Understanding the controversial impact of new societal trends on long-term energy demand in European countries

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Keywords

energy policy, long-term scenarios, energy demand models, new societal trends

Abstract

The development of future energy demand is dependent on the complex relationship between technological and social innovations, the economic and political conditions that define societal behaviours and the influence of 'mega-trends' on systems. The beginning phases of the NewTRENDs project – the EU study commissioned under the H2020 program – was designed to identify and outline the elements of this complexity to improve upon the current state of energy demand models. We argue that to more accurately capture the system dynamics that effect energy demand, the traditional technology-focused modelling approach must be extended to account for new societal trends – emerging issues, institution shifts, conditions and additional factors that have substantial, and potentially disruptive, impacts on future energy demand.

In this paper, we identify the new societal trends that are expected to be most relevant or disruptive for future energy demand. This is done in three consecutive steps. First, we selected energy relevant new societal trends based on an analysis of previous foresight studies and long-term energy demand scenarios. Second, in three expert workshops the trends were clustered and their potential importance and disruptiveness was assessed. Third and finally, the narratives for the resulting 14 major new societal trend clusters were developed describing the potential mechanisms of their controversial impact and disruptiveness for future energy demand.

This paper builds the foundation for future work, where the identified trend clusters and narratives will inform the enhancement of energy demand models, which are frequently used to model European long-term energy and emissions scenarios. Furthermore, the narratives build the basis for scenario work and the cross-sectoral modelling of the trends. This contributes to a better understanding of potential non-linear developments of future energy demand and how energy (efficiency) policies could be designed to take these trends meaningfully into account.

Introduction

Climate change and environmental degradation present a significant threat to Europe and the world. To overcome these challenges, the European Commission has developed the European Union's (EU) new growth strategy called "The European Green Deal", aiming to make Europe the first climate neutral continent in the world by 2050, in line with the objectives of the Paris Agreement (UNEP, 2014). This action plan aims to make the EU's economy sustainable by moving to a circular economy to boost the efficient use of resources, restoring biodiversity and cutting pollution (European Commission, 2019a). In 2020, the European Commission presented a plan to reduce EU greenhouse gas (GHG) emissions by at least 55 % by 2030, compared to 1990 levels, in order to achieve climate neutrality by 2050 (European Commission, 2020a). This new target is based on a comprehensive impact assessment of the social, economic and environmental impacts of GHG emissions. Nevertheless, the European Parliament raised the bar even further, proposing a reduction of 60 % in 2030, compared to 1990 levels, and in-

sisted that both the EU and all individual member states must become climate-neutral by 2050 for the EU to achieve "negative emissions" (European Parliament, 2020).

The EU long-term strategy 2050 develops possible scenarios for a climate neutral EU in 2050 (European Commission, 2020b), aiming at the full deployment of all technology options, while other scenarios assume an increase in climate awareness of EU citizens translating into lifestyle changes and consumer choices, as well as a more circular economy (European Commission, 2020b). The achievement of the long-term EU climate goals implies the continued progress towards a low-carbon society, in which both technological and non-technological factors influence the success of reaching national and regional targets for energy and climate. Building from previous research, non-technological factors with the potential to impact future energy demand now have a broader framing as new societal trends.

New societal trends can be understood as societal changes that emerge from a) global and regional megatrends, b) socio-economic system shifts in response to policy or c) new or restructured institutions, d) global or regional events, and e) combinations of one or more of these factors that propels the emergence of the unexpected. This broad framing opens a mode for historically "niche" trends to enter into consideration for quantitative estimations – and create a new communication bridge for qualitative and quantitative approaches to long-term scenario development processes (Brugger et al., 2021). New societal trends have the potential to dramatically change future energy consumption and cross-sectoral demand because they are not simply the extrapolation of presently observed trends ("continuous or linear trends"), but represent manifold niche trends under a broader concept whose individual and collective effects may become disruptive if embraced by larger parts of the society. This definition of new societal trends includes:

- transition of consumers to "prosumagers";
- move towards a circular economy and a low-carbon industry;
- digitalisation of the economy and of private lives;
- trends towards a shared economy.

We acknowledge that some of these new societal trends, in particular digitalisation and its impact on energy consumption (e.g. IEA, 2017; EUSEW, 2019), but also the sharing economy (e.g. Perboli et al., 2018) and the circular economy (SITRA, 2018) have already received quite some attention in the literature. However, a full quantitative and consistent investigation of new societal trends in energy demand modelling, including the analysis of data and modelling gaps to quantification, is missing (European Commission, 2019b). Such an analysis can help to unveil the energy increasing and decreasing mechanisms that underlie the various trends and thus inform policy makers to address unintended effects of new societal trends as well as potentially disruptive trends early as they unfold (Fraunhofer ISI, 2019; EUSEW, 2019).

Currently, national low-carbon energy scenarios extending through 2050 developed in European countries take into account the general social context of energy transition (e.g. population, GHG intensity, average standard of living, education level etc.). However, non-technological factors that influence energy demand are often not yet integrated in these scenarios. A number of scenarios present a major step forward by integrating new societal trends, such as digitalisation, sharing economy, circular economy or prosumaging, but more progress is necessary to improve the empirical basis for new societal trends and their representation in models, in particular covering the demand side. In addition, not much research has been done on how new societal trends may play simultaneously in opposite directions (i.e. decreasing and increasing energy demand at the same time), as well as how they may reinforce or contradict each other. Additionally, the identification of policy measures needed to ensure new societal trends contribute positively to sustainable development, remains an open line of inquiry. Therefore, the main goal of this research is to identify potential new societal trends that may influence the future European energy demand, to assess their potential to effect change and to integrate these assessments into the relevant demand-side models for quantitative analysis in scenario development.

This research builds the foundation for future work within the NewTRENDs project, where the identified new social trend clusters and narratives will inform the enhancement of energy demand models frequently used to model European long-term scenarios. Furthermore, narratives of the new societal trends build the basis for scenario work and the cross-sectoral modelling of the trends in the continuing work of the NewTRENDs project. The process and results presented here contribute to a better understanding of potential non-linear developments of future energy demand, and might inform the design of energy (efficiency) policies to account for these trends in a meaningful manner.

Methodology

In this research, we identify and analyse the new societal trends that are expected to be most relevant or disruptive for future energy demand. We explicitly take trends into consideration, which might have increasing as well as those that might have decreasing effects. This is done in three consecutive steps (see Figure 1):

- **Step 1.** First, energy relevant new societal trends are selected based on an analysis of previous foresight studies and long-term energy demand scenarios.
- **Step 2.** Second, in three expert workshops the trends are clustered and their potential importance and disruptiveness is assessed.
- **Step 3.** Third and finally, narratives for the resulting 14 major trend clusters are developed describing the potential mechanisms of their impact and disruptiveness for future energy demand.

Environmental scanning (Slaughter, 1999; Toivonen and Viitanen, 2016) and horizon scanning (Cuhls, 2020; Könnölä et al., 2012) methodologies are essential to the factor discovery and identification in **Step 1**. To better facilitate the NewTRENDs workshop series, initial research focuses on identifying key *factors* – trends, social conditions, emerging issues, events – that create societal change and could influence future energy demand. These factors are gathered from a review of previously published foresight research including holistic assessments of

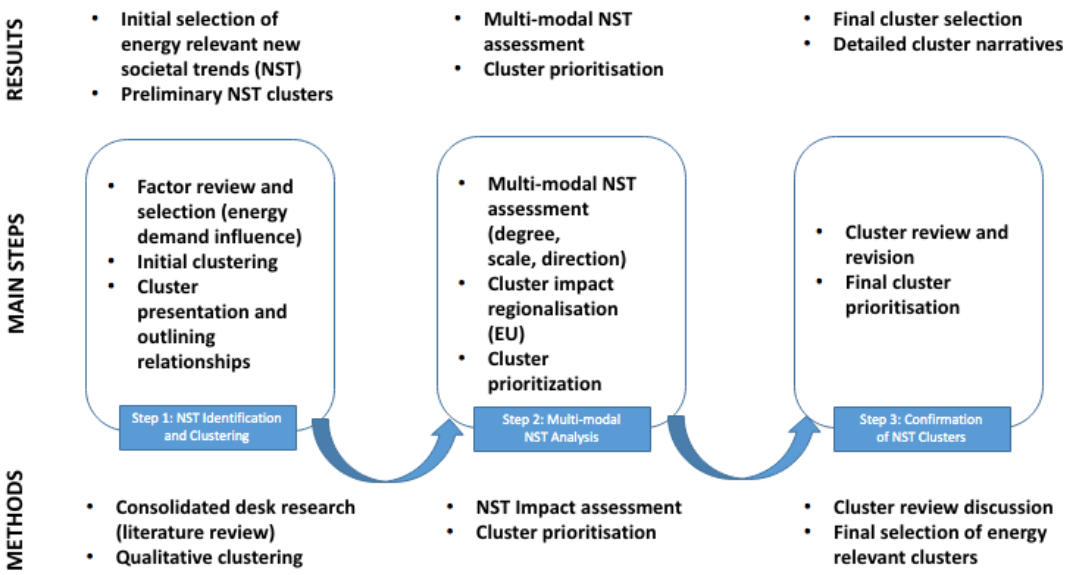

Figure 1. Process of selection of new societal trend clusters.

changes affecting the futures of the EU (European Commission, 2020c; Gaub, 2019), global systems of governance (Rosa and Roess, 2019), and social innovations (Warnke et al., 2019; Zweck et al., 2015).

In total, over 240 factors influencing societal change are identified through research and utilised as the basis for the first and the second workshops, each playing a central role in **Step 2** of this overall work. Starting with the identified factors, initial clustering is conducted to gather closely related factors into the broader new societal trend candidates (Glenn, 2003). The clustering exercise is run in parallel (Keenan and Popper, 2007) with a conceptual mapping activity that encourages participants to articulate relationships between the factors within each cluster (Saritas and Nugroho, 2012). The mapping activities are conducted both internal within the newly created clusters, and between the clusters, enabling the possibility for a two-tiered analysis of the results while acknowledging the social constructionist perspective on futures knowledge (Fuller and Loogma, 2009). These clusters, and the underlying factors of their composition, are the primary inputs for the factor assessment work that are engaged in the second workshop. The NewTRENDs workshop series is designed to leverage expert knowledge in the identification of new societal trends – clusters of previously identified *factors* – with the strongest potential to influence future energy demand. Identification activities are coupled with methods to map and clarify interrelationships between these factors, to provide future modelling efforts with conceptual outlines.

The goal of **Step 3** is to synthesise narratives for factor clusters and prioritise those clusters with respect to the overarching goal of the NewTRENDs project (European Commission, 2019b) – the enhancement of energy demand models to account for new societal trends shaping future energy demand. The development of cluster narratives is included to clearly communicate the reasoning behind the inclusion of certain factors within each cluster and to articulate the interrelational dynamics that were given during expert discussions (Milojević and Inayatullah, 2015). These narratives are meant to illustrate the core dynamics and effects of each cluster as highlighted during expert review and are meant to guide future modelling efforts. However, these narratives may ultimately turn out to be only partially true or even false, since they represent a record of current expert discussions, but not statements of empirical facts; telling the story of how new societal trends might be explored using quantitative methods, in an effort to engage the community of modellers who will undertake that translation (Moezzi et al., 2017). As the final workshop includes members of the NewTRENDs consortium community of modellers, the cluster narratives are meant to foster critical discussion and ultimately facilitate the selection of new societal trend clusters to take forward into modelling research.

Given the on-going Covid-19 pandemic and the accompanying restrictions on travel and person-to-person meetings, the workshops are designed to take place using two online platforms. Microsoft Teams[1] is used for audio and visual communication, while Miro[2] is used as an online whiteboard application for interactive exchanges. In general, feedback on the use of these mediums for digital workshop activities is positive, though certain elements of in-person meetings are irreplaceable and technical difficulties continue to present challenges.

WORKSHOPS

The first workshop: Initial review and horizon scanning

Given the breadth of new societal trends uncovered during initial research, the initial review and clustering activities are organised within three distinct categories: social, economic and political. This structures each work groups' analysis and enables greater differentiation between factor effects on energy

1. https://www.microsoft.com/en-us/microsoft-teams/group-chat-software
2. https://miro.com

demand. New societal trend clusters are initially seeded by selections based on their potential to shift energy demand. Clusters are then augmented with additional new societal trends based on group discussion. Further, each workgroup presents an overview of the group's clusters in a plenary meeting. During this discussion, similarities and relationships between clusters are outlined and noted by facilitators in a publicly visual medium (the digital whiteboard).

The first workshop includes:

- review of research results and identification of additional social trends and dynamics that were not previously identified;
- initial selection of the social trends and dynamics with respect to their effect on future energy demand;
- creation of initial clusters of social factors according to themes or concepts identified by participants;
- description of initial relationship between identified clusters based on either a) individual factors relating across clusters, or b) holistic relationships between clusters as defined by participants.

The second workshop: Assessment and preliminary prioritisation of trends

The assessment phase of the second workshop is designed to gather more detailed expert examination of the new societal trends gathered in the clusters produced from the previous workshop. The assessment process asks experts to locate each factor within a two-axis scale to estimate both the degree of impact (low, medium, high) and the scale at which the factor's impacts can be observed (micro, meso, macro). The assessment discussion is based on the results from the second workshop, narratives are formulated, which summarise the most important dynamics that have been identified by the experts for each cluster. These descriptive narratives highlight the underlying factors that have the greatest impact, their interrelationships to others and potentials for disruptive change through combinations or dynamic environmental conditions. These narratives become the centrepiece for the third workshop.

The second workshop includes:

- review of factor clusters produced in the first workshop, and underlying factors in each cluster;
- assessment of underlying factors within each cluster based on a biaxial grid (impact, scale) with colour coding to show directionality of change;
- discussion of those underlying factors that have the potential to be disruptive forces in future energy demand, creating non-linear changes either alone or in combination with other cluster factors;
- selection of the factor clusters that should be prioritised in future attempts to model energy demand dynamics.

Third workshop: Review of trends' narratives and final prioritisation

The final activity is held in plenary of the consortium leadership and attendant experts. This activity is focused on finalising a categorisation scheme that would classify the identified clusters regarding their inclusion in future NewTRENDs work packages.

The third workshop includes:

- review and assessment of cluster narratives;
- editing and expanding of cluster narratives;
- plenary discussion for final prioritisation.

An informal classification schema – described below – is utilised during the discussion with four categories for clusters:

- **"Universal"** – all work packages must address these clusters and included factors in their research and development. They are not required to model, all of them, but they must clarify the reasoning behind leaving one or more of these clusters out of future research.
- **"Nice to Have"** – these are clusters and factors that are identified as being of high priority, but not mandatory. Consortium teams are encouraged to include as many of these clusters as possible, but are not required to justify their exclusion.
- **"Optional"** – these clusters are deemed to be of relatively low priority and could be considered under special circumstances (for instance, the cluster is related to on-going research efforts).
- **"Future research"** – the final category is reserved for clusters that are considered to be beyond the scope of NewTRENDs model development efforts at this time. They are suggested as future research avenues that could be explored in follow up projects.

During this activity, the clusters are placed within the aforementioned categories, cluster aggregation is finalised as suggested by the experts, and final consensus is achieved through dialog and debate amongst NewTRENDs consortium members.

Results

THE FIRST WORKSHOP

Starting from 241 initial factors – defined as trends, issues and developments, which were gathered from precursory research, 22 clusters were created in three small workgroups during the first workshop. Each cluster composed of different number of underlying factors. The following summarised new societal trend cluster distribution between thematic workgroups:

- **"Society and lifestyle" (social)** workgroup: 6 clusters
- **"Business and industry" (economic)** workgroup: 8 clusters
- **"Politics and governance" (political)** workgroup: 8 clusters

As a result, each category consisted of almost the same number of clusters, which means that they contributed equally to the further analysis.

After creation the clusters a plenary discussion was facilitated to conceptualise how they and their compositional factors were connected to one another. During discussion, these

Table 1. The list of 20 clusters with description and underlying factors.

Cluster	Description	Number of underlying factors
Decentralised Work	Remote working allow workers to operate from anywhere	4
Water Issues	Increasing water scarcity effects multiple aspects of society	17
Sustainable Cities	The development of urban living spaces to meet future challenges	16
Climate Change and Behaviour	Increasing climate change concerns requiring changing consumer behaviour	16
From Owning to Sharing	The growing sharing culture enables innovative ideas in exchange of knowledge and promotes sharing platforms	5
New Labour	Increasing relevance of labour for societal participation	13
Digitalisation	New challenges and requirements of the progressing digitalization	20
Urbanisation	Changing perceptions of inequalities caused by the rural and urban divide	18
Green Transition	Determining an appropriate policy mix for relevant challenges	5
Green Finance	Increasing recognition of behavioural impact leading to new financial services	19
Migration and Displacement	Increasing global migration which requires fair access to water and modern energy services	8
Growing Middle Class	Growing urban middle class potentially contributing to sustainable urban development	6
Energy Poverty	Energy poverty and inequalities caused by rising energy prices	5
Growing Youthful Population	Growing population in Global South requiring sustainable education, high Internet coverage and social innovation	17
Healthy Aging	Increasing life expectancy and aging workforce in Global North due to advances in digital healthcare	10
Rebound Effect	Policy consequences detract from efficacy due to adaptation (market, consumer etc.)	15
Geopolitics and Global Forces	Role of the geopolitical dimension in trade, social aspects, demand/ supply sides	12
Socioeconomic Equality	Ensuring equality in providing basic needs (basic income, health coverage, etc.)	8
Evolving Democratic System	Political systems adapting to social platforms, data streams, changing demographics	13
Great Depression II	Depression affecting the financial situation in the countries and increasing migrations	8

22 clusters were converted to 20 final clusters: 2 clusters were merged with existing ones, given similarities in subject matter. The final new societal trend clusters, their short description (for workshop purposes) and the number of new societal trend factors that compose them (Table 1), were the primary products of **Step 1** in our methodological approach.

It is worth noting that many of the initial factors emerging from discovery research were associated to numerous clusters, and were often identified by multiple thematic workgroups. Sometimes the clustering of these repeatedly identified factors reflected similarities in group rationalisation. For example, the factor "Localised food systems" was placed in the "Urbanisation" cluster by the "social" workgroup, and was allocated to the "Sustainable Cities" cluster by the "economic" workgroup. However, in other instances, factors were selected by different workgroups for decidedly different reasons regarding future energy demand. For instance, "Migration" related factors were selected by all three workgroups, were distributed across 6 different clusters and became an entire cluster according to the "political" workgroup. In some of these clusters, intensified migration was thought to increase energy demand, whereas in other clusters climate refugees, migrating to escape unliveable conditions, brought with them transferrable behaviours to limit energy consumption. Both of these patterns – tracing both similarities and differences across workgroups – were observed across not less than 24 of the initial factors that went into the creation of the clusters. These findings inspired our decision to create the multi-modal impact assessment activity that came to be central to our second workshop. The knowledge that some factors were selected both across thematic workgroups, and according the context of the clusters in which they were located, inspired us to look more closely at these similarities and differences.

THE SECOND WORKSHOP

The second workshop produced a more detailed understanding of the composition and internal relationships of the previously identified new societal trend clusters with respect to future energy demand. The activities included a multi-modal assessment of each underlying cluster factor, and with respect to effect on future energy demand at different scales. Additionally, the second workshop provided the first expert-based prioritisation of the clusters. This ranked list became an essential input to the third workshop, because the highest ranked clusters will set out the work plans and requirements for the next stages of the NewTRENDs project.

Cluster (trend) assessment: degree, scale, direction

Based on the discussions with the experts during the second workshop, each cluster and its underlying trends was assessed using the following metrics (see example of assessment for "Sustainable Cities" cluster in Table 2):

- **"Impact degree"** (High/Medium/Low)
- **"Impact scale"** (Macro/Meso/Micro)
- **"Impact direction"** (Decreasing/Increasing/Shifting)

Impact degree assessment (High/Medium/Low)

The analysis of impact degree showed that the clusters under investigation may have:

- high impact (f.e. "Digitalisation");
- medium impact (f.e. "Socioeconomic Equality", "Energy Poverty", "Healthy Aging");
- high and low impact (f.e. "From Owing to Sharing"); or
- low and medium impact on future energy demand (f.e. "Sustainable Cities", "Decentralised Work").

It is important to note, that even within the clusters with high influence, estimations of impact of their underlying factors on energy demand are different. For example, within the "Digitalisation" cluster, some trends may simultaneously have high impact (f.e. "Reindustrialisation", "Rise of digital traffic"), medium impact (f.e. "Acceleration of virtual work (COVID-19)", "Digital literacy and skills") and low impact (f.e. "Digital competency pressure as a social organisational task", "Corporate gamification", "Green ICT").

Impact scale assessment (Macro/Meso/Micro)

The assessment of impact scale indicated that the clusters under investigation may have influence:

- on macro level (f.e. "Digitalisation");
- on macro and micro level (f.e. "From Owing to Sharing");
- on meso level (f.e. "Sustainable Cities", "Decentralised Work", "Energy Poverty", "Healthy Aging"); or
- on micro level (f.e. "Socioeconomic Equality").

As in case of impact analysis, the scale assessment may also vary within one particular cluster. Within the cluster "Sustainable Cit-

Table 2. The example of cluster assessment (degree, scale, direction).

Underlying trends: *** selected by experts** **** selected by experts and called disruptive** ***** additional trends proposed by experts**	**Degree assessment**	**Scale assessment**	**Direction assessment**	**Additional narratives**
Sustainable Cities: *The development of urban living spaces to meet future challenges.*				
1)* Population size of urban settlements	Low	Meso	Shifting	
2)* Rise in the number of urban settlements	Medium	Meso	Shifting	
3)* Increased urbanisation	Medium	Macro	Decreasing	
4)* Increasing land area of cities	Medium	Micro	Increasing	
5)* Urban governance – solving global challenges locally in cities	Medium	Meso	Decreasing	
6) The global urban middle class – tipping the scales of sustainable urban development?	–	–	–	
7)* Local food circles	Medium	Micro	Decreasing	
8)* Localised food systems	Medium	Micro	Decreasing	
9)** Car-free city	Medium	Meso	Decreasing	"Car-free" concept allows cities to be "sustainable", making them more attractive (greening, local food, public space).
10)* New transport models (hubs)	Medium	Macro	Decreasing	
11)* New cities without the necessity of a car	Low	Meso	Decreasing	
12)* Transportation systems *** Autonomous driving / sharing cars or vehicles (not only for cities)	High	Macro	Decreasing	
13)* Community gardening	Low	Meso	Decreasing	
14)* Reconquering the public space	Low	Micro	Decreasing	
15)** Hyper-connectivity	High	Macro	Increasing	Hyper-connectivity: data transport globally, data amount change, data availability, consumption and production patterns lead to infrastructure changes.
16)* Greening urban areas	Low	Meso	Decreasing	

ies", for example, there are trends that have a significant impact on different levels at the same time: on macro (f.e. "Increased urbanisation", "New transport models (hubs)", "Hyper-connectivity"), meso (f.e. "Rise in the number of urban settlements", "Urban governance", "Car-free city", "Community gardening") and micro level (f.e. "Increasing land area of cities", "Localised food systems", "Reconquering the public space").

Impact direction assessment (Decreasing/Increasing/Shifting)
The estimations of impact direction split the clusters (trends) into:

- decreasing (f.e. "Digitalisation", "Sustainable Cities", "From Owing to Sharing");
- decreasing or increasing (f.e. "Decentralised Work", "Energy Poverty", "Healthy Aging"); or
- decreasing/increasing/shifting energy demand to other sectors (f.e. "Socioeconomic Equality").

Once again, the analysis showed that in some cases one cluster includes the trends with different direction of impact. For example, the cluster "Digitalisation" consists of the trends with high-decreasing (f.e. "Acceleration of virtual work (COVID-19)", "Digital literacy and skills", "Disruption of ownership models"), high-increasing ("Rise of digital traffic") and high-shifting influence ("Reindustrialisation"). Likewise, the cluster "Socioeconomic Equality" includes the trends with high-decreasing (f.e. "Social cohesion"), high-increasing (f.e. "Unconditional minimum basic income") and high-shifting influence (f.e. "Universal health coverage").

Therefore, the analysis of cluster assessment based on the 3-dimensional metrics, indicated that the majority of clusters under investigation might have controversial influence on future energy demand: in terms of degree, scale or direction of their impact. Many high-impact trends (high-decreasing or high-increasing) were named by experts as "disruptive", as they are essential in terms of their influence on energy consumption and development in different sectors.

Identification of disruptive trends

The experts selected and described the most disruptive trends under each cluster and in some cases proposed additional related trends that may also potentially influence future energy consumption patterns and demand. In addition, experts selected the most disruptive trends within the clusters providing the clarifying remarks (narratives) for trends, especially with respect to assessments. They included:

- high- or medium-decreasing disruptive trends (f.e. "Acceleration of virtual work (COVID-19)", "Disruption of ownership models", "Car-free city");
- high-increasing disruptive trends (f.e. "Hyper-connectivity", "Unconditional minimum basic income");
- high-shifting disruptive trends (f.e. "Universal health coverage").

The analysis showed that on average two disruptive trends were detected within each cluster, with the maximum number of three disruptive trends referring to the cluster "Digitalisation", which means that this cluster is especially important in terms of its influence on future energy demand.

Assessment of regional influences

Moreover, it is important to note that the clusters under investigation may impact energy demand differently in specific regions. That is why additional information on how new societal trends may influence regional development was also collected during the second workshop.

The preliminary analysis indicated that the following clusters may have the most significant impact on energy consumption in European countries, as they lay at the intersection of the European sub-regions: "Digitalisation", "Evolving Democratic System" and "Rebound Effect".

Cluster prioritisation

During the second workshop, 10 clusters with the highest priority were selected from 20 clusters through the expert voting (see Table 3).

These 10 priority clusters included 2 social ("Climate Change and Behaviour", "Water Issues"), 4 economic ("Green Transition", "Decentralised Work", "From Owning to Sharing", "Energy Poverty") and 4 political clusters ("Digitalisation", "Sustainable Cities", "Socioeconomic Equality", "Healthy Aging"). They were considered by experts as the most important to be taken to the further analysis.

THE THIRD WORKSHOP

The third workshop produced a final list of clusters (see Table 4), categorised according to the clusters' integration with upcoming NewTRENDs work packages. This included the creation of one entirely new cluster ("Circular Economy") and two amalgamated clusters ("Socio-Economic Dynamics" and "Demographic Change"). The final result was that there were 14+ total clusters, with 7 identified as "universal", 4 identified as "nice to have", 3 identified as "optional" and 1 cluster placed into the "parking lot" for future research.

The final cluster narratives were reviewed and revised according to the feedback received from participants of the third workshop. These final narratives also reflect additional changes that were made to the clusters through merging or regrouping clusters, and in one case the development of a wholly new cluster ("Circular Economy"). The third workshop discussion was organised to ensure that the NewTRENDs project's goals and future work aligned with the results of the trend discovery and assessment process.

Several new clusters emerged from the discussions of the final workshop. Within the **"universal"** category there were two notable changes that emerged from the group discussion of the cluster narratives and categorisation process. Firstly, the group decided that the "Urbanisation" cluster would be folded into the "Sustainable Cities" cluster. The merging of these two topics was deemed logical given the historical importance of urbanisation trends for energy demand modelling and the contemporary importance of sustainable cities to policy discussions. The second major change within this cluster category was the creation of the "Circular Economy" cluster. Given that this topic is central to the NewTRENDs project, this new cluster should be included for development and assessment in future work.

Table 3. The results of cluster prioritisation (voting).

Cluster name	Category	Prioritisation (votes received)
1. Digitalisation	*Political*	*14*
2. Sustainable Cities	*Political*	*12*
3. Green Transition	*Economic*	*9*
4. Decentralised Work	*Economic*	*8*
5. Climate Change and Behaviour	*Social*	*7*
6. From Owning to Sharing	*Economic*	*7*
7. Energy Poverty	*Economic*	*5*
8. Socioeconomic Equality	*Political*	*5*
9. Water Issues	*Social*	*4*
10. Healthy Aging	*Political*	*4*
Urbanisation	Social	3
Green Finance	Economic	3
Growing Youthful Population	Social	3
Great depression II	Economic	3
Rebound Effect	Social	3
Geopolitics and Global Forces	Political	2
New Labour	Social	1
Migration and Displacement	Political	1
Growing Middle Class	Economic	1
Evolving Democratic System	Political	0

Table 4. The final list of clusters.

Universal	Nice to have	Optional	Future research
Digitalisation	Socio-Economic Dynamics	Geopolitics and Global Forces	Evolving Democratic System
Sustainable Cities	Water Issues	Great Depression II	
Green Transition	Green Finance	New Labour	
Decentralised Work	Demographic Change		
From Owning to Sharing			
Climate Change and Behaviour			
Circular Economy			

While there were no significant changes in **"optional"** category, under the **"nice to have"** category four clusters were to be addressed by future NewTRENDs work, two new clusters were created to accommodate related clusters with smaller levels of support individually. "Socio-Economic Dynamics" was created as an umbrella cluster for several interrelated clusters. The clusters that now fall into the "Socio-Economic Dynamics" cluster include: "Energy Poverty", "Rebound Effects", "Growing Middle Class" and "Socioeconomic Equality". The second new cluster to emerge within this category is the "Demographic Change" cluster, a combination of "Healthy Aging", "Growing Youthful Populations" and "Migration and Displacement".

The cluster "Evolving Democratic System" was referred to the **"future research"** category to be addressed at the next stages of the NewTRENDs project.

Discussion

Through the in-depth examination of the final 14 trend clusters, we derive at the key findings and discuss important aspects, which help to better understand the future impact of new societal trends on energy demand, and more specifically help to guide future research in this area.

First, we observe **controversial impacts** of new societal trends. As can be seen from the workshops results, the direction of impact of a specific trend is not always obvious – it may increase and decrease future energy demand at the same time. While some trends like a circular and a sharing economy are expected to have a rather clear decreasing impact on energy demand, for other trends, such as digitalisation, the direction of the impact depends on many factors. Furthermore, even trends that have an overall clear decreasing impact might have increasing impacts in certain sectors. Additionally, rebound effects have to be considered for all those trends. Therefore, the controversial impact of the trends on future energy demand should be analysed in more detail.

Second, some new societal trends are potentially **disruptive** for future energy demand. During the workshops a number of trends were considered by the experts as disruptive, which means that they may influence many sectors, create entire new markets and even displace others in the near future. Therefore, it would be especially important to analyse how such disruptive clusters and trends (f.e. in circular economy and digitalisation) may influence the other trends in different sectors. In addition, investigating the connections between disruptive new societal trends seem to be very useful for

further understanding of their joint contribution to energy transition.

Third, the discussion in the workshops has shown, that particular attention should be placed on issues of **sufficiency**. The most controversial question is whether the sufficiency matters should be included in the modelling, taking into account that it is not discussed in detail which policies are needed to make this sufficiency happen. The experts agreed that sufficiency in consumer behaviour would have a huge impact on future energy demand, but it would be difficult to be implemented without accompanying policies. Therefore, the analysis of lifestyle changes not just as "tricking" parameters, would shed light on more clear understanding of what do they really mean and what are the narrative insights on sufficiency and behavioural changes.

Fourth, many **uncertainties** are related to new societal trends. Besides the trends that are likely to happen, it is important to investigate uncertainties and risks, which are unlikely but may have a significant impact on future energy demand. The question is how to identify and deal with uncertainties associated with new societal trends. The conventional research methods may be not enough to do that and new approaches are needed to explore energy transition as a complex, interconnected, multilevel and vulnerable process, which can respond both to systemic risks and to creative opportunities.

Fifth, **cross-impact analysis** may shed light on interrelationships between new societal trends. The analysis has shown that the trends from different trend clusters (and also from different categories) and the clusters themselves are interconnected. The same trends may occur in different clusters: f.e. "Managing migration" refers to "Sustainable Cities", "New Labour" and "Great Depression", while "Open access" refers to "Digitalisation" and "Sharing Economy". Therefore, it would be helpful to do cross-impact analysis to investigate these interrelationships in order to understand the whole "inter-connected" picture. This can be done through network analysis, which may help reveal the implicit relationships between clusters or specific trends.

Sixth, **cross-sectoral analysis** may answer the question how these clusters and trends actually influence future energy demand in different sectors, as well as identify the "trends-connectors" between sectors under investigation in the NewTRENDs project:

- Built environment (transition of consumers to prosumagers in the frame of energy communities);
- Industry/Tertiary (impact of a circular economy in industry and of digitalisation in the tertiary sector);
- Transport/Tertiary (impact of the shared economy on energy demand in transport and tertiary sector).

Finally, starting from this research and moving to preparation for the modelling, it would be also interesting to draw a conclusion about what parameters of the new societal trends are especially important for **energy policy**, as well as what things need to be regulated or managed to make sure there is no negative impact from specific trends. This analysis may also be connected to the development of low-carbon energy scenarios, showing how different impacts of these trends may work out, because some of them may actually, mainly being unmanaged, lead to higher energy use, and other things may lead to lower energy consumption. Within the climate-concerned world that means some things need to be managed by policy makers, but at the same time may also lead to unwanted things (rebound effect). Therefore, it is very challenging to identify the technological and social changes that should be supported, being sure that they positively contribute to sustainable energy transition.

Conclusion

Taking into account substantial and potentially disruptive impacts of new social trends (such as circular and shared economy, digitalisation of economic and private life, prosumaging etc.) on future energy demand, the main goal of this paper was to analyse how such trends may influence the European future energy demand (increasing, decreasing or shifting to other sectors) in order to integrate these assessments into the relevant demand side models for quantitative analysis in the further scenario development.

This research was conducted in three methodological steps. First, energy relevant new societal trends were selected based on an analysis of previous foresight studies and long-term energy demand scenarios. Second, in three expert workshops the trends were clustered and their potential importance and disruptiveness was assessed using the three-dimensional metrics (impact degree, impact scale, impact direction). As a result, 20 clusters were developed, and 10 of them were selected through expert voting as "priority" clusters: "Digitalisation", "Sustainable Cities", "Green Transition", "Decentralised Work", "Climate Change and Behaviour", "From Owning to Sharing", "Energy Poverty", "Socioeconomic Equality", "Water Issues" and "Healthy Aging". Third and finally, after discussion of 20 clusters with experts, the final list of 14+ new societal trend clusters was created, where they were classified into four categories: "universal" (7 trends), "nice to have" (4 trends), "optional" (3 trends) and "future research" (1 trend). In addition, the narratives for the resulting 14 major trend clusters were developed to describe the potential mechanisms of their impact and disruptiveness for future energy demand.

The analysis has shown that the resulting clusters and their underlying trends may have a controversial impact on future energy demand (simultaneously decreasing, increasing and shifting it to other sectors) and therefore should be analysed more in detail to assess their final contribution to energy transition. Such additional issues, as disruptiveness of trends, sufficiency matters, uncertainties related to trends, cross-impact and cross-sectoral analysis, as well as associated policy measures, should also be taken into account to understand the complete picture of their influence on future European energy consumption.

The results of this study build the basis for future work, where the identified trend clusters and narratives will inform the enhancement of energy demand models, which are frequently used to model the European long-term scenarios. Furthermore, the narratives will contribute to scenario development and cross-sectoral modelling of the trends. This will lead to a better understanding of potential non-linear developments of future energy demand and how energy (efficiency) policies could be designed to take these trends meaningfully into account.

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