-cultural aspects.

Box 5-1 On shocks and historic moments.

"If I think where it was born, it was Fukushima, Chernobyl, etc. why do we now want to overcome things? It's a global common experience of accidents." *From the Berlin focus group*

Box 5-2 On the complexity of the energy transition.

"The complexity of the energy transition is not done justice by singling out one or a couple of most important factors. Instead, I think that the importance of different factors will largely depend on contextual variables such as the technology and the region involved. With regard to factors, I think the problematic of the energy transition requires thinking of constellations of multiple factors." *From an expert interview*

5.2 Discussion of methodological strengths and weaknesses

The conclusions drawn from the research conducted are subject to a variety of caveats, due to:

- This research process being iterative and evolving during the process rather than following a rigid and established academic theory; the present research had to develop the methodologies first in order to attempt deriving information.
- Imperfect testing conditions during the focus groups and expert interviews.
- Categorisation decisions and statistical choices made, particularly with respect to the Assessment Matrix.

a. Implementation of Focus Groups

Clarity of language

Box 5-3 Quotation on language used in Preliminary Framework.

"Please use language that is meaningful and evident to all." – participant, June 26, 2014, Brussels

In the collection of feedback from the focus groups and expert interviews, some quantitative results and deviations may have occurred due to **lack of clarity in the language** of the Preliminary Framework. Some Factors may not have been defined clearly, leading to confusion among some participants. Furthermore, there was a great deviation between the recorded averages (focus groups vs. expert interviews) of certain Factors in the "scoring" activity,[31] suggesting that further explanation of the Factors in the focus group was necessary for participants to score the Factors more highly (or vice versa). Examples of the four most extreme differentials in scores are available in the table below.

[31] There are also other likely reasons for differences in recorded averages between the focus group and expert interview participants including stakeholder group and many other factors that cannot be accounted for here.

Box 5-4 Comment in reference to "Project management", one of the preliminary 15 Factors presented in the focus groups.

"'Management' is a bad word. It makes us think of a project manager. Change the word in your research. The word 'manager' is about control and goal displacement." – participant, June 26, 2014, Brussels

The Preliminary Framework imposed a hierarchy and arrangement of aspects in energy transition processes. Focus group collaborators had further criticism on word choice and structure which has been collected in **Errore. L'origine riferimento non è stata trovata.** in the Annex.

Table 5-1. Differences between the focus groups and expert interviews in terms of importance of certain factors in energy transition were scored.

Factor	Avg. focus groups	Avg. expert interviews	Deviations	Total Avg.
E2: Learning and dissemination beyond the region	5.5	6.8	-1.3	6.5
E3: Legal and incentives framework for project implementation	7.3	8.9	-1.5	8.5
P1: Regional and cultural considerations in design	8.0	6.3	1.7	6.7
P5: Potential environmental impact	5.7	7.0	-1.3	6.7

Dominant personalities

Furthermore, the table above demonstrates the possibility of **groupthink** coming into play during the focus groups. The differences in scores presented above between the activities could have been the result of dominant speakers contributing to the focus groups and influencing opinion (for example, someone pointed several times to **(E2)** 'Dissemination beyond the region' as being less relevant than other factors because of cultural differences across Europe which may have influenced others in the session).

Gender diversity of participants and in research process

A total of 9 (out of 38) females took part in the focus groups and expert interviews. During the Brussels focus group, five out of the six participants (all of whom were male) noted "strong agreement" that male decision making was not only a key Factor in energy transition but a key influence on how reports such as the present one are written.

Again, the criticisms could be addressed with higher numbers of participants and a more careful selection of participants. Yet, this needs to be seen also in the context of real world circumstances where more male experts seem to be available or more experts from certain countries seem to be willing to participate in English language focus groups. That said, the direction is clear and more energy should be directed towards a more balanced sample composition.

a. *Analysis of the Anticipatory Experiences*

Another concern is directed at the 23 Anticipatory Experiences. Although they only contributed to a minor degree to the results of this paper, the limitations of their analysis shall be explained briefly at this point, both to justify the limited use of the results and for completeness sake.

Theoretical issues with Anticipatory Experiences

One of the reasons it is difficult to draw meaningful conclusions from the Assessment Matrix and geographically disperse Anticipatory Experience approach is that by grouping a collection of successful, environmentally-related local initiatives, we are conflating projects into categories that should not always be combined. For example, there may be properties of Anticipatory Experiences in different countries that are unique and could not be extrapolated to the EU level. The following four categories explain the limitations of the AE approach in further detail.

1) Location

   Different countries have different economic, political, geographic and cultural properties and situations.

   - Such a diversity of **legal frameworks** and national incentives schemes for energy transition-related projects makes it difficult to draw conclusions with respect to: government efficiency, technology installation, citizen participation in energy transition, etc.
   - Varying natural **resource endowments** across Europe is an independent variable that influences many economic aspects (for example, consider the Norwegian economy's stability on the heels of Statoil) and cultural attitudes toward eco-sustainable technologies.
   - The unaccounted-for influence of individual and societal **wealth** on the success of Anticipatory Experiences.
   - The role of **cultural aspects** not captured yet.

2) The Anticipatory Experiences cover different techno-economic sectors and are thus possibly not fully interchangeable as drivers and barriers could very well differ significantly from sector to sector. The following sectors are covered:
   - Heat
   - Electricity
   - Transport
3) A similar line of argument can be applied to the question of the technology employed in the Anticipatory experience as even within the same country and same sector, very different technologies are available. Thus, drivers and barriers could differ significantly which has also not been captured in the present analysis.
4) Finally, the approach or type of project may have played a role yet was not accounted for in the sample selection. Different project designs might elicit very different drivers and barriers:
   - Bottom-up vs. top-down (e.g. offshore wind park vs. decentralised roof-top solar installations).

- Different funding models (community-owned vs. ownership by an institutional investor) – while it is true that funding was accounted for as a Factor in the Framework, the sample may have been biased in that sense as well.

Statistical issue #1: A limited sample size

The initial quantitative assessment of 23 Anticipatory Experiences delivered an insufficiently large sample. Due to this issue, an interpretation of the results needs to be treated with a high degree of caution. Insufficient sample size causes regression models prone to instability and may result in a relatively low level of statistical power (i.e. probability of a correct rejection of the false null hypothesis). The problem of potential model instability was assessed across the 1000 iterations or the regression estimation based on the randomly decreased pool of observations.

Statistical issues #2: Potential scoring bias in the Assessment Matrix?

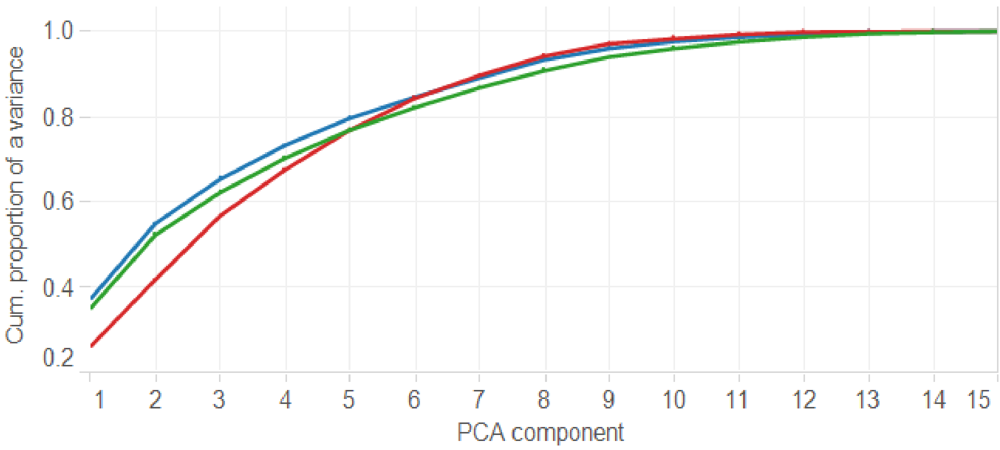
The second issue was the potential bias of scoring introduced due to the subjectivity of assessment by the four different participating researchers and assessors while assessing the Anticipatory Experiences in the Assessment Matrix. Each assessor was assigned a different pool of Anticipatory Experiences, corresponding to her or his expertise and the upfront knowledge of particular cases. Each project was assessed just by one partner according to the guidelines but several scores had to be adjusted by the author team for the sake of qualitative and quantitative consistency. These adjustments took place before the statistical analysis was conducted.

Regardless of the revised scoring scale, specific calibration of scores towards a project's qualitative performance could vary across partners. Indeed, the distributions of the scores assigned by different partners were somewhat different (see Figure) – some of them utilized the whole scoring scale while others awarded positive scores almost entirely. This potential subjectivity could affect the results of the analysis. It was found, though, through a PCA analysis that the interrelationships among the Factors were not strongly influenced by differing scoring approaches.[32]

[32] To check this issue, a PCA analysis was recomputed, excluding AEs assessed by specific researchers. Respective curves of the variance cumulated across the components remained fairly similar to the curve derived for all AEs (**Errore. L'origine riferimento non è stata trovata.**). Similarity of the curves indicates that factors remained fairly independent, regardless of the exclusion of scores by a specific research partner.

Figure 5-1. Distribution of scores assigned within particular Domain by different researchers.

Figure 5-2. Cumulative proportion of variance captured by the subsequent components of the principal component analysis (PCA) performed for all projects (green line), excluding the projects assessed by Ecologic Institute (blue line) and excluding the projects asse



6. Conclusions

The findings from Chapter 4 lead to a number of conclusions, both regarding methodology for identifying Factors and the relevance of Factors for the low-carbon energy transition.

> ***Overview of key insights from qualitative and quantitative research on energy transition***
>
> - The *"Social, Political Movement and Grassroots Factors"* dimension (Citizens' orientation to change, engagement in movements and projects at the local level, willingness to pay in part for initiatives) is a foundation for smooth energy transition.
> - External governance and financial instruments help bottom-up initiatives scale to a regional or national level.
> - Behaviour change and transformation in the personal dimension are key to measurable success of transition.

6.1 Revised Framework

While a number of findings can hardly be generalised due to the low number of data points in the analysis, some very crucial lessons can be taken from the research:

- revision of the Factor naming and descriptions (clear language)
- revision of the perspectives (going from static to a dynamic concept)
- considering Factors in connection, not individually

Based on the findings above, it became apparent that the Preliminary Framework needed to be adapted. Factors were recombined, added, deleted and grouped differently. The revision as presented here is still not final as more research will be necessary in order to substantiate the findings further and reduce the risk of bias as much as possible[33]. The new framework keeps the three domains *E - Market, External and Governance Factors, S - Social, Political Movement and Grassroots Factors and P - Personal, Cultural and Site-specific Factors* but the domains do not order the framework any longer. The revised key ingredients in energy transition are as follows:

[33] Additional feedback in the form of focus groups or expert interviews to verify the accuracy of this Final Framework was out of the scope of the project due to budgetary limitations.

Table 6-1 Revised Key Factors in energy transition (and domain).

Pre-conditions (leverage points in the system)	**Triggers** (change of flows in system)	**Impact** (behaviour or systemic change)
Openness of individuals to social change and change processes (S)	Engagement of individuals in local projects, existence of change agents (S)	New socio-cultural power structures; change in participatory processes (S)
Political leadership (covering various levels of governance) (S)	Legal framework, incentives, regulation (E)	New political power structures (S)
Human capital (E)	Effective implementation (project management, technical training, information) (P)	New interaction of individuals with technology, society and environment (P)
Positive economic impact of the project / measure (P)	Funding models (S)	Evolution of new business models (S)
Market signals (E)	Massive shocks, external disruptions to system (E)	New financial and economic power structures (S)

The revised Framework shows considerably fewer Factors in the P domain compared to the initial Preliminary Framework. It remains open at this point whether this is related to original description of P-factors or the fact that the "impact" Factors (the factors that happen in time after implementation/"triggers") seem less relevant in the overall picture.

On the other hand, there is no reason why all domains – i.e. *Market, External, and Governance Factors* (E), *Social, Political Movement, and Grassroots Factors* (S) and *Personal, Cultural, and Site-specific Factors* (P) should have equal relevance in the drivers and barriers of the energy transition. In fact, it was one of the aims of the present research to examine which Factors are most relevant – without any *a priori* judgment on the equal presence of domains.

A more complete Final Framework has been developed further with labelling, new descriptions and ties to the Preliminary Framework. This Final Framework will be used in subsequent MILESECURE-2050 work, specifically the SMET model. The Final Framework represents the culmination of standalone research and the synthesis of previous work in the MILESECURE-2050 project. The research conducted has married macro-perspectives on economics, infrastructure and the energy system with anthropological, sociological and behavioural understandings of energy transition into a common language and terminology as well as prepared this knowledge for novel, new modelling exercises.

This revised Framework can be found in Table 6-2.

Table 6-2. Final Framework of Key Factors in Energy Transition, based on analysis and qualitative expert opinion

Area	Factor Title	Link to Factors of Preliminary Framework	Factor Role	Factor Description
Participatory decision making	Openness of individuals to social change and change processes (S)	S3, P5, P3	**Pre-conditions** (leverage points in the system)	Orientation to grassroots activities, broad (non-narrow) worldview, and interest in eco-initiatives with expected or demonstrated environmental and social benefits.
	Engagement of individuals in local projects, existence of change agents (S)	S2	**Triggers** (change of flows in system)	The role of citizens in designing, spearheading, and implementing eco-initiatives.
	New socio-cultural power structures; change in participatory processes (S)	E2, S4	**Impact** (behaviour or systemic change)	A democratisation of decisions in society and the public engaged in driving eco-initiatives through learning and dissemination beyond the region.
Policy context	Political leadership (covering various levels of governance) (S)	S4	**Pre-conditions** (leverage points in the system)	Political legacy and priority of tackling complex energy challenges.
	Legal framework, incentives, regulation (E)	E3	**Triggers** (change of flows in system)	Mechanisms, incentives, and instruments put in place by governments to scale eco-initiatives.
	New political power structures (S)	S4	**Impact** (behaviour or systemic change)	An agile, efficient, and dynamic participatory governance system.
Adoption, implementation and uptake of **innovative solutions**	Professionals with education and capacity to support societal transition (S)	E1	**Pre-conditions** (leverage points in the system)	Versatile, intelligent group of people ready to change industry, take on new challenges, and execute or implement required steps in energy transition.
	Effective implementation (project management, technical training, information) (P)	P2, P1	**Triggers** (change of flows in system)	Operations, evaluation, and monitoring effectively deployed and suitably adapted in local context (sociocultural comfort, considerations, or lifestyles).
	New interaction of individuals with technology, society and environment (P)	P1, P2, S5	**Impact** (behaviour or systemic change)	Initiative outcomes change the human habits, the relationship between technology and individuals, their view on the environment, and their contributions in society.

Area	Factor Title	Link to Factors of Preliminary Framework	Factor Role	Factor Description
Financial and entrepreneurial aspects	Positive economic impact of demonstration projects / measure (P)	P4	**Pre-conditions** (leverage points in the system)	Potential profitability of the project and potential effects on local employment and value added.
	Relevant project funding models (S)	S1	**Triggers** (change of flows in system)	How diverse funding sources and fundraising methods, including local ownership models, are.
	Evolution of new business models (S)	S1	**Impact** (behaviour or systemic change)	Potential for entrepreneurial innovations to encourage new intiatives.
Macro (economic, political, geopolitical) factors	Market signals (E)	E4	**Pre-conditions** (leverage points in the system)	Cost trends and macroeconomic factors influence CapEx flows and project development structures.
	Massive shocks, external disruptions to system (E)	E5	**Triggers** (change of flows in system)	Dramatic events create political, geopolitical and societal moment for response.
	New financial and economic paradigm (S)	No link with preliminary framework	**Impact** (behaviour or systemic change)	Revamping of how environment and eco-initiatives are valued (in the context of resources and capital).

6.2 Areas of further research

The current research activity led to a number of further research questions which cannot be answered within this report but should be addressed in subsequent work.

- As a very first step, the revised Framework ought to be examined through a similar process of using the Assessment Matrix, focus groups and expert interviews to validate the revised Factors.
- Subsequently, the sample sizes both for the number of Anticipatory Experiences as well as the number of experts involved should be increased considerably, thus allowing the statistical analysis to be made on better grounds.
- If necessary, a further refinement of the Framework will be required.

Independently of these suggested further research steps, the results of the present examination will be the basis for developing parameters and variables in low-carbon energy scenarios which will be modelled within MILESECURE-2050 using the SMET model to supply findings to the CGE-FEU[34] and IMACLIM-R models.

[34] Computable General Equilibrium – Final Energy Use

7. Works Cited

Bilbao-Osorio, B., and Rodríguez-Pose A. (2004). “From R&D to Innovation and Economic Growth in the EU.” *Growth and Change* Vol. 35. pp 434–455.

Caiati, G., L. d'Andrea, M. Montefalcone (2010). “Societal Dynamic of Energy Transition.” Pathways for carbon transitions (PACT) Project

Caiati, G., G. Quinti, P. Kazakopoulos, and I. Sitko, (2013). Report on integrated analysis of local anticipatory experiences in energy transition in Europe.” D2.1 of MILESECURE-2050 project.

Caiati, G., G. Quinti, M. Santangelo, S. Crivello, P. Kazakopoulos, and I. Sitko. (2014). “Report on comparative analysis.” D2.2 of MILESECURE-2050 project.

Davis, Steven J and Robert H Socolow. 2014. “Commitment accounting of CO2 emissions”. *Environmental Research Letters* Vol. 9. doi:10.1088/1748-9326/9/8/084018

European Commission. (2014). "Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: A policy framework for climate and energy in the period from 2020 to 2030." COM(2014) 15 final.

European Commission. (2013). “A 2030 framework for climate and energy policies.” Green Paper. COM(2013) 169 final.

European Commission. (2011). "Energy Roadmap 2050." COM(2011) 885 final.

Eurostat. (2014). *EU energy in figures.* Statistical pocketbook 2014. Luxembourg: Publications Office of the European Union. ISSN 1977-4559.

Fattouh, B. (2007). "How secure are Middle East oil supplies." *Oxford Institute for Energy Studies*. WPM 33. Oxford.

Gracceva, F., and P. Zeniewski (2012). "Quantitative assessment of energy security. A framework and an overview of selected studies." *European Commission Joint Research Centre, Institute for Energy and Transport*. Scientific and Policy Report. Petten.

Kemp, R., M. van Asselt, & J. Rotmans. (2001). “More evolution than revolution: transition management in public policy.” Foresight 3.

Kharecha, Pushker A., and James E. Hansen. (2013). “Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power.” *Environmental Science & Technology,* Vol. 47, Issue 9. pp. 4889-4895.

Machol B. and Rizk S. (2013). "Economic value of U.S. fossil fuel electricity health impacts." *Environment International,* Vol. 52. pp. 75-80.

Mitchell, J. V. (2002). "Renewing Energy Security." *The Royal Institute for International Affairs, Sustainable Development Programme*. London.

Stirling, A. (2009). "The Dynamics of Security. Stability, durability, resilience, robustness." *University of Sussex, Kohn Centre, Royal Society*. "Energy Security in a Multipolar World." London.

Warner, Ethan S., and Garvin A. Heath. (2012). "Life Cycle Greenhouse Gas Emissions of Nuclear Electricity Generation." *Journal of Industrial Ecology*, Vol. 16, Issue Supplement S1. pp. S73–S92.

WHO - World Health Organization. (2011). “The social dimensions of climate change.” Discussion Draft 48.

8. Annex

8.1 Methodology of developing preliminary Framework

In developing a first attempt at the matrix of factors, it is necessary to consider the 44 factors from the PACT project in order to divide the “political” and “technological” factors into terms of E,S,P, as defined in the approach. Where appropriate additional factors will also be introduced, during the iterative process of the literature review and ultimately focus groups and expert interviews.

A. **Generating**: locating factors from existing research

The 44 factors from LSC’s work on the PACT project Task 4.1. "Driving socio-economic forces and actors, acceptability, heritage, policies” Societal Dynamics of Energy Transition were pasted into an Excel spreadsheet with a description of each indicator.

Step 1: Labelling factors according to new MILESECUR-2050 domains

To assist with the combining of factors, each factor is given an E, S, or P (or when appropriate, a combination) to outline on which axis of the triangle the factor would primarily lie. The table of results is included below:

Table 8-1. Assignment of Personal, Social, or Extrosomatic energy factor to 44 PACT Factors

FACTOR TE1 Adapting technologies to social and environmental contexts	P
FACTOR TE2 Capacity building of technicians and professionals	E
FACTOR TE3 Link between local cognitive capital and global knowledge	P, S
FACTOR TE4 Technical assistance and maintenance	P, S
FACTOR TE5 Flexible project-designing geared to complexity	P
FACTOR TE6 Spreading of technological responsibility	S
FACTOR TE7 Continuous innovation	P
FACTOR TO1 Resistance to innovation by professionals and developers	E
FACTOR TO2 Citizens’ resistance linked to the search for individual and family autonomy	P
FACTOR TO3 Disagreement on practical solutions concerning the organisation of daily life (convenience)	P
FACTOR TO4 Tensions linked to the protection of privacy and to individual and family security	P

FACTOR TO5 Resistance due to essential needs for comfort and cleanliness	P
FACTOR TO6 Prejudice towards energy transition	S
FACTOR TO7 Poor socialisation of technological innovation	E
FACTOR TO8 Presence of critical aspects and errors in project-designing	P
FACTOR TO9 Presence of critical aspects concerning the poor competence of technicians	E
FACTOR TO10 Poor knowledge-management orientation	E
FACTOR PE1 Presence of leadership of adequate quality	S
FACTOR PE2 Programming the political process	S
FACTOR PE3 Citizens’ orientation to change	S
FACTOR PE4 Other actors’ orientation to change	S
FACTOR PE5 Citizens’ active participation in the energy transition	S
FACTOR PE6 Building consensus	S
FACTOR PE7 Public communication and awareness-raising	S
FACTOR PE8 Starting up a networking system	S
FACTOR PE9 Capacity-building of citizens and of public administration personnel	S, P
FACTOR PE10 Creating an adequate and flexible regulatory framework	S
FACTOR PE11 Functioning of an integrated networked fund-raising system	S
FACTOR PE12 Decision-making	S
FACTOR PE13 Adopting a high quality management system	S
FACTOR PE14 Self-reflexivity and applying lessons learnt	S

FACTOR PE15 Social, cultural and economic impact	P
FACTOR PO1 Resistance in public administration	S
FACTOR PO2 Resistance by political forces	S
FACTOR PO3 Opposition of movements and citizens	S
FACTOR PO4 Juridical and administrative difficulties	S
FACTOR PO5 Poor control over costs	E
FACTOR PO6 Difficulty in accessing funds	S
FACTOR PO7 Undesired effects of user selection Rationale	P
FACTOR PO8 Poor capacity to control energy performance and system quality	E
FACTOR PO9 Shortcomings in the circulation of technical, social and political information	E, P
FACTOR PO10 Citizens' poor self-reliance in using eco-sustainable technologies	P
FACTOR PO11 Low priority given to energy saving by public service providers	P

B. **Narrowing**: imposing an international and supranational constraint on factors

Step 2: Combining factors

At this stage, the authors decided to aim for a total of 15 factors, with five along each segment of the E-P-S triangle.

Remove the "obstacle" factors that were determined to be inversions of "enabler" indicators. The Anticipatory Experience (AE) matrix incorporates negative scoring to reflect a strong barrier (as opposed to a strong driver). Include more detailed sub-indicators in spreadsheet (from PACT report) to guide later assessment by project partners in assessing 25 AEs. That is, detailed sub-indicators will serve as guiding performance indicators that will allow WP3 partners to qualitatively rank the 25 AEs in the AE matrix qualitatively. Step 2 will also combine the thematically similar factors from the PACT report. The actions taken in the first matrix are as follows:

REMOVED/COMBINED:

- "FACTOR PO6 - Difficulty in accessing funds;" combined with "FACTOR PE11Functioning of an integrated networked fund-raising system" to become "FACTOR S1 Funding"
- "FACTOR PO3 - Opposition of movements and citizens;" "FACTOR TE6 Spreading of technological responsibility;" "FACTOR PO2 Resistance by political forces;"and "FACTOR TO6 - Prejudice towards energy transition"

combined with “FACTOR PE5 Citizens’ active participation in the energy transition” to become “FACTOR S2 Citizens’ participation in the energy transition”

- “FACTOR PE4 - Other actors’ orientation to change,” “FACTOR PO1 - Resistance in public administration,” combined with “FACTOR PE3 Citizens’ orientation to change” to become “FACTOR S3 Orientation to change”
- “FACTOR PE1 Presence of leadership of adequate quality,” “FACTOR PE2 Programming the political process,” ”FACTOR PE10 Creating an adequate and flexible regulatory framework,” “FACTOR PE12 Decision-making,” “FACTOR PE8 Starting up a networking system,” parts of “FACTOR PE9 Capacity-building of citizens and of public administration personnel” to become “FACTOR S4 Political programming, leadership, and regulation”
- “FACTOR PE7 Public communication and awareness-raising,” “FACTOR TE3 Link between local cognitive capital and global knowledge,” “FACTOR PE9 Capacity-building of citizens and of public administration personnel,” “FACTOR PE6 Building consensus,” part of “FACTOR PO9 Shortcomings in the circulation of technical, social and political information” to become “FACTOR S5 Local informational and educational outreach”
- “FACTOR TO3 - Disagreement on practical solutions concerning the organisation of daily life (convenience)” and “FACTOR TO4 - Tensions linked to the protection of privacy and to individual and family security,” “FACTOR TO4 - Tensions linked to the protection of privacy and to individual and family security,” “FACTOR PO10 Citizens’ poor self-reliance in using eco-sustainable technologies” “FACTOR TO5 - Resistance due to essential needs for comfort and cleanliness,” “FACTOR TE5 - Flexible project-designing geared to complexity,” “FACTOR TE1 - Adapting technologies to social and environmental contexts,” and combine with “FACTOR TO2 Citizens’ resistance linked to the search for individual and family autonomy” to become “FACTOR P1 Regional and cultural considerations in design”
- “FACTOR PE13 Adopting a high quality management system,” “FACTOR TE4 Technical assistance and maintenance,” “FACTOR TO8 Presence of critical aspects and errors in project-designing,” “FACTOR PO7 Undesired effects of user selection Rationale” and “FACTOR PO8 Poor capacity to control energy performance and system quality” “FACTOR P2 Project management”
- “FACTOR TO1 - Resistance to innovation by professionals and developers,” “FACTOR PO1 Resistance in public administration,” “FACTOR TO9 Presence of critical aspects concerning the poor competence of technicians,” parts of “FACTOR PO9 Shortcomings in the circulation of technical, social and political information,” and parts of “FACTOR PE9 Capacity-building of citizens and of public administration personnel” combine with “FACTOR TE2 Capacity building of technicians and professionals” to become “FACTOR E1 Competency of implementers”
- “FACTOR PE14 Self-reflexivity and applying lessons learnt” combine with "FACTOR TO10 Poor knowledge-management orientation" to become “FACTOR E2 Learning and dissemination beyond the region”
- “FACTOR PO11 Low priority given to energy saving by public service providers” and mix with elements of “FACTOR PO5 Poor control over costs” to become “FACTOR E3 Legal and incentives framework for project implementation” and “FACTOR E4 Market and technological trends”

SPLIT:

- "FACTOR PE15 Social, cultural and economic impact" becomes "FACTOR P3 Social and cultural impact," "FACTOR P4 Economic impact, " and "FACTOR P5 Environmental impact"

Some factors were simply renamed to adjust their scope, as appropriate.

NEW NAME:

- "FACTOR TO7 Poor socialisation of technological innovation" becomes "FACTOR E5 Technological and other dependences"

C. **Generating**: adding input from expert sources

Step 3: Include perspectives from the consortium

An early draft version of the evolving framework was circulated among the researchers in the MILESECURE-2050 consortium. Some collected feedback on the early draft framework was offered and is summarised below:

- Key elements of energy transition not sufficiently included in the matrix:
    - National energy policy
    - Energy security (import dependency, threats to energy system)
    - Geography (resource endowment, economic strategic location)
- Unclear in which domain policy makers play a role – "social" or "eXternal"
- Are local narratives considered? Risk perceptions of certain technologies? Energy poverty?
- Significant overlap among some of the social drivers and barriers

D. **Narrowing**: considering redundancies among factors

After receiving the expert input, factors we renamed and descriptions rewritten.

Step 4: Determine less significant factors

Several factors were deemed less important than the others that were combined more easily. Furthermore, some of these factors did not play a major role in MILESECURE-2050 Deliverable 2.1.

REMOVED:

- "FACTOR PO4 Juridical and administrative difficulties"
- "FACTOR TE7 Continuous innovation"

Table 8-2. An early draft of the Framework (factors + descriptions)

Domain and Factor		Description
E	FACTOR E1 Competency of implementers	Varying staff responsible for the maintenance and implementation of the new energy technologies may bring different attitudes and received variable training.
	FACTOR E2 Learning and dissemination beyond the region	To what extent project developers and government disseminate successes and exchange with other relevant professionals.
	FACTOR E3 Legal and incentives framework for project implementation	How structures in place between government and economic interests facilitate project development.
	FACTOR E4 Market and technological trends	Cost trends and macroeconomic factors influence governance and project development structures.

Domain and Factor		Description
	FACTOR E5 Technological and other dependences	Legal, trade, or technological characteristics of the low-carbon project creates local independence from or dependence on external processes.
S	FACTOR S1 Funding and Ownership	How diverse funding sources and fundraising methods, including local ownership models, are.
	FACTOR S2 Citizens' participation in the energy transition	Active civilian campaigns can catalyse political processes, contribute to economic conditions, and even affect maintenance / management processes of low-carbon technology.
	FACTOR S3 Orientation to change	Leadership and organisational qualities of human capital and presence of environmentally-minded law at the local level.
	FACTOR S4 Political programming, leadership, and regulation	To what extent the local political structure explores transparent, new funding / regulation options, and a proactive approach to facilitating low-carbon technology.
	FACTOR S5 Local informational and educational outreach	Presence and effectiveness of campaign efforts to inform community of technical and other aspects of low-carbon technology.
P	FACTOR P1 Regional and cultural considerations in design	Local design of technologies can be suitably adapted to local sociocultural characteristics or challenge lifestyles.
	FACTOR P2 Project management	Operational structures evaluate and respond to technology, system, and user performance in different ways.
	FACTOR P3 Social and cultural impact	Low-carbon technology affects recreational and cultural opportunities, influencing lifestyle and community more broadly.
	FACTOR P4 Economic impact	Low-carbon technology creates or inhibits new local economic and financial opportunities.
	FACTOR P5 Environmental impact	Low-carbon technology has documented, clear, and visible immediate result on local water, biodiversity, air quality, or other environmental aspect.

E. **Elaborating**: introducing sub-indicators that illustrate how the factors perform

Step 5: Sub-indicator development

Within this research, we have referred to multiple hierarchies in the drivers and barriers Framework. At the top level are the domains – 1) market, external, and governance factors; 2) social, political movements, grassroots factors; 3) personal, cultural, and site-specific factors. At the next level down are the Factors, each of which covers an idea that may include several drivers and barriers. In a way, these can be considered clusters, or general descriptions of the more specific, tangible aspects that still represent the Factor. The sub-indicators are below the factors, and these are more measurable, less abstract.

As the PACT report served as an inspiration for the MILESECURE factor matrix of societal processes of energy transitions, the author team also examined the "sub-indicators" of relevance for each "factor" in the PACT report. While merging and combining factors in the aforementioned steps, the author team also appended the original sub-indicators into these new “factor” categories. These “banks” of factors served as a starting point to narrow down to a more reasonable number. Suggestions from the consortium also influenced the selection of the sub-indicators. 4-5 of the most critical of these “Important representations of the Factor” were chosen for each factor, and influenced by the literature review conducted, PACT research, earlier MILESECURE-2050 work, and expert opinion in Step 3 above.

The sub-indicators, or “important representations of the Factor,” served a practical purpose in the research process. They guided the MILESECURE-2050 researchers in assessing Anticipatory Experiences along the lines of the final 15 Factors. Clear sub-indicators gave the researchers ideas and food for thought on how to holistically assess the 23 AEs.

The preliminary version of the Framework (with the sub-indicators) can be found in Chapter 3.1.

8.2 Strengths of Drivers and Barriers in Anticipatory Experiences – Assessment Matrix

Table 8-3 Strengths of Drivers and Barriers in Anticipatory Experiences – Assessment Matrix.

Factor	Project Name	Juhnde Bio Energy Village	Eco-Mobility in Bremen	Frankfurt Passive House Capital	Vauban	Findhorn Ecovillage	BedZed	Baywind Energy Co-operative	Clough-jordan Ecovillage	Eko Vikki	Project-Zero	Western Harbour	Kalundborg Eco-Industrial Park	Transition Town Totnes	Amsterdam Bike City	Copenhagen City of Cyclist	Samsoe	Super-blocks	Eva Lanx-mere	Grand Lyon's (Rennais-sance /Concerto)	Civitas Ljubljana	Sistema Peccioli	Torri Superiori	Warsaw Mobility Plan
	City	Juhnde	Bremen	Frankfurt	Freiburg	Moray	London	Cumbria	Clough-jordan	Helsinki	Sonder-borg	Malmo	Kalundborg	Totnes	Amsterdam	Copenhagen	Samsoe	Vitoria-Gasteiz	Culemborg	Lyon	Ljubljana	Peccioli	Torri Superiore	Warsaw
	Country	Germany	Germany	Germany	Germany	United Kingdom	United Kingdom	United Kingdom	Ireland	Finland	Denmark	Sweden	Denmark	United Kingdom	Netherlands	Denmark	Denmark	Spain	Netherlands	France	Slovenia	Italy	Italy	Poland
	Assessment	Ecologic	Ecologic	Ecologic	Ecologic	USAL	USAL	USAL	USAL	USAL	USAL	USAL	LSC	LSC	LSC	LSC	LSC	LSC	LSC	LSC	LSC	LSC	LSC	IEn
FACTOR **E1**: Competency and training of technical professionals	Assessment (-3 to 3)	2	2	2	1	2	3	-1	1	2	2	3	2	1	1	2	2	3	2	2	1	2	1	2
FACTOR **E2**: Learning and dissemination beyond the region	Assessment (-3 to 3)	3	2	2	2	2	3	2	2	0	3	1	3	3	2	3	2	2	3	1	2	1	2	3
FACTOR **E3**: Legal and incentives framework for project implementation	Assessment (-3 to 3)	2	2	1	-1	1	1	2	1	3	1	3	0	0	2	3	3	1	1	3	2	-2	-2	3
FACTOR **E4**: Market and technological trends	Assessment (-3 to 3)	2	1	2	2	1	2	2	1	2	2	3	2	1	3	3	-1	0	2	0	1	1	0	3
FACTOR **E5**: New independences caused by new technology, effects on security of supply	Assessment (-3 to 3)	2	2	0	2	3	2	2	2	1	1	0	3	1	2	2	3	1	2	0	0	3	1	2
FACTOR **S1**: Funding and Ownership	Assessment (-3 to 3)	2	1	1	1	3	-1	3	2	1	-1	-1	1	3	0	0	3	2	3	1	0	3	3	3
FACTOR **S2**: Citizens' engagement in the energy transition	Assessment (-3 to 3)	3	2	1	3	3	0	3	3	-2	-1	-1	0	3	1	2	3	3	3	1	2	2	3	3
FACTOR **S3**: Orientation to change	Assessment (-3 to 3)	2	1	3	3	3	0	2	3	0	2	-1	1	3	2	3	2	3	3	1	2	2	3	1

	Project Name	Juhnde Bio Energy Village	Eco-Mobility in Bremen	Frankfurt Passive House Capital	Vauban	Findhorn Ecovillage	BedZed	Baywind Energy Co-operative	Clough-jordan Ecovillage	Eko Vikki	Project-Zero	Western Harbour	Kalundborg Eco-Industrial Park	Transition Town Totnes	Amsterdam Bike City	Copenhagen City of Cyclist	Samsoe	Super-blocks	Eva Lanx-mere	Grand Lyon's (Rennais-sance /Concerto)	Civitas Ljubljana	Sistema Peccioli	Torri Superiori	Warsaw Mobility Plan
FACTOR **S4**: Political programming, leadership, and regulation	Assessment (-3 to 3)	3	2	3	0	3	1	1	3	-2	2	2	2	3	2	2	3	2	3	1	1	3	1	0
FACTOR **S5**: Local informational and educational outreach	Assessment (-3 to 3)	3	3	3	2	1	2	-1	3	-1	3	-1	3	3	2	1	3	2	3	2	3	1	3	3
FACTOR **P1**: Regional and cultural considerations in design	Assessment (-3 to 3)	3	3	3	3	2	3	1	1	0	0	0	2	1	3	3	2	3	1	0	2	2	2	1
FACTOR **P2**: Project management	Assessment (-3 to 3)	3	2	2	2	1	1	-1	1	-1	3	1	3	2	0	0	1	3	2	2	1	2	1	2
FACTOR **P3**: Potential social and cultural impact	Assessment (-3 to 3)	2	3	1	2	1	1	1	2	1	0	1	2	3	3	3	3	2	3	0	3	2	3	3
FACTOR **P4**: Potential economic impact	Assessment (-3 to 3)	3	2	1	1	1	0	0	0	0	2	3	2	2	2	2	3	1	1	1	2	3	2	1
FACTOR **P5**: Potential environmental impact	Assessment (-3 to 3)	1	2	2	2	1	1	-1	3	-1	3	1	2	1	2	3	3	2	2	1	1	1	1	1

8.3 Focus Groups and Expert Interview materials

Table 8-4. Expert Interview Questionnaire

#	Question		Responses	Open-ended responses
1	(warm up question) How important is the energy transition to you?			
2	Take a look again at the fifteen factors in energy transition you read about. We would ask you to score the following factors in energy transition processes from least important (1) to most important (10). Each factor can be both a driver and barrier, depending on circumstances. The factors are divided into groups: external, social, and personal aspects. Please consider the scores relative to each other.	FACTOR E1: Competency and training of technical professionals		
		FACTOR E2: Learning and dissemination beyond the region		
		FACTOR E3: Legal and incentives framework for project implementation		
		FACTOR E4: Market and technological trends		
		FACTOR E5: New independences caused by new technology, effects on security of supply		
		FACTOR S1: Funding and Ownership		
		FACTOR S2: Citizens' engagement in the energy transition		
		FACTOR S3: Orientation to change		
		FACTOR S4: Political programming, leadership, and regulation		
		FACTOR S5: Local informational and educational outreach		
		FACTOR P1: Regional and cultural considerations in design		
		FACTOR P2: Project management		
		FACTOR P3: Potential social and cultural impact		
		FACTOR P4: Potential economic impact		
		FACTOR P5: Potential environmental impact		

3	Now please rank the energy transition process groupings (external, social, and personal aspects) from most important to least important.		
4	In your opinion, what are the two most important factors in energy transition processes from these 15 factors? *(note for interviewer: you may need to reread the list of factors)*		
5	Are any of the factors particularly irrelevant or less applicable to energy transitions at the national or supranational level? *(note for interviewer: you may need to reread the list of factors)*		
6	Are any of the factors interdependent or relate to the performance of other factors? If so, how strong is the interdependence? *(note for interviewer: you may need to reread the list of factors)*		
7	Would you describe certain drivers or barriers as triggers (from the list of factors provided or your personal experiences)? Do any particular early factors influence later drivers or barriers? Which ones are strongest?		
8	Can you think of any particular drivers and barriers in an energy transition that might not be captured by the grouping we are discussing?		
9	Do you have any additional feedback on the key elements in energy transition?		

8.4 Statistical methodology used in Quantitative Evaluation

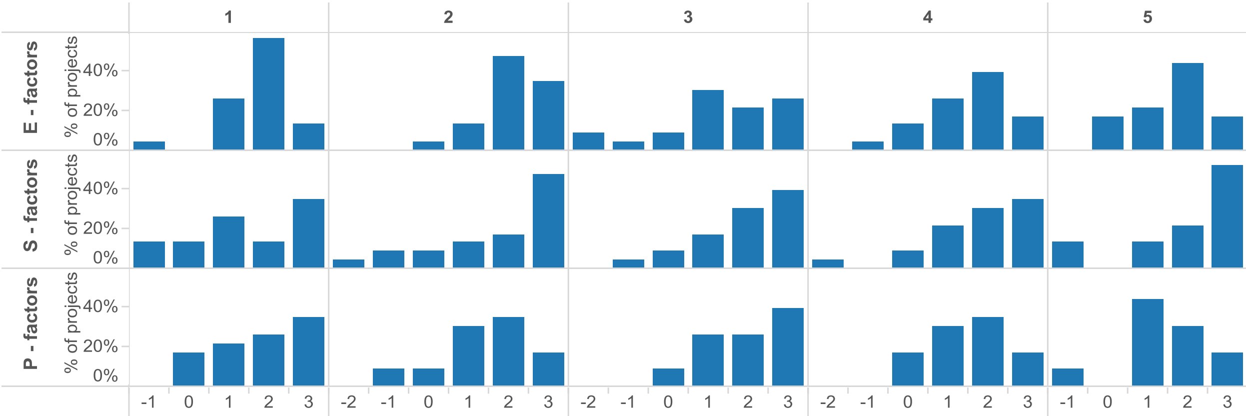
In this annex we provide a detailed description of the methodology and results of the procedures applied to analyse the interactions between the 15 factors of energy transition building on the analysis of the Assessment Matrix. While the results statistical analysis have only limited relevance due to the small sample size, the following section illustrates the effectiveness of the proposed methodology and provides a blueprint for further application to larger data sets.

Linear Regression
Linear correlation between factors served as the initial indication of their general relationship. It was quantified with the Pearson's r and r^2 coefficients based on the least-squares estimation and the original range of scores attached to factors. Significance of the individual parameters was tested with the standard t-test, preserving only models with p-values of at least 95%.

Principal Component Analysis
Assessment of the level of correlation between different factors was supplemented by the Principal Component Analysis (PCA). In general, this technique aims to reduce data dimensionality based on the transformation of the original observations into linearly uncorrelated variables, called principal components. Those components are derived in relation to data variability in such way that the first one captures the largest portion of a variance and the following components subsequently less and less variance. For a highly correlated dataset, the majority of variance can be accumulated in just several components. Exploration of the possible variance compression across the energy transition factors helps to indicate how many strong dependencies one should expect across the dataset.

Binary logistic regression
Logistic regression estimates dependence across variables together with the probability of a response variable being affected by a particular predictor. Mathematically, it relies on the logic transformation being robust to some of the common problems of the standard linear model, e.g. non-normal distribution of errors. In a classical form, which was applied in this analysis, logistic regression models a binary response variable. Therefore, we simplified original assessment of projects and considered factors acting as potential "key drivers" or conversely as potential "obstacles" of an energy transition process. It is important to note that each factor could be both - a driver and an obstacle – depending on a considered project. Scores of 2 and 3 were treated as an indication of a factor being a key driver for particular projects. An obstacle was considered with the original scores of 0 and below. Such a non-symmetric split of values was selected based on the actual distributions of scores which were for most of factors skewed towards positive values (Figure 8-1). While scores of 2 and 3 were common across all studied projects, the number of occurrences of negative scores was considerably low for some factors, preventing logistic models from reaching a stable statistical outcome. Following the aforementioned procedure, we received 30 response variables of a binary character – 15 assessing each factor as a potential "key driver" and 15 considering factors as potential "obstacles." Each response variable was juxtaposed with the remaining 14 factors (explanatory variables) which stayed within the original range of values. Due to the limited sample size, we restricted the analysis to univariate approaches (one explanatory variable at a time), testing 420 logistic models in total.

Figure 8-1. Distributions of scores assigned to the Factors of energy transition in the Assessment Matrix. Designed scale of scores ranged from -3 to 3.



a. *Linear correlation between factors*

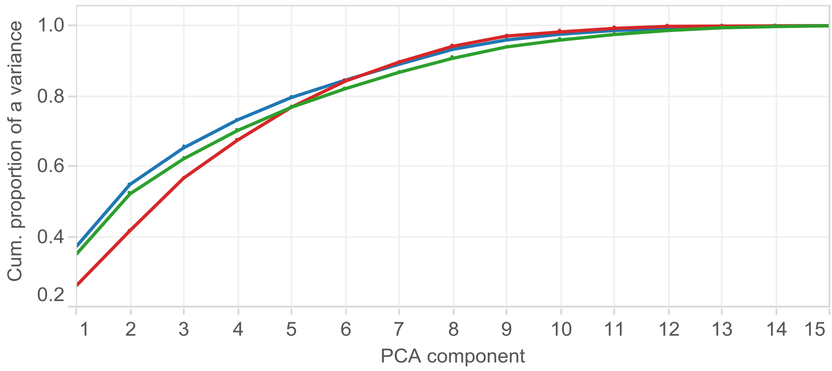
Results of the linear regression analysis are presented in Table 8-5 which lists 19 pairs of factors with statistically significant correlations. Nevertheless, none of these relations can be assessed as considerably strong. The majority of combinations exhibited correlation at the level of 0.4 (in two cases the relation is negative) which translated into an r^2 of only 0.2. The strongest correlation, above 0.5 r^2, was observed between S1 and S2 factors: *Funding and Ownership* and *Citizens' engagement in the energy transition*. The latter one was also correlated at the r^2 = 0.5 with the S3 factor addressing *Orientation to change*. The third relation with the r^2 > 0.4 took place between S5 *Local informational and educational outreach* and P2 *Project Management*.

Table 8-5 Linear correlation between the factors of energy transition, significant at the p-value of 0.05.

Factor 1	Factor 2	Pearson's r	r^2	Significance (p-value)
S2	S1	0.734	0.539	0.0001
S3	S2	0.707	0.500	0.0002
S5	P2	0.652	0.425	0.0008
S5	P5	0.608	0.370	0.0021
S5	E2	0.606	0.367	0.0022
S2	P3	0.558	0.312	0.0056
S4	P5	0.539	0.291	0.0079
S3	S1	0.484	0.235	0.0192
S4	P4	0.451	0.204	0.0307
S4	S3	0.445	0.198	0.0333
P5	P2	0.442	0.196	0.0346
P5	E2	0.442	0.195	0.0348
P2	E1	0.435	0.189	0.0379
P3	P1	0.426	0.181	0.0427
S5	S3	0.424	0.180	0.0439
S5	P3	0.419	0.175	0.0468
P2	E2	0.418	0.175	0.0473
S1	E4	-0.444	-0.197	0.0338
S3	E3	-0.446	-0.199	0.0327

A generally low level of linear correlation was confirmed by the Principal Component Analysis (PCA). PCA aims to reduce the original data spectrum into a smaller number of artificial “mixed” dimensions, called principal components, on the condition of retaining a substantial portion of the overall data variability. Those new dimensions are computed based on the covariance between original variables; therefore, the high level of a potential compression indicates many close correlations among variables. In case of the energy transition factors, we observed a slow accumulation of a variance across the subsequent principal components, reaching 95% of the overall variance only around the 10th component (Figure 8-2). This fact indicated that one should expect only few strong linear relationships between the factors. Other than that, factors appeared independent.

Figure 8-2. Cumulative proportion of variance captured by the subsequent components of the principal component analysis (PCA) performed for all projects (green line), excluding the projects assessed by Ecologic (blue line), and excluding the projects assessed by the University of Salford (red line).



Relative strength of the dependences discovered by different logistic models was compared based on term coefficients. Higher coefficients indicated the higher likelihood of getting a successful score[35] of the response factor as the explanatory factor increased by a unit, and therefore, it pointed to a stronger dependence. Exponentiated, the term coefficient can be understood as the odds of success, that is the ratio between the probability of success and the probability of failure. For instance, odds of 4 indicate that the chances of success are 4 to 1, that is 4 out of the 5 cases, equivalent to a probability of 80%.

Significance of a given coefficient was tested with the Wald-test, preserving only models with the significance of at least 95% (p-value <= 0.05). Significance of the whole model was assessed with the drop-in-deviance test (also called the likelihood-ratio test) which reached above 98% in all of the previously retained cases. Goodness of fit was measured based on the Akaike Information Criterion (AIC). As the particular value of AIC depends on the specific data, the indicator does not have an objective meaning. However, it helped with the relative comparisons of models estimated based on similar variables, indicating a better fit as the AIC value decreased. Finally, stability of a model was tested in terms of a standard deviation of a term coefficient across the 1000 model iterations based on the sample of observations randomly decreased to 80%.

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[35] A term “success” refers to a modelling process and not to an actual success of a project in the field of energy transition. In this case, a success is simply a situation of getting a response variable of 1, which corresponds to the original scores of 2 or 3 when modelling “key drivers” and to the scores of 0 and below for the models considering obstacles.

The first of several steps in testing the usability and comprehensiveness of the hypothesis (framework) was to study the 23 Anticipatory Experiences (see Caiati et al. 2013 and Caiati et al. 2014 for further information).

b. Initial qualitative review of results

The authors conducted an initial qualitative analysis to uncover trends and insights from the completed Assessment Matrix. In general, most factors contributed as drivers to the processes within the Anticipatory Experiences. That is, the majority of Factors on average had scores above 0 which means that they played a role in supporting energy transition, rather than obstructing it, in the Anticipatory Experiences.

- Factor S2: Citizens' engagement in the energy transition and Factor S5: Local informational and educational outreach registered the most scores of "3", suggesting that these were key drivers across the board in the Anticipatory Experiences.
- The Factors that were least common to appear as a strong driver (score of 3) were: E1: Competency and training of technical professionals, P2: Project management and P4: Potential economic impact. These Factors are perhaps less critical when considering energy transition at a supranational or international level.
- The domain with the greatest occurrence of scores of 3 (key drivers) was the S-domain *Social, Political Movement and Grassroots Factors* (in comparison to the E-domain *Market, External and Governance Factors* and the P-domain *Personal, Cultural and Site-specific Factors*).

c. Factors interrelated - Modelling whether drivers and obstacles depend on the performance of other factors

As already mentioned, in this part of the analysis we treat each of the 15 factors as a potential enabler or a barrier of the energy transition process. A factor was labelled as "key driver" for the projects with scores of 2 and 3 and as "obstacle" for the scores of 0 or lower.

Logistic regression indicated 16 statistically significant dependences among key drivers and 9 dependences among obstacles. Term coefficients received for the drivers' dependences were, in general, positive, which meant that the likelihood of a strong role of one driver within a project increased with the increasing score of another explanatory factor[36]. Term coefficients for obstacle models were systematically negative, pointing to an decrease in the likelihood of a driving force with the decrease of the predictor value. The values of coefficients exceeded 3 for the driver models and -2 for the obstacle cases. Comparing across the models, higher absolute value of coefficient suggested stronger dependence with the probability of "driver" or "obstacle" concentrated around just high absolute scores of explanatory factors. This effect of the coefficient value can be well observed across the plots in Figure 10-3.

A substantial portion of discovered dependences involved interactions among S-factors. Among driver models, the strongest dependence was observed between *Funding and Ownership* (S2) and *Citizens' engagement in energy transition* (S1).

[36] An exceptional case of the negative dependence in E3 ~ S3 model was prone to the biggest instability and with the highest AIC coefficient, which made it the least reliable across all models.

Interestingly, the relationship was bidirectional as well as mirrored in the obstacle analysis (see Figure 10-3a, b). The strongest dependence across the obstacle models was spotted for the *Citizen's engagement* (S2) on the *Orientation to change* factor (S3). The corresponding relationship in terms of drivers was significant in both directions (S2~S3 and S3~S2) but was prone to substantial deviation of a coefficient and thus less reliable. Another model relating two S-factors considered the driver in the *Orientation to change* factor dependent on the *Political programming, leadership and regulations* (S4). Nonetheless, the corresponding term coefficient was relatively low and AIC value relatively high compared to the aforementioned relationships of other S-factors.

Table 8-6 Statistically significant models for factors acting as drivers of the energy transition (getting a score of 2 or 3 for a given response factor).[37]

Response factor successful	**Explanatory factor**	**Log-odds** (term coeff.)	**Odds** exp(coeff.)	**Significance of the coeff.**	**Significance of the model**	**AIC**	**Stability of the model** (δ of coeff.)
S1	S2	3.510	33.448	0.0166	0.00001	15.262	0.172
S4	P5	2.088	8.069	0.0481	0.0017	23.846	0.226
E2	P1	1.694	5.441	0.0420	0.0072	18.027	0.279
S2	S1	1.529	4.914	0.0146	0.0004	21.266	0.227
S3	S4	1.003	2.726	0.0496	0.0168	26.551	0.275
P3	S5	0.989	2.689	0.039	0.0083	26.757	0.226
P3	S2	0.968	2.633	0.0184	0.0037	25.308	0.186
E2	S2	0.859	2.361	0.0377	0.0172	19.579	0.229
S2	P3	1.652	5.217	0.0148	0.0022	24.310	0.454
S5	P2	1.485	4.415	0.0277	0.0040	22.128	0.351
E2	S3	1.432	4.187	0.0338	0.0074	18.072	0.348
S2	S3	1.388	4.007	0.0209	0.0034	25.118	0.349
S4	P4	1.283	3.607	0.0362	0.0146	27.760	0.353
E2	S5	1.068	2.910	0.0230	0.0077	18.161	0.369
S3	S2	0.886	2.425	0.0216	0.0066	24.884	0.303
E3	S3	-1.020	0.361	0.0473	0.0195	30.384	0.489

Table 8-7 Statistically significant models for factors acting as obstacles of the energy transition (getting a score of less or equal 0 for a given response factor).[38]

Response factor (failing)	**Explanatory factor**	**Log-odds** (term coeff.)	**Odds** exp(coeff.)	**Significance of the coeff.**	**Significance of the model**	**AIC**	**Stability of the model** (δ of coeff.)
S2	S3	-2.178	0.113	0.0265	0.0005	15.891	0.184
P1	E2	-1.835	0.160	0.0495	0.0160	19.453	0.287
P1	S2	-1.839	0.159	0.0370	0.0003	12.211	0.147
P4	P2	-1.667	0.189	0.0310	0.0044	17.163	0.256
S2	S1	-1.538	0.215	0.0262	0.0017	18.216	0.254
S1	S2	-0.710	0.492	0.0416	0.0245	25.345	0.104
S2	P3	-1.433	0.239	0.0407	0.0133	21.960	0.383
P1	E5	-1.804	0.165	0.0353	0.0086	18.343	0.329
P1	S3	-1.432	0.239	0.0338	0.0074	18.072	0.359

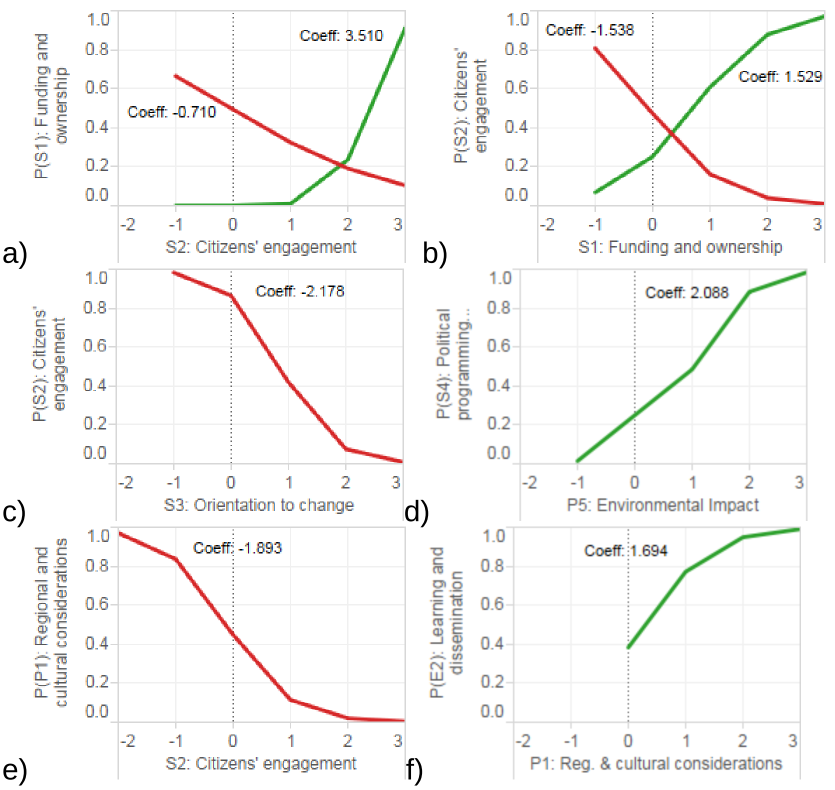
[37] Models are sorted according to the terms coefficient, indicating strength of a discovered dependence, and split into two groups of stability – more reliable with δ < 0.3 (grey shading) and less reliable with δ >= 0.3.
[38] Models are sorted according to the terms coefficient, indicating strength of a discovered dependence, and split into two groups of stability – more reliable with δ < 0.3 (grey shading) and less reliable with δ >= 0.3.

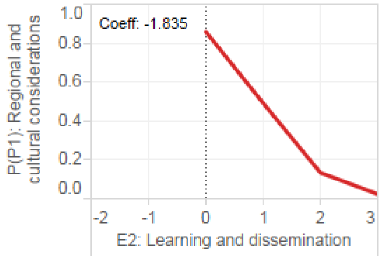
S-factors were also discovered to commonly interact with factors from the E- and P-domains, both as response and explanatory variables. High scores in the *Political programming, leadership and regulations* factor (S4) were found to depend on the positive scoring of the *Potential environmental impact* (P5) with a relatively high coefficient of 2 (Figure 8-3d). Another example was the factor *Regional and cultural considerations in design* (P1) as an obstacle which was likely to occur with low levels of *Citizen engagement* (S2) (Figure 8-3e).

Among interactions between factors across E- and P- domains, the strongest one was found between the *Regional and cultural considerations in design* (P1) and *Learning and dissemination beyond the region* (E2) which was also bidirectional (Figure 8-3f,g). While P1 as an obstacle became more likely with the poor performance in E2, E2's performance as a driver was prone to depend on the increased scores of P1. Another considerable relationship occurred with *Potential economic impact* (P4) as an obstacle dependant on *Project management* (P2). Less profound relationships, together with the corresponding parameters, can be read from Tables 8-6 and 8-7.

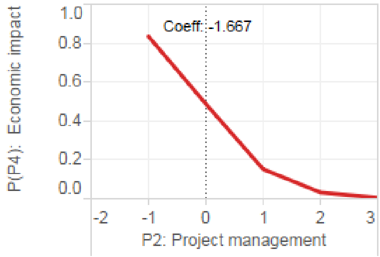
The final observation concerned two factors which did not exhibit any significant relations with the remaining factors, neither in terms of success nor failure. These were E1 – *Competency and training of technical professionals* and E4 – *Market and technological trends* which seem to act independently from the rest of factors.

Figure 8-3. Probability of factors serving as drivers (green) or obstacles (red) for the most profound dependences discovered between the energy transition factors.




P(P1): Regional and cultural considerations
Coeff: -1.835
1.0
0.8
0.6
0.4
0.2
0.0
-2
-1
0
1
2
3
E2: Learning and dissemination

g)


P(P4): Economic impact
Coeff: -1.667
1.0
0.8
0.6
0.4
0.2
0.0
-2
-1
0
1
2
3
P2: Project management

h)