

# A Foresight Exercise in the Energy Sector to 2050

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This Hot Energy Topic aims at defining and assessing megatrends impacting the future energy system of the European Union (EU) to the year 2050. This paper discusses the results of an internal opinion pool, targeted at INSIGHT\_E’s energy experts, and, performed between 13<sup>th</sup> and 29<sup>th</sup> January 2016. The survey allowed respondents to assess the impact of megatrends on three specific impact areas: energy consumption, greenhouse gas emissions and affordability, in the EU. This paper provides insights on the underlying impact of each megatrend on the energy system, on the degree of uncertainty of the impact outcome, and on how a foresight analysis can support policy development towards the European Union’s long term decarbonisation objectives of 80-95% to 2050 compared to 1990.

The term “**megatrends**” was shaped in 1982 by John Naisbitt<sup>1</sup>, who described them as “large social, economic, political, and technological changes, (...), they influence us for some time – between seven and ten years, or longer.”

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Impact to 2050 <sup>2</sup> on...		
...energy consumption ▼	...GHG emissions ▼	...affordability ▼
EU Primary Energy Consumption 1,777 Mtoe in 2014	EU GHG missions 4,611 Mt CO <sub>2</sub> equivalent in 2013	EU Energy Import Bill: 300 bn Euros in 2013

The results from the survey on the megatrends generally indicate a relative decoupling<sup>3</sup> of energy consumption and greenhouse gas emissions towards 2050. This means a lower rate of growth of energy consumption relative to greenhouse gas emissions. The relation to other impact areas (energy consumption and affordability) varies from one megatrend to the other.

<b>Geopolitics, global governance and resource management</b>	The geopolitical dimension related to global security remains a key determinant of energy markets in 2050. In this context, Europe will gain from import diversification. Europe will be well positioned in clean energy and innovation policies. A negative impact on affordability is expected due to rising scarcity of rare earth metals and water resources.
<b>Demographics - Urbanisation</b>	A majority of the demographic and urbanisation megatrends will lead to a decrease in energy consumption and a relative decoupling of energy and emissions.
<b>Digitalisation</b>	Digitalisation megatrends will lead to an increase in overall energy consumption, particularly electricity. There is a clear consensus that a reliance on digitalisation will penetrate daily life and that a relative decoupling of energy and emissions will be attained.
<b>Behavioural and social trends</b>	Social individualization <sup>4</sup> will lead to an increase in energy consumption. Decentralisation of political power is foreseen to have a negative impact on affordability. Connectivity (mainly social media use) will lead to higher energy consumption.

<sup>1</sup> Naisbitt, John, Megatrends - Ten New Directions Transforming Our Lives, New York, 1982.

<sup>2</sup> European Commission and EC “In-depth study of European Energy Security” COM 2014/330

<sup>3</sup> Two kinds of decoupling can be distinguished: *Relative* decoupling indicates that the rate at which GHG emissions increase is lower than the rate at which energy consumption increases. In contrast, *absolute* decoupling means that an increase in energy consumption would not go along with an increase in GHG emissions.

## Geopolitics, global governance and resource management

The energy map reflects the geographically dependent nature of resource extraction feeding the world's energy demand. This geographical dispersion provides the foundations of the geopolitical dimension related to energy markets. The degree of coordination among oil producers (the Organization of Petroleum Exporters Countries - OPEC) encompassing rising unrests in producing countries (Middle East, Venezuela), and its interactions with the main consuming regions (United States, Europe, Asia)<sup>4</sup>, characterize this megatrend. The global trend towards renewables can also be considered as having a specific geopolitical dimension<sup>5</sup>. Climate change leading to an average temperature rise creates new challenges in relation to the use of water for energy production<sup>6</sup>.

### Military conflicts and terrorists' threats

Physical military interventions may halt energy trade and lead to energy prices' spikes, thereby affecting energy affordability for consuming regions<sup>7,8</sup>.

*60% of survey respondents agree on the fact that military conflicts and terrorist threats will be manifested in 2050 and that they will contribute to sustained energy prices' uncertainty. The consortium thinks that import diversification is the most relevant policy action for Europe in such a scenario.*

<sup>4</sup> The new economics of oil, Oxford Energy Studies, October 2015

<sup>5</sup> European Union Institute For Security Studies : Renewables: do they matter for foreign policy?, Iana Dreyer, 2013

<sup>6</sup> Water and Energy in the GCC: Securing Scarce Water in Oil-Rich Countries, Ifri, Laura Parmigiani, September 2015.

<sup>7</sup> International Energy Security: Common Concept for energy producing, consuming and transit countries – Energy Charter Secretariat – 2015.

<sup>8</sup> Changes in geopolitics, political economy and markets alter the energy landscape <http://www.brookings.edu/~media/research/files/reports/2015/05/def-2015/english-pdf.pdf>

## Energy efficiency policies - European clean energy and innovation policies - Energy transit diversification

**Energy efficiency policies** encompass product- and fuel-based efficiency measures. In energy efficiency, megatrend characterization needs to take into account the 'rebound effect' whereby energy efficiency measures can lead to increasing the energy used, thereby minimising the expected impact from initial savings.

*100% of survey respondents agree (while 30% strongly agree) with the perspective of new energy trade routes providing import diversification to Europe. Only 30% of survey respondents consider that Europe need actively focusing on energy efficiency, as a policy response to supply scarcity. This response may be interpreted as a fear that supply diversification benefits may be offset against the perspective of lower energy demand. The majority of respondents (60%) consider that Europe will act as a "reference" player in renewables and clean energy.*

### New actors in international policy making

Since late '90s, climate knowledge and awareness is spreading to a wider group of stakeholders<sup>9</sup>: Non-Governmental Organizations (NGOs), city-governing bodies and businesses. These aim at promoting the exploitation of clean modes of energy resources, and the phasing-out of fossil fuel energy subsidies.

*A majority of survey respondent (50% of survey respondents agree or strongly agree) consider that non-state actors will gain more influence in global governance.*

<sup>9</sup> The Role of Non-State Actors in the International Climate Change Negotiations: Understanding Agency through Functionality Profiles, Nasiritousi, Hjerpe, Linnér, *Science and Policy Research, Linköping University, Nya Kåkenhus, SE-601 74, Norrköping, Sweden*

### Africa and India's access to energy

By 2050, Africa and India bring a revolution in the form of clean and accessible access to energy. This allows them to meet their massive energy needs and to support economic development.

*80% of the respondents are neutral or disagree with the rapid development of Africa and India in clean access to energy.*

### Increasing relevance of critical metals and rare earth in energy technologies

Modern technologies, either renewable energy carriers demanding energy conversion technologies, e.g., Neodymium/Dysprosium in case of wind energy, or energy using devices, require critical metals or rare earth. Their characteristics allow for higher energy and resource efficiencies coupled with fairly smart technologies, like smart meters and appliances. As a result, critical metals and rare earth could become strategic raw material sources.<sup>10</sup>

*A slight majority (60% of respondents) predicts increasing relevance of critical metals and rare earth on the affordability of energy in future European energy system. Respondents unanimously consider that the impact on the European energy system due to amongst others increasing costs and dependency of resource policies of foreign countries, like China, shall be negative.*

### Water scarcity

Climate change is likely to influence the affordability of water in many regions and thus will impede its use for energy purposes, e.g., limited availability of water as cooling agent and to produce hydro power.<sup>11</sup>

Due to climate change, water availability in some southern European regions are expected to decrease.

*Half of the respondents consider that the impact on energy consumption is most important. But no clear-cut opinion can be identified. 60% of survey respondents expect an increase in energy consumption. Contrasting this, those who favour affordability (40%) as a most important impact, expect unanimously negative impacts of water scarcity on affordability of energy.*

### Survey Conclusion - Geopolitics, global governance and resource management

INSIGHT\_E's view is that the geopolitical dimension related to global security will remain a key determinant of energy markets evolutions. In a context of global insecurity and uncertain energy prices, the consortium considers that Europe will gain from import diversification. The majority of respondents consider that Europe will lead in clean energy and innovation policies relative to other major consuming regions like Africa or India.

Meanwhile, INSIGHT\_E does not perceive a clear shift in the patterns of global governance, in relation to the climate agenda. In the management of rare earth and water resources, the consortium sees a negative impact on affordability as likely. It tends to consider that the impact on energy consumption will be, however, positive.

<sup>10</sup> Adamas Intelligence (2014): Rare earth market outlook: supply, demand and pricing from 2014-2020. Sudbury.

<sup>11</sup> Koch, H.; Vögele, S.; Kaltofen, M.; et al (2014): Security of water supply and electricity production: Aspects of integrated management. Water resources management, 1987(28), pp. 1-14.

## Demographic change and urbanisation

In the years to come, the world population will continue to grow and reach 9.7 billion by 2050 whereas Europe's population is projected to shrink by 12.5%<sup>12</sup>. **In Europe the population is expected to be over 80% urbanised by 2050<sup>13</sup>. A specific feature of urbanisation is the emergence of megacities with more than 10 million inhabitants.** At the same time, the life expectancy and the share of elderly will increase. Demographic development shows regional differences, as measured by the indicators of population and birth rate, life expectancy, ageing population and migration.

**Ageing of the population  
Individualisation of society  
Decrease in potentially active employees  
Social individualization / Decline of collective institutions**

These four megatrends are closely related, because an ageing population leads to more single-person households and a lower number of potentially active employees. The diverse energy needs of individuals greatly impact the ability of politicians to harmonise a policy response.

Declining birth rates and increasing life expectancy will lead to an ageing of the population in EU countries. As shown by Figure 1, Italy and Germany are particularly affected by this trend today. The share of the EU population aged 65 and older almost doubled between 1950 and 2010 from 8.2% to 16.2%. In 2050, more than one out of every four will be aged 65 or older. By 2050, 24 European countries are expected to have a ratio of less than 2 potentially active employees (aged 20 to 64) per retiree ( $\geq 65$ ).<sup>14</sup> The ageing of society will influence

<sup>12</sup> United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. ESA/P/WP.241.

<sup>13</sup> UN 2014: United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).

<sup>14</sup> Federal Agency for Civic Education 2011 : Altersstruktur und Bevölkerungsentwicklung,

energy consumption due to changing lifestyles, housing conditions and consumption habits. For example, **the rise in elderly single-person households will play a role in higher energy consumption per capita**, also as a result of the "remanence effect"<sup>15</sup>. Simultaneously, the requirement for motorised mobility is likely to decrease reducing the utilisation of existing infrastructures and the mobility-induced emissions.

Similarly, the younger population strives for individuality, which entails new forms of living and dwellings, such as a decreasing number of household members. This will lead to **higher energy consumption per capita due to a higher use of electronic devices and appliances.**<sup>16 17</sup> In 2014, 33% of all EU-28 households were single-person households, with Sweden and Denmark holding the highest shares.

Small families and single households dominate the structure of urban areas (to a larger extent) and rural areas (to a lesser extent). Furthermore, stable social ties are coming under stress, as traditional understanding of collective institutions is changing, e.g. growing share of patchwork families<sup>18</sup>. Changes in work orientation, in organisational strategies and in consumer preferences pose unique challenges to the business world, e.g., in terms of an increasing heterogeneity of consumer needs<sup>19</sup> and, potentially, to policy makers.

<http://www.bpb.de/nachschlagen/zahlen-und-fakten/europa/70503/altersstruktur>

<sup>15</sup> The heat energy consumption habits of the elderly remaining in the (relatively above-average sized) family home becomes inefficient

<sup>16</sup> Lapillonne, B., Pollier, K., Samci N. (2015): Energy Efficiency Trends for households in the EU. <http://www.odyssee-mure.eu/publications/efficiency-by-sector/household/household-eu.pdf>. 18.03.2016.

<sup>17</sup> Eurostat 2014: Household composition statistics 2014, [http://ec.europa.eu/eurostat/statistics-explained/index.php/Household\\_composition\\_statistics](http://ec.europa.eu/eurostat/statistics-explained/index.php/Household_composition_statistics)

<sup>18</sup> OECD: Trends shaping education 2016, Paris, 2016

<sup>19</sup> Huppés 1987: The Western Edge: Work and Management in the Information Age, Kluwer Academic Publishers, Dordrecht.

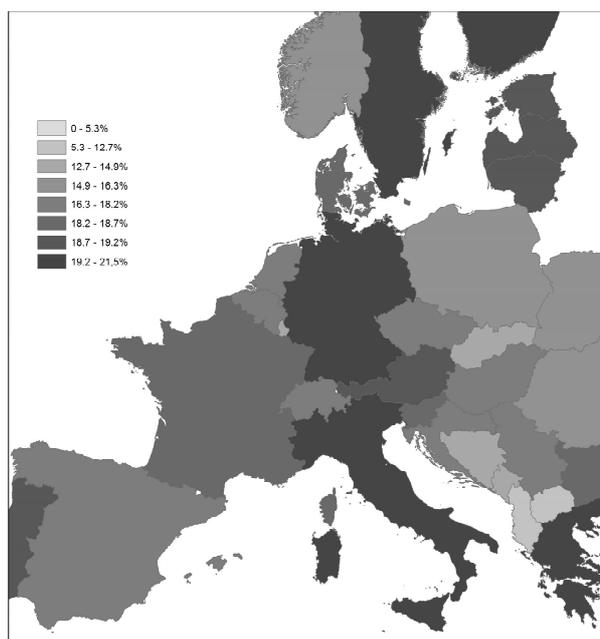


Figure 1: Percentage of population in European countries aged 65 and older (based on data from The World Factbook<sup>20</sup>)

Only about 40% of survey respondents agree that this megatrend leads to a decoupling of energy and emissions, while overall an increase in the energy consumption can be expected, especially due to the increased number of singles. Surprisingly, the decrease in potentially active employees is not expected to have a significant impact on energy consumption.

80% of survey respondents declare that the most significant impact factor of social individualisation is energy consumption, where a likely increase of energy consumption is expected. 20% favours a positive impact on affordability.

### Migration

Migration can have a positive impact on economic and social development by rebalancing labour markets and accelerating innovative ideas and technologies. Migration flows can also influence the age structure and the population size. Recently, the inflow of migrants and refugees into Europe in 2015

<sup>20</sup> The World Factbook 2013-14: Washington, DC: Central Intelligence Agency 2013, <https://www.cia.gov/library/publications/the-world-factbook/fields/2010.html>

exceeded one million, mostly affected by poverty and current conflicts in countries of the Middle East and Africa.<sup>21</sup> In the future, economic and demographic asymmetries between countries are likely to remain driving forces of migration (UN 2015).

*Only 40% of survey respondents agreed that migration leads to a decoupling of energy and emissions, while the respondents were split on whether this would lead to an increase of energy consumption or have no impact.*

### Urbanisation and megacities

#### Shrinking regions in Europe Sustainable city development

While in 1990 there were 10 megacities worldwide the number today has nearly tripled, of which the majority is located in the global south. In Europe, London and Paris have metropolitan areas which are considered megacities.<sup>22</sup>

The ongoing process of urbanisation promotes the emergence of megacities. In parallel with the trend of growing urbanised regions there are shrinking regions due to rural exodus entailing negative impacts in terms of a raising average age of population, declining innovative capability, levels of income and reduced access to the public transport network. The resulting induced loss of tax revenues and real estate values remain a significant concern.

In order to limit the accumulation of negative impacts associated with growing urbanisation (congestion, air pollution, social divide, dilapidated districts) **sustainable city development and smart city concepts will attain a greater significance in order to maintain and improve quality of life and economic competitiveness.** The conceptual prioritisation is diverse and may include the development of efficient traffic systems and interfaces and the improvement of intermodal

<sup>21</sup> Eurostat 2016: Asylum quarterly report, [http://ec.europa.eu/eurostat/statistics-explained/index.php/Asylum\\_quarterly\\_report](http://ec.europa.eu/eurostat/statistics-explained/index.php/Asylum_quarterly_report)

<sup>22</sup> UN 2014: United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).

passenger transport.

*In general, experts do not strongly agree that either of these three megatrends will lead to a decoupling of energy and emissions. However, with regards to energy consumption, while Urbanisation and Megacities is expected to lead to a slight decrease in energy, Shrinking regions is believed to have no great impact on energy consumption, and Sustainable city development will lead to a moderate decrease in energy consumption, where cities are both the cause and the solution of the problem.*

### European regions form development clusters

In recent decades, growth regions have emerged across Europe. Examples include Paris, London, Catalonia, parts of Baden-Wuerttemberg and Bavaria in Germany and the region around Milan. These development clusters prosper disproportionately, tending to become increasingly attractive to immigration and as potential models for other regions.

*Only 30% of survey respondents agreed that this megatrend leads to a decoupling of energy and emissions, while in general no impact on energy consumption is to be expected.*

### Survey Conclusion – Demographic change and urbanisation

INSIGHT\_E's view is that the majority of the demographic change and urbanisation megatrends will lead to a decrease in energy consumption and will generally lead to a decoupling of energy and emissions. However, certain megatrends show uncertainty as to whether energy consumption will increase or not have an impact at all. This leads to potentially misleading conclusions, but at the same time points to the need to further research the links between megatrends and energy consumption.

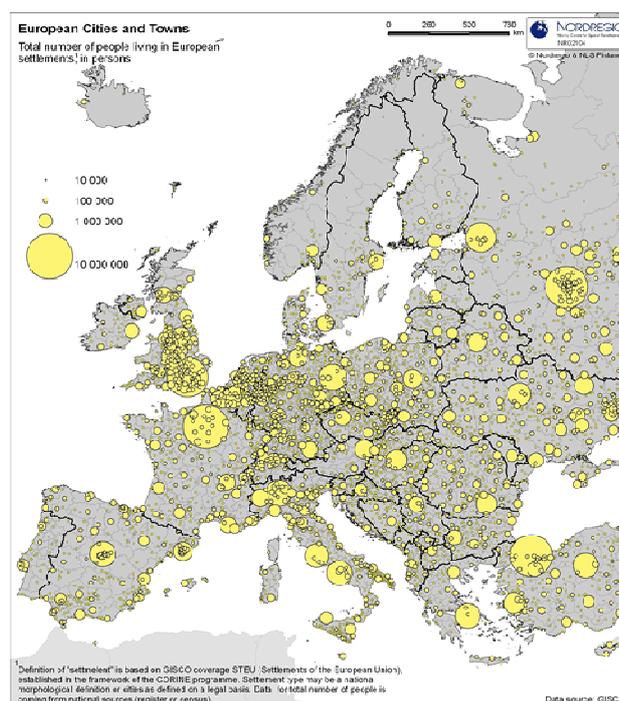


Figure 2: Urbanisation in Europe<sup>23</sup>

### Digitalisation

Internet and communication technologies (ICT) have become widely available to the general public where about 80% of all EU-28 households have access to the internet.<sup>24</sup>

The Web 3.0 (Internet of Things) already connects billions of objects to the Internet using computers, smartphones and tablets. Physical products can be equipped with sensors and transducers to send information or to receive instructions. Radio-frequency identification (RFID) chips are even capable of locating mass-produced products. The transformation in industrial production is accompanied by the penetration of digitalisation in everyday life. The so-called digital natives have already created a collaborative culture. Digitalisation and virtualisation lead to temporal and spatial decoupling of social activities and processes

<sup>23</sup> <http://www.nordregio.se/en/Maps--Graphs/08-Urban-and-regional-divisions/European-cities-and-towns/>

<sup>24</sup> [http://ec.europa.eu/eurostat/statistics-explained/index.php/Information\\_society\\_statistics\\_-\\_households\\_and\\_individuals](http://ec.europa.eu/eurostat/statistics-explained/index.php/Information_society_statistics_-_households_and_individuals)

while simultaneously accelerating these. Constant availability on the Internet - "always on" - is a reality in most countries.

### **Online trading and e-commerce displacing "traditional trade"**

Online trading, encompassing the marketing and sales of goods and services via the internet, is already very popular. The personal contact between the customer and the provider of goods and services is gradually replaced by virtual relations.<sup>25</sup> In 2014 50% of all individuals in the EU-28 aged 16 to 74 ordered goods or services over the internet for private use.

**60% of survey respondents agreed that online trading leads to a decoupling of energy and emissions.** While personal energy consumption will decrease, there will be a shift in this energy consumption towards deliveries, but at the same time a reduction in the energy required to power shop buildings. **Expert opinions are split between the energy consumption increasing or decreasing.**

### **Intelligent infrastructure becomes increasingly significant**

#### **Internet of Things connects everything with the Internet**

These two megatrends are closely related, because intelligent infrastructures enable Internet of Things (IoT) by connecting physical objects to the internet allowing communication and interaction: people, electronic devices and sites (via webcams) will be connected with permanently updated information networks. Intelligent infrastructures can be employed in multiple sectors: energy and water supply, mobility, buildings, and communication.

*60% of survey respondents agreed that intelligent infrastructures lead to a decoupling of energy and emissions, while increasing the overall energy consumption. In this regard, automation would enable demand*

<sup>25</sup> [http://ec.europa.eu/eurostat/statistics-explained/index.php/Information\\_society\\_statistics\\_-\\_households\\_and\\_individuals](http://ec.europa.eu/eurostat/statistics-explained/index.php/Information_society_statistics_-_households_and_individuals)

*response applications to reduce peak electricity consumption. 50% of survey respondents agreed that the Internet of Things lead to a decoupling of energy and emissions, while the opinion is split on whether the energy consumption will increase or have no impact.*

### **Robotics and automation become the dominant form of manufacturing Industry 4.0 becomes reality**

Robotics replace manual production and aims at increasing overall efficiency and reducing operating costs. After penetrating manufacturing processes, robotics also becomes part of the households (robot vacuums). Future potential areas of application are medical robots supporting surgery and care robots.

Robotics and automation pave the way for Industry 4.0. The intelligent factory of the future connects production processes with modern information and communication technologies. This will enable production equipment to coordinate manufacturing processes or raw materials/products to manage their completion independently.

*50% of survey respondents agreed that robotics and automation lead to a decoupling of energy and emissions, while increasing the overall energy consumption, particularly in electricity. Only 33% of survey respondents agreed that Industry 4.0 will lead to a decoupling of energy and emissions, while increasing the overall energy consumption.*

### **Survey Conclusion - Digitalisation**

INSIGHT\_E's view<sup>26</sup> is that the majority of the digitalisation megatrends will lead to an increase in overall energy consumption, particularly electricity. There is also a clear agreement that a decoupling of energy and emissions will be attained. However, there is also a certain level of uncertainty regarding whether the consumption will decrease or simply shift towards other services. There is a clear agreement that a reliance on digitalisation will penetrate daily life.

<sup>26</sup> See Figure 1 in the Appendix

## Behavioural and social trends

Technological progress in the last decades allows for a better adapting of individual life style to personal perceptions of individual life (e.g., due to the market entry of affordable mobile phones).

Pushed by technical progress the demands for skilled personal in industries and services will increase. A consequence is improved education and changes in the organization of work, and also in the demands of individuals, which could be seen as a 'pull' factor for further technical progress.

The transformation of the energy systems to 2050 will be driven by a societal vision of how such a future system should look like.

### Connectivity leads to a "mood of openness"

Individualization accompanied by advances in IT-technologies lead to a "mood for openness" ie a broad willingness to share information using social media<sup>27</sup>. Energy-relevant information can be spread more smoothly.

*The vast majority (70%) sees the impact on energy consumption as the most important one. However, the direction of the impact is rather disputed: a small majority expects an increasing energy consumption (57% vs. 43%). The remaining respondents see in (20%; positive impact) and greenhouse gas emissions (a negative impact is likely) the most relevant impacts on the energy system.*

### Increasing educational attainment

Knowledge-based economies with improved offers for e-learning and enhanced income prospects promote an increasing educational attainment.<sup>28</sup>

The possible channels to shape the future energy systems are manifold:

- Increasing demand for energy related products and services;

- E-learning is energy dependent, but fewer paper products could be required;
- Substitution of energy-intensive outputs by less-energy intensive service demands;
- New network patterns and increased data transmission and data storages (cloud computing) expected.

*A slight majority of the respondent (56%) chooses energy consumption as the most important impact factor; mitigating impacts of increased educational attainment are unanimously expected.*

*A minority (33%) sees enhanced affordability of energy as most relevant, projecting a positive impact. The rest considers reduced greenhouse gas emissions as most relevant.*

### Decentralization of political power

Advances in global education and IT-technology have helped allow individuals to push for transparency and participation in government and public decision-making. In (some) European countries a new role for governments in public decision-making could happen<sup>29</sup>.

*The majority of respondents (75%) considers the impact on affordability as most dominant. A two-third majority expects a negative outcome, due to a decentralization of political power. The assessments of the rest of respondents are equally distributed to consumption of energy (mitigating impact) and on greenhouse gas emissions (lowering is likely).*

### Survey conclusion – Behavioural and social trends

Based on the survey results, the most undisputed connection between a megatrend and an impact factor is the case of **social individualization that will lead to an increase in energy consumption.**

<sup>27</sup> KPMG: Future state 2030: The global megatrends shaping governments, 2014.

<sup>28</sup> OECD: Trends shaping education 2016, Paris, 2016.

<sup>29</sup> KPMG: Future state 2030: The global megatrends shaping governments, 2014

## Conclusions

This paper is limited to the analysis of each megatrend on underlying impact factors. Although, it does not directly correlate a relative future weight to the assessment of each megatrend up to 2050, some conclusions can be inferred from the above discussion.

The survey reflects the view that **geopolitics** mainly impact energy markets through the supply dynamic of import dependency, resource scarcity, and supply diversification. Towards 2050, Europe will remain an energy importer on the global energy market, but the diversification of imports to the energy system will alleviate risks of external dependencies and will mitigate the impact of **geopolitics** on the energy system.

**Europe's internal trends of demographic change and urbanisation, together with behavioural and social trends, will have far reaching impacts that, will tend to exert a certain unpredictable degree of pressure on energy consumption** – with the ageing population and increased single households increasing consumption, but increased awareness and more efficient technologies decreasing consumption.

Looking at the megatrend **behavioural and social trends** the consortium sees in most cases the impacts on energy consumption as most important, yet the impacts are not always unidirectional.

- ⇒ According to the survey, a **"decentralization" of the political system** has an adverse impact on affordability. This highly disputable result has to be analysed in more detail.
- ⇒ The megatrend towards **urbanisation** will affect how and where the population lives as well as the infrastructure required to service demands possibly leading to inequalities between regions. The related **demographic change**, such as the ageing population and increased number of single households will lead

to a need to design methods to harness the increasingly heterogeneous society.

- ⇒ Following the results of the survey, **social individualization will be leading to an increase in energy consumption.**

**Digitalisation** will shape industry 4.0 and will influence energy flows within the affected industries.

- ⇒ **A smart use of energy is to be expected. The precise impact of a smart use for the energy system is still unclear.** However, with the increasing energy prices and ever increasing number of poorer households, the total penetration of smart solutions for the residential sector is questionable and multi-pronged approaches should be explored to ensure that overarching energy and climate change objectives are still achieved with a diverse residential customer base.
- ⇒ **The expected increase in electricity consumption due to more online trading is coupled with a shift towards greater energy consumption with associated transportation services.** A specific policy response might look towards enhancing the coordination of logistics centres with international trade. Although this has local implications, the global nature of online trading could have far-reaching implications if the related environmental impact of international deliveries, where the market price of goods might be less than local options, is not evaluated in an environmental impact assessment.

The survey results indicate that **digitalisation together with behavioural and social trends can be considered as transformational trends**, having many interactions, in terms of their impact on the energy system, **while leading to a relative decoupling of energy and emissions.**

As a result, emission mitigation scenarios based modelling to 2050 for the European Union need to be complemented by impact assessment of digitalisation and behavioural and social trends.

Another uncertainty relates to the outcome of a global international climate agreement. Scenarios to 2050 also need to consider the degree to which **there will be a cohesive global governance framework in the field of climate action**. This could be assessed in terms of probability outcome of success vs failures of climate action. The success of a global governance will hinge upon further transformations of global energy demand through the electrification of the transportation sector or an enhanced role of biomass. However, for such a transformation to occur, global scarcity of food and water also need to be taken into account, as reported in the **2016 Global Risks Reports of the World Economic Forum<sup>30</sup>**.

*For further reading or information, please visit [www.insightenergy.org](http://www.insightenergy.org)*

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<sup>30</sup> Global Risks Report, 2016, 11th Edition, World Economic Forum,  
[http://www3.weforum.org/docs/GRR/WEF\\_GRR16.pdf](http://www3.weforum.org/docs/GRR/WEF_GRR16.pdf)

## Appendix: Survey Results

Table 1

Megatrend		
Digitalisation		
	Impact on energy consumption	Decoupling of energy and emissions
<b>1.1 Online Trading and E-commerce displace "traditional" trade</b>	- to +	Yes
<b>1.2 Digitalisation of media is established</b>	- to 0	No
<b>1.3 Robotics and automation become the dominant form of manufacturing</b>	+	Yes
<b>1.4 Intelligent Infrastructure becomes increasingly significant</b>	- to 0	Yes
<b>1.5 Internet of Things connects everything with the Internet</b>	0	Yes
<b>1.6 Industry 4.0 becomes reality</b>	- to +	No
Demographic Change and Urbanisation		
	Impact on energy consumption	Decoupling of energy and emissions
<b>2.1 The elderly makes up the majority of the population in Europe</b>	- to +	No
<b>2.2 The "single society" dominates and individualisation makes society diverse, but also unmanageable</b>	+	No
<b>2.3 The number of potentially active employees decreases</b>	0	No
<b>2.4 The influx of asylum seekers has a strong influence on future development</b>	0 to +	No
<b>2.5 Urbanisation and megacities lead towards a world of smart cities</b>	-	No
<b>2.6 European regions form development clusters</b>	0	No
<b>2.7 Shrinking regions in Europe become more widespread</b>	0	Neutral
<b>2.8 Sustainable City development is an important topic</b>	-	No

<b>Geopolitics and Global Governance</b>			
	<b>Impact on energy consumption</b>	<b>Impact on greenhouse gas emissions</b>	<b>impact on affordability</b>
<i>3.1 Military conflicts and terrorists' attacks put European energy import flows at risk</i>	-	0	-
<i>3.2 Europe accelerates energy efficiency measures while the rest of the world battles for resources</i>	-	-	+
<i>3.3 Opening of new energy trade routes constitutes a factor of transit diversification for Europe</i>	0	0	+
<i>3.4 Europe clean energy and innovation policies set out references for the rest of the world</i>	- to +	-	- to +
<i>3.5 NGOs, businesses and cities enforce a new climate change governance framework at local level</i>	-	-	- to +
<i>3.6 Africa and India bring a revolution in the form of clean and accessible access to energy</i>	-	-	- to +
<b>Behaviour and Social Aspects</b>			
	<b>Impact on energy consumption</b>	<b>Impact on greenhouse gas emissions</b>	<b>impact on affordability</b>
<i>4.1 Social individualization (small household in both rural and urban areas) and the decline in collective institutions</i>	+	0	+
<i>4.2 Connectivity leads towards a "mood for openness"</i>	+ to -	-	+
<i>4.3 Increasing educational attainment</i>	+	-	+
<i>4.4 Decentralisation of political power</i>	-	+	-(to +)
<b>Resource Management</b>			
	<b>Impact on energy consumption</b>	<b>impact on affordability</b>	
<i>5.1 Increasing relevance of critical metals / rare earth in energy technologies</i>	+	-	
<i>5.2 Water scarcity - Water feedstock for power generation becomes scarce</i>	- to +	-	

Figure 1: Survey results - Digitalisation

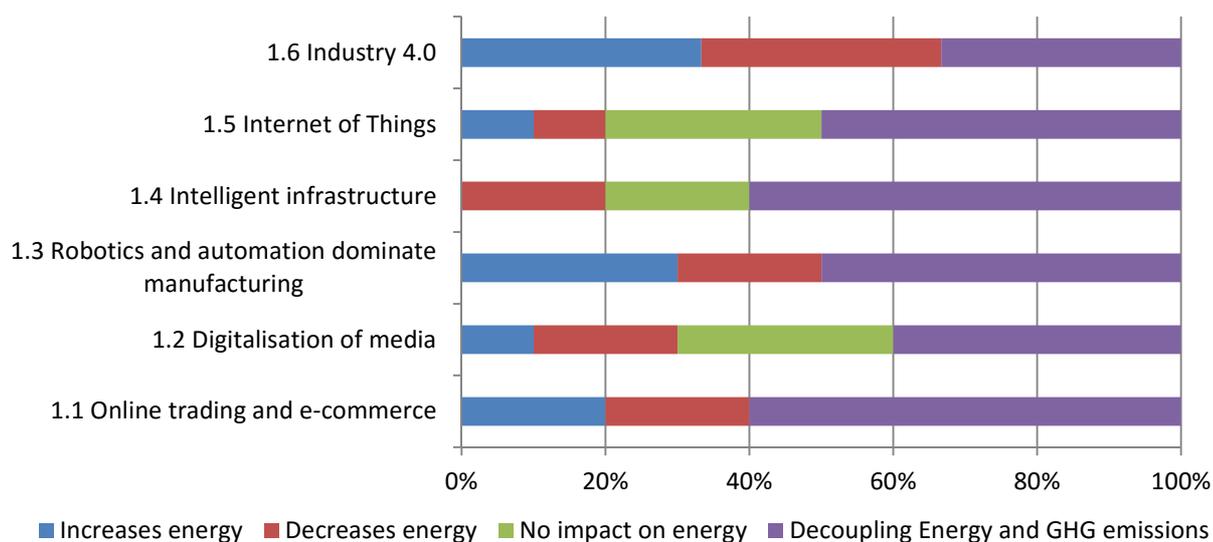


Figure 2: Survey results - Demographic change and urbanisation

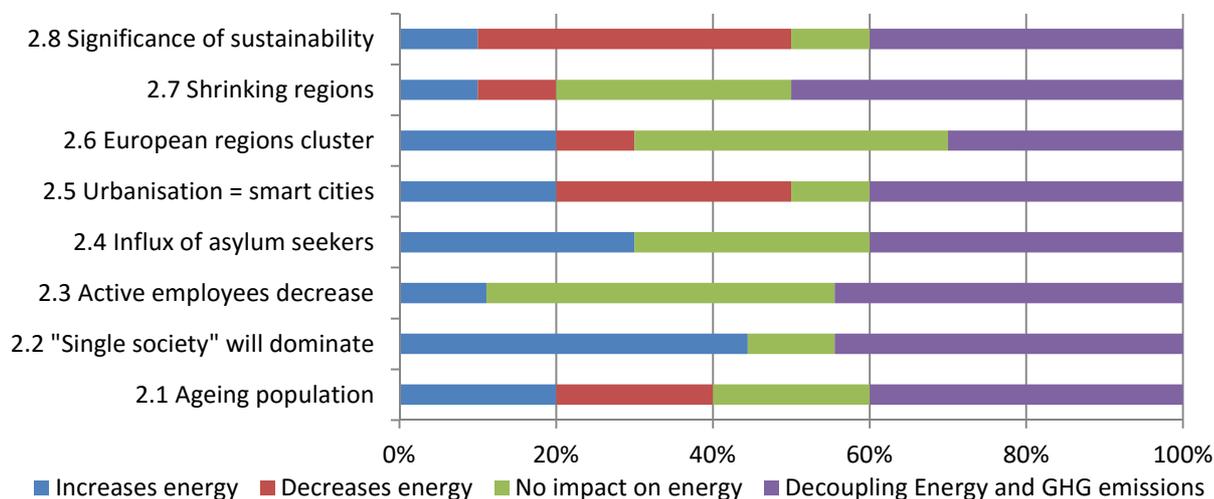
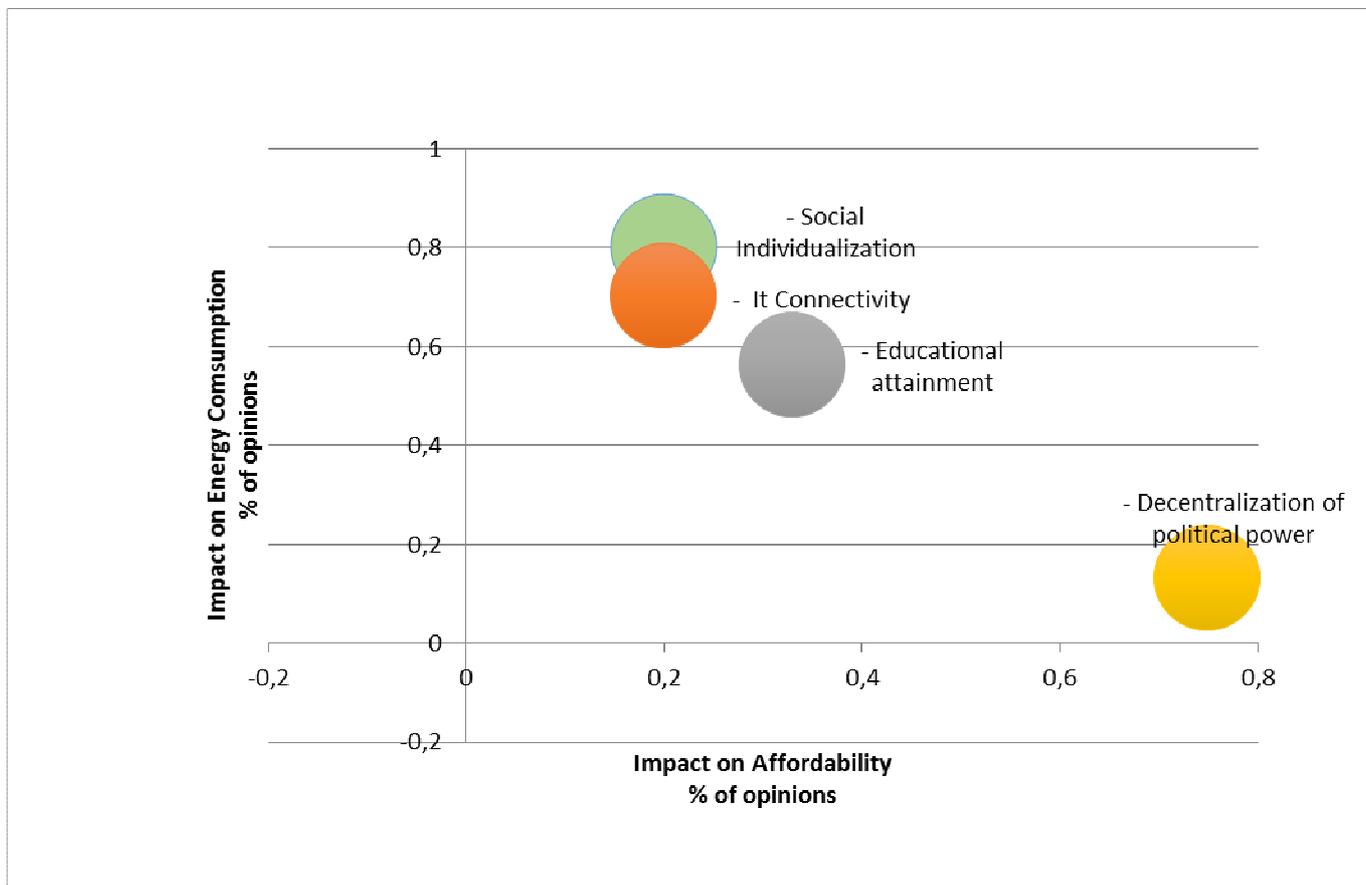


Figure 3: Mapping Behavioral and Social Trends



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Figure 4 : Survey Results : Geopolitics and Global Governance

