

Joint IIASA-RITE International Workshop: Towards Improved Understanding, Concepts, Policies and Models of Energy Demand

11-13 November 2019
IIASA, Laxenburg, Austria

Workshop Summary

OVERVIEW

The [second](#) in a series of joint IIASA-RITE international workshops exploring the potential for reducing energy demand to mitigate the impacts of climate change in the context of sustainable development was held at IIASA in Laxenburg, Austria on [11-13 November 2019](#). The inaugural meeting was held in Nara, Japan, [25-27 September 2018](#).

The meeting at IIASA was attended by 57 participants from 19 countries (Appendix 1) and comprised individuals from a range of disciplines including modelers, social scientists, economists, engineers, and practitioners across different sectors including transport, buildings, energy, and climate. A particular strength of the meeting was the number of young researchers present.

The objectives of the workshop included both scientific exchange and to provide a forum for discussing demand-side research and policy issues, as well as to promote community building to expand the research, policy dimensions, and impacts of demand side approaches to climate mitigation and the Sustainable Development Goals (SDGs).

The topics discussed covered a wide range of energy demand themes including (Appendix 2):

- Energy demand – an evolving landscape
- Energy demand and digitalization
- Demand research needs
- Demand, lifestyles, social aspects of mitigation in the IPCC 6th Assessment Report
- Transport demand, new business models, and modeling
- Energy access, efficiency and resource demands for sustainable development

Important advances in both modeling and demonstration projects of low energy demand solutions were presented including deep retrofit solutions for office buildings lowering energy demand to such levels that buildings become net energy producers, new city-level simulations of shared mobility solutions as well as integrated assessment model quantification of global impacts of shared mobility solutions, and novel approaches to rural electrification via microgrids for furthering productive uses of electricity. At the same time, participants repeatedly emphasized the slow uptake of low demand concepts in the scientific and policy communities, requiring a renewed effort to improve communication and outreach.

A major point of discussion during the meeting was that increasingly energy demand is being investigated through a services lens, which is also a novel perspective taken up in the IPCC 6th Assessment Report currently under development. Energy services and demands are also increasingly seen as more than just part of the climate mitigation agenda but considered more broadly in the context of sustainable development and the SDGs, in particular in the context of decent living standards for all. Mitigating the impacts of climate change will not simply be achieved by electrification of the energy system with concomitant decarbonization of the electricity sector, but rather must be accompanied by dramatic reductions in energy demand through both increasing energy efficiencies across all sectors and reducing energy demand of both individuals, through personal choices, and industry and commerce through new business models, incentives, or regulatory approaches. However, such approaches may be difficult in the developing world where energy demand is projected to increase as increasingly more people gain access to clean energy forms and electricity to meet basic human needs and wellbeing.

Much of the discussions focused on potentials for demand reductions in the transport and buildings sectors. The increased use of electric vehicles (including autonomous vehicles), ride sharing, and decarbonized mass public transport has considerable potential to reduce overall energy demand for passenger travel through reductions in use of conventional fossil fuel powered vehicles, but may, at the same time, displace other means of low impact transport such as walking and cycling. It is important to understand personal motivations in transport choices to maximize the underlying potential with novel empirical survey data presented at the workshop. While considerable progress is being made in modeling low demand options in the passenger transport sector there has been little attention paid to the freight sector which accounts for a significant proportion of energy use and emissions. Similarly, the adoption of energy neutral buildings (either new or through retrofitting) may reduce energy demand dramatically although with considerable upfront capital costs. Undoubtedly digitalization in its many guises may also reduce energy demand through for example, substitution, but also has the potential to increase consumerism, and therefore demand, not to mention the significant energy demands associated with processing and maintaining data services.

Although it was agreed that progress is being made in some sectors to reduce energy demand and that there is significant untapped potential to achieve more with the right policies, regulation and incentives, the pace of change is too slow if the world is to achieve its climate and SDG aspirations by 2030 and 2050. Continued incrementalism will not achieve the targets and there was an increased sense of urgency to develop radical transformational solutions. Although there was a call for more research to be undertaken it was generally agreed that much more can be done already with existing knowledge, technologies and best practices. The research community needs to better engage with policy and decision makers to find ways to accelerate the implementation of already well understood solutions and to provide input into the development of more radical scenarios for achieving the necessary energy demand reductions.

In addition to the formal and informal discussions the meeting also featured a poster session for young researchers to showcase and discuss new and novel approaches to investigating energy demand. A total of 14 posters were presented with awards being presented to the five best posters (Appendix 3).

SUMMARY AND HIGHLIGHTS OF PRESENTATIONS

Opening Session: Welcome and Framing

The workshop was opened by **Arnulf Grubler** (IIASA) and **Kenji Yamaji** (RITE) who together welcomed participants and provided an overview of the agenda and motivation for this second workshop, highlighting the need to promote research on the integration of social infrastructure, the sharing economy and information and material flow systems to reduce energy demand to help mitigate climate change in the context of sustainable development.

Keigo Akimoto framed the workshop discussions by arguing that disruptive low-demand scenarios are driven by both innovation push as well as by policy pull factors. Low energy demand scenarios have greater potential to enable the deep emissions reductions needed to achieve the IPCC's 1.5°C target at a much lower carbon price than more conventional energy supply-side scenarios (Figure 1).

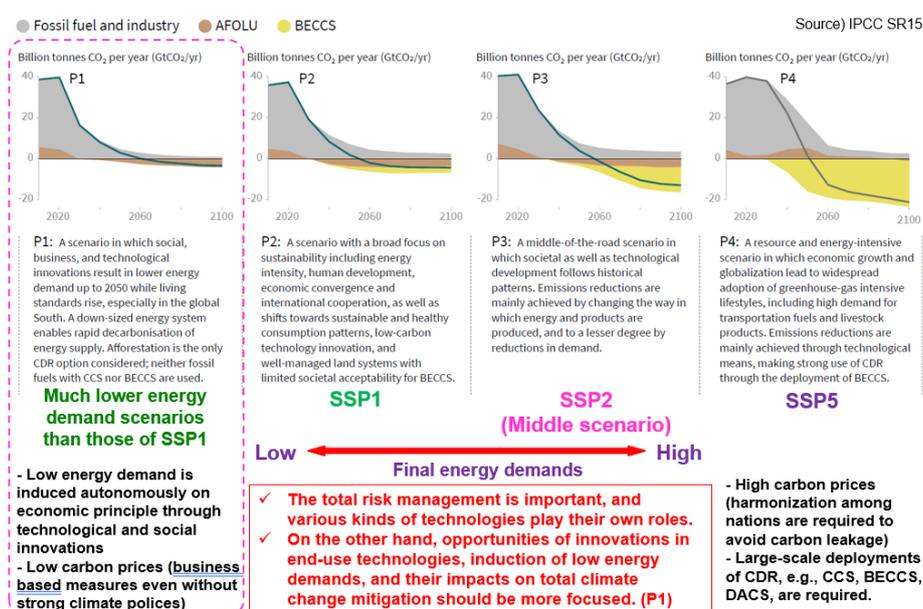


Figure 1. Low demand scenario in the context of the IPCC scenarios discussed in the IPCC Special Report on 1.5 °C and its advantages for climate mitigation efforts.

Such deep emissions at an affordable cost will also be key to achieving multiple sustainable development goals (SDGs). He argued that there was significant room for improvement in energy end-use sectors by overcoming some of the large inherent costs through digitalization and related technologies. Low demand solutions thus are attractive from a climate and SDG policy perspective (policy pull factors). A wide range of emerging technological and social innovations constitute important push factors for low demand scenarios. Examples of disruptive end-use innovations include shifts from individuals to networks, from ownership to usership of devices and end-use technologies, leading towards a sharing and circular economy underpinned by an integration of physical and virtual spaces, as is the objective of the Japanese Society 5.0 concept. Such novel end-use products and services are more likely to diffuse more rapidly than supply-side changes. He also highlighted the fact the low-energy demand is not simply a matter of reducing direct energy consumption, for example, reducing

electricity or transport demand, but consideration must also be given to reducing indirect energy consumption, for example, improving agricultural production and reducing food wastage and the associated embodied energy costs. Although reducing energy demand offers significant benefits for emissions reductions and climate mitigation, we must be mindful of potential rebound effects, such as increased energy demand associated with data centers and data processing, adoption of less energy efficient behaviors (e.g., moving from public transport to ride sharing), and increases in energy intensive activities (e.g., vacations) due to increases in leisure time.

Plenary Session I: Energy Demand – An Evolving Landscape

[Charlie Wilson](#) gave participants a summary of the inaugural joint IIASA-RITE low energy demand workshop, entitled '*Rethinking Energy Demand*' held in Nara Japan in September 2018. He summarized the outcomes of the workshop across three broad themes:

Big Picture Research Consensus

- Energy is consumed to provide **services** that meet **human needs**.
- There is enormous potential to **transform energy services** and reduce emissions.
- **New forms** of energy-service provision are being tested and implemented commercially already including shared mobility, smart grids, and integrated designs for resource efficiency. These all provide a laboratory for experimentation as well as for research on the feasibility and impacts of low demand solutions.

Energy Demand Research Frontiers

- Energy demand is **heterogeneous** and analyzed from **different perspectives**. These can be integrated through hierarchical frameworks with the objective of generalizing insights on 'what works' from a range of different perspectives.
- **New metrics** for energy services and provisioning systems beyond demand, cost, technology and income are increasingly explored including frameworks such as time use, or human wellbeing concepts.
- Low demand futures shift attention to **materials, land-use**, supply flexibility and demand response, as well as integration of multiple demands (food, energy, materials) which represents a research frontier particularly for Integrated Assessment Models (IAMs).

Data, Methods and Models: New Needs and Challenges

- **New data sources** are required with high temporal & spatial resolution. These are already available via increase digitalization, but pose substantial challenges and potential constraints from data protection concerns that need to be addressed.
- Collecting & **linking data** on 'non-observables' (e.g. amenities derived from service provision) are widely recognized as critically important. These need to be collected through standardized surveys, global observatories, and through collaborations among the research communities with the private and public sectors, which represents a significant resource (funding) challenge.

- The analytical frontier are **multi-scale and hierarchical analytical** approaches and models. Recent examples include the use of urban ABMs, and the coupling of sectoral-systems models, e.g. energy systems with materials demand and supply models.
- The importance of **methodological pluralism** is widely recognized. Yet, novel insights that can inform business model and policy innovation will only emerge from comparative evaluation and synthesis of different approaches which requires a dedicated effort and scientific exchange opportunities, such as offered with this demand workshop series.

He finished with a list of follow-up priorities from the workshop including:

- Use the 'Rethinking Energy Demand' platform to **build network** of demand-side researchers across disciplines and globally.
- Develop proposals for **regional or city-scale hubs** for collaboration on specific implementation challenges of low demand options.
- Develop **collaborative relationships** between research communities and technology, utility, financial, and building sector actors.
- Move from improved scientific **understanding to actions** for meeting sustainable development goals.

[Nebojsa Nakicenovic](#) updated participants on the work of The World in 2050 (TWI2050) initiative: an international partnership between science and policy that aims to provide science-based solutions and pathways for simultaneously achieving the 17 SDGs and the Paris Climate Agreement and longer-term sustainability by 2050. TWI2050 focuses on six transformations (Figure 2) that capture much of the global, regional, and local dynamics and encompass the major drivers of future changes: (i) human capacity and demography; (ii) consumption and production; (iii) decarbonization and energy; (iv) food, biosphere and water; (v) smart cities; and (vi) digital revolution.



Figure 2. Six Transformations, which are at the core of achieving the SDGs as formulated by The World in 2050 (TWI2050) Initiative.

Together these sustainability transformations represent a people-centered perspective: building local, national and global societies and economies which secure wealth creation,

poverty reduction, fair distribution and inclusiveness necessary for human prosperity. They are necessary and potentially sufficient to achieve the SDGs if addressed holistically in unison. There is considerable potential to reduce energy and materials demands across all six transformations. Nakicenovic focused particularly on the impact of digitalization as the key platform for achieving the six transformations and rapidly reducing energy and materials demands, particularly given the historically rapid diffusion of digital technologies. This topic is covered more fully in the recent TWI2050 report on [The Digital Revolution and Sustainable Development: Opportunities and Challenges](#) and discussed in Parallel Session II (see below).

[Joyashree Roy](#) discussed the topic of demand, efficiency and lifestyles from the perspective of the Global South and highlighted how widespread inequality is a barrier to both sustainable development and political participation. Such inequalities, which are globally increasing, are not restricted to simple North/South geographies but are also present between different communities within countries. Providing basic needs and increasing wellbeing for all will require more resources and increased carbon emissions. However, increasingly wellbeing growth, as opposed to income and resource consumption growth, is seen as more important for addressing inequality. Although such wellbeing growth may be achieved in disadvantaged communities in the Global North without an increase in energy and resource demands, an absolute increase in demand will be required in the Global South for increased wellbeing, through provision of currently lacking basic needs. However, recent studies in India have shown (Figure 3) that it is possible to decouple energy demand and activity growth.

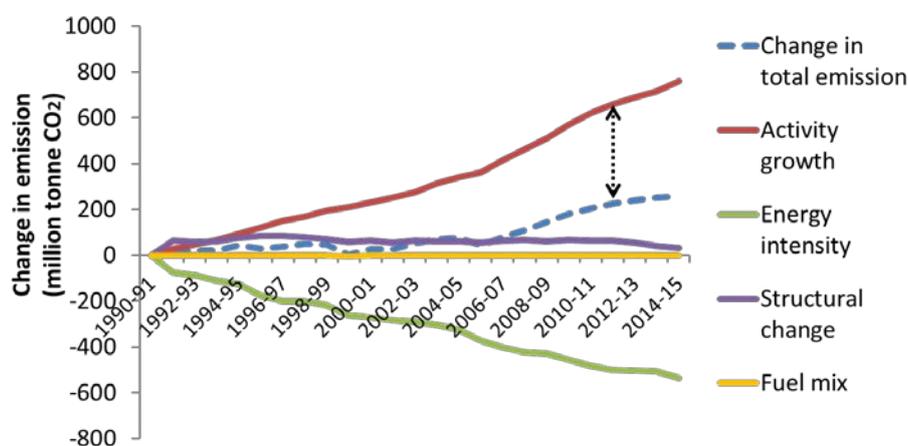


Figure 3. Decomposition of emissions and drivers in India since 1990, showing the critical importance of efficiency in the decoupling of human activities and environmental impacts (emissions).

Roy argued that reducing demand through increasing energy efficiency is possible in the Global South via leapfrogging with increased uptake of energy efficient technologies and service provision models. A move to a more collectivist lifestyle rather than one based on individualism where consumption is based on need rather than demand will be a critical determinant of increased wellbeing. There was considerable discussion on the potential rebound effects of increased wellbeing in the global south particularly with respect to the potential significant increase in demand for cooling in warm countries.

[David McCollum](#) discussed three revolutions shaping future energy demand with a particular focus on the transportation sector, viz. electrification, shared services, and automation (autonomous vehicles), Figure 4.

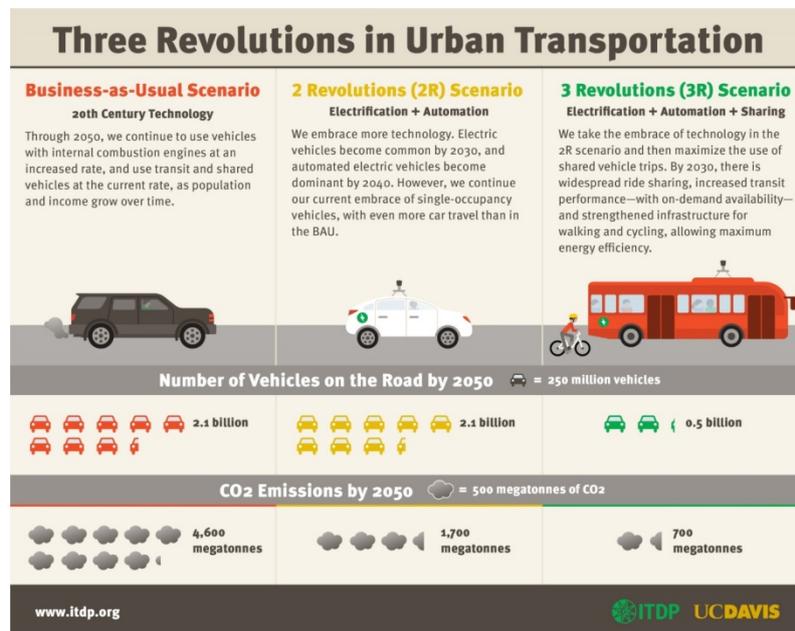


Figure 4. Three scenarios for reshaping urban transport and their implications for materials, energy, and CO₂ emissions.

The growth in fully electric vehicles has been swift with production passing two million units per year in 2018. Electric vehicles are set to represent 10-15% on new vehicle sales by 2025, however 44% of sales are restricted to just 25 markets in China, Japan, Europe and the USA. Purchase decisions for EVs are based on both financial and non-financial decisions (e.g., range anxiety, charging infrastructure, etc.) and are very heterogeneous both with and across societies. Within the building sector, the move to electrification, particularly for heating and cooling, has been steadily increasing although at a slower pace due to the relatively slow turnover rate of building stock. There is also considerable potential for further electrification of the industrial sector with the appropriate market incentives. The adoption of shared mobility services has been rapid over the last decade. True ridesharing (i.e., two or more people sharing a single vehicle) has the potential to significantly reduce energy consumption through reductions in private car ownership and/or use, however it is important to understand the heterogeneity among consumers on their willingness to share. In addition, shared mobility services, both ride sharing and individual services such as e-scooters, have the potential to move consumers away from more traditional environmentally friendly transport modes such as walking, cycling or mass urban transport. There is potential for greater emissions reductions through increasing ride sharing via electrification of the fleet. The impact of the introduction of automated electric vehicles on energy demand appears heterogeneous including both energy reduction as well as increase effects.

Parallel Session I: Demand Research Needs – What do we know and what do we need to know?

Participants divided into three groups with the major points of discussion summarized below:

Group 1: Foundational Assumptions

Energy services is widely accepted as an appropriate analytical lens through which to understand energy demand, as it links demand with useful functions and the wellbeing they provide. However, energy services research has not progressed significantly in recent years - why? Five reasons were identified:

- Heterogeneity – the amount and type of energy services consumed by individuals and households are highly heterogeneous;
- Contingency – the type of energy services provided and consumed are highly contingent on diverse cultural, economic and geographic contexts;
- Measurability – direct measures of energy service usually fail to pick up differences in quality, and in some cases are only indirectly related to the service (e.g., m² of floor area for thermal comfort);
- Commensurability – energy services are expressed in different metrics which makes it hard to compare between services;
- Prescriptiveness – energy services are seen as hard to intervene in by policymakers as they are perceived to be in the private consumption domain.

Despite these difficulties, energy services still provides a critical analytical link from energy demand to wellbeing (the reason energy is consumed in the first place). Wellbeing should be packaged and translated into a set of energy service needs, not just for the poor (as in Decent Living Standards), but as a generic framework for understanding energy demand across all income segments.

Group 2: Analysis

The discussion identified a range of research and analytical challenges and priorities including:

- Need for more collaboration because analysis is typically done in disciplinary ways – more comprehensive and integrated analysis there is needed with multidisciplinary teams;
- Physical and human sphere interactions and provisioning systems (infrastructure, economics, politics) are key in understanding systems of demand and wellbeing provisioning. However, untangling these relationships with currently limited data is challenging;
- Quantifying heterogeneity is critical, as are better ways of quantifying end-use patterns;
- The concept of a rational or average consumer does not exist. Significant differences in preferences for similar socio-economic and demographic groups do exist. Understanding behaviors and heterogeneity and linking those to economic and social factors and models are thus needed to provide better insights;
- Not only disciplinary silos but sectoral silos are equally a barrier – not only for research but especially for devising integrated solutions. Existing forecasting models are

unrealistic because there is little understanding of the integration between drivers and how these interact to affect demand;

- Evaluation of life cycles of goods and services could be a promising complementary way of determining existing losses and possibility for energy demand and emissions reductions across entire resource extraction, processing and conversion chains;
- Understanding of the potential of the shared economy as a means to lower demand is still very incomplete and regulation for this is scanty – and not delivering as much as it could;
- Lastly, the discussion focused on integration and generalization of and from diverse approaches. It was noted that micro simulations are so driven by local contextual drivers that it becomes difficult to scale up to inform more macro or aggregate models that can inform policy at national or regional scales. At the same time, A grand theory or unifying framework is not in sight and might represent an overwhelming research challenge. As a way out the discussion suggested as a good starting point more efforts into comparing and assessing across studies. This will require the development on metrics to judge how well theoretical frameworks hold up to reality, e.g. through backcasting exercises. In addition, gathering case studies and micro studies to perform meta-analysis across studies can help inform larger scale assessments and analysis and prepare the ground for more holistic frameworks.

Group 3: Interventions

The group briefly reviewed dominant policy tools applied or proposed in the context of climate mitigation and the SDGs. The discussion differentiated between taxes, standards, as well as “soft” policy tools (e.g. labeling, information, education). Despite varied views, there was consensus that the scope for improved and deepened policy impact analyses is vast with a particular research need to aim to develop equivalent-impact measures of diverse policy instruments under different settings (e.g. existence of barriers, of co-benefits, or co-costs).

In terms of research, the discussion also identified several promising areas including: better quantification of co-benefits, especially SDG co-benefits of resource savings; operationalization of concepts of avoiding lock-in and leapfrogging and quantification of their economic and social benefits; as well as explicit representation of access to basic services and infrastructures to be able to inform policy of the benefits of access provision or the costs of lack of access.

Also policy analyses need to integrate political economy as well as stakeholder interests more explicitly. As cautionary note it was observed that even with improvements, policy models and analyses might ultimately become very detailed and complex, thus tedious to develop and implement, and difficult to communicate to policy makers and society.

Parallel Session II: Digitalization

There are both positive and negative impacts of increasing digitalization on energy and resource demand. Undoubtedly increasing energy efficiency through new more efficient digital

technologies and device convergence and substitution will significantly reduce demand, however, the increased use of digital devices could also increase demand, consumption and materials use (with embedded energy costs). In addition, there will be significantly increased energy use for handling and processing increased data, particularly with increasing automation. Digitalization may also enable increased secondary simultaneous activities which may increase or decrease demand and consumption. As planned obsolescence and rapid turnover of digital technologies and devices actually increases energy consumption, future digitalization will need to be considered in the context of a move towards a more circular economy, taking into consideration total lifetime (life-cycle) energy use.

The final impact of digitalization on energy demand is thus not yet known – there is a need for more data, for example, through smart metering. Additionally, as many digital technologies and devices are resource intensive there is a need for wider cost benefit analyses of potential environmental impacts.

One of the major considerations in increasing digitalization centers on systems security and reliability, and data privacy. These will impact significantly on the public acceptance of increasing digitalization. Already there is evidence of the public turning away from digital platforms and technologies that present data risks and this is likely to increase as more personal data, for example, health records, become digitized. Potential energy reductions from automation and artificial intelligence may not be realized if the uptake of these technologies fails to garner widespread public acceptance.

Unfortunately, given the speed of technology development, government policy and regulation are constantly playing catch up and are seriously both lagging and lacking. In fact, the whole governance system around a future heavily digitalized society is lacking and there is an urgent need for more innovative governance models that can deal with the rapid pace of change.

Finally, digitalization may benefit energy demand research through provision of online surveys of individual preferences, direct and indirect monitoring of individual activities in real time, and providing citizen generated data. The challenge will be in how to match the pace of research with the pace of change.

Plenary Session II: Demand, Lifestyles, Social Aspects of Mitigation in AR6

Felix Creutzig presented his current conceptualization of the structure, contents and research gaps for Chapter 5 of the forthcoming IPCC 6th Assessment Report. The chapter's coverage of demand, lifestyles and social aspects represents an important "first" for the IPCC WGIII assessments that have to date focused on technological and economic aspects almost exclusively. Creutzig provided an additional rationale for this new focus in IPCC: We are already seeing the environmental impacts of climate change that are affecting the lifestyles of people. Future mitigation actions must therefore protect livelihoods of people with the dual goals of mitigating climate change and improving human wellbeing, with clear linkages to the SDGs. One of the challenges will be to find practical and universal metrics for wellbeing and decent living standards. The Chapter will focus on service provision to people using low carbon energy sources rather than upstream supply systems. A key element covered in the Chapter will be inequality and how it relates to how much trust different groups have in governments to enact more action on climate. Also covered will be the 'new economies' –

shared/circular/digital and their interactions with demand. The effectiveness of these new economic frameworks will be dependent on public policy and governance. A key factor in reducing energy demand is personal choice and decision making, with the major challenge being how to elicit long-term pervasive behavioral change, encompassing the concepts of active learning, enabling infrastructure, and social norms. A major challenge for the Chapter will be the integration of different social science theories from economics, psychology, to sociology, and cultural studies into a coherent and cogent narrative, but given the good progress to date, Creutzig is optimistic that the chapter will provide a foundational contribution to AR6.

[Linda Steg](#) continued the theme of social science aspects of climate mitigation with particular reference to the energy sector chapter of the IPCC 6th Assessment Report. She discussed the different feasibility dimensions of limiting warming to 1.5°C – technological, economic, environmental, geophysical, institutional, and social/cultural. Focusing on the latter, she ascribed the critical determinants to be public acceptability of options and technologies and the likelihood of the required behavior change. Socially feasible mitigation options include new low emissions energy sources, energy storage, and energy transport. Demand side options include adopting and using low carbon energy sources, implementing resource efficiency in buildings, implementing technology to match demand and supply of renewables, adopting energy efficient technology, changing user behavior, and reducing indirect energy use. She then went on to discuss the various barriers and enablers to behavioral change such as context (physical, geographic and climate conditions, available products and technology, infrastructure, institutions and culture, regulations, and financial conditions), abilities (knowledge, income), cognitions (biases, heuristics, habits), and motivations. She described four types of motivation, hedonistic, egoistic, altruistic, and biospheric, that influence personal choice and decision making and shape public acceptability, that need to be understood and considered when designing and implementing interventions to change behavior. Such interventions include targeting key barriers and enablers through tailored approaches that target multiple factors, changing the context, providing financial incentives, providing tailored information and feedback, utilizing social influencers, and targeting motivation in a consistent manner. The likely key factors influencing public acceptance of mitigation options are economic costs and benefits, procedural fairness, trust in the technology and institutions, and equity (Figure 5).

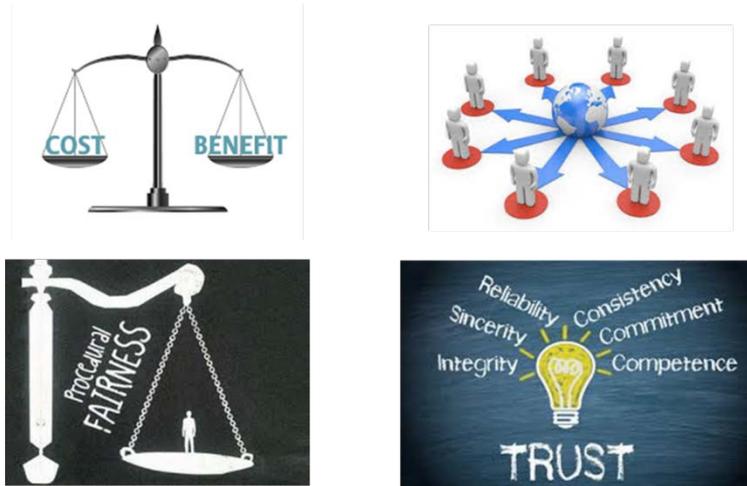


Figure 5. Four major factors affecting public acceptance of mitigation measures.

Diana Urge-Vorsatz discussed how best to assess mitigation potentials in the IPCC with particular reference to the buildings sector. The key questions for assessing different mitigation options are: how much can be mitigated through different measures, strategies, sectors, technologies, and policies; how much will it cost; how much can be done at different cost levels; what should be the starting point; and what are the big opportunities? She argued that different accounting methods may estimate different mitigation potentials across sectors and that it was important to consider both direct and indirect emissions in any assessment. She considers that the buildings sector, which represents approximately 6.5% of direct emissions and 12% of indirect emissions, presents considerable mitigation potential, with modelling suggesting an up to 40% reduction in building final energy use by 2050. She provided a compelling example of a retrofitted high-rise office building that went from consuming over 800 kWh/m² annually (about twice that of a modern office building) to be a net energy producer, primarily through systems optimization, rather than replacement technologies (Figure 6).

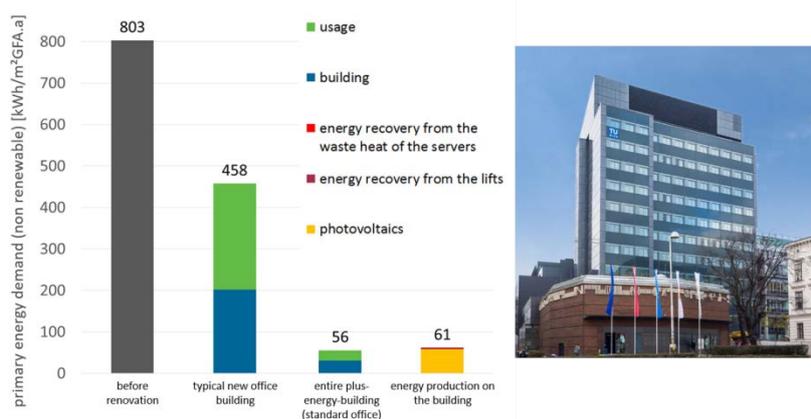


Figure 6. Energy use before and after deep efficiency retrofit of a high-rise office building (Technical University Vienna). Energy demand was lowered to such an extent that the building becomes a net energy producer.

Such energy neutral or energy plus building solutions afford considerable potential to reduce energy demand and emissions, but often come with significant upfront costs and relatively slow diffusion rates due to the inherent inertia and slow turnover rates in the building sector.

Urge-Vorsatz then went on to discuss whether the traditional IPCC sectoral approach is the best method of assessing mitigation potentials and whether or not a more systems approach might be more relevant and meaningful particularly for cross-sectoral general-purpose technologies such as electrification and digitalization. Further challenges for current assessment methods are the difficulties in assessing the mitigation potential of new technologies versus changes in behavior, culture and values. She posed the question as to the need to reconceptualize potentials assessment in the context of full decarbonization and strike a balance between disciplinary and methodological pluralism and simplicity.

Discussion

The three presentations of Plenary Session II were followed by a moderated round-table discussion. Keywan Riahi served as moderator.

A major point for consideration was how to quantify the impact of behavioral change on demand reductions, and what are the relevant policy changes needed to elicit such changes, particularly given the importance of context specificity for personal decision making. It was agreed that such a lack of quantification and policy framework was a major impediment for modeling low energy demand scenarios.

Another point of discussion was how, and under what conditions, does demand side change lead to systemic changes in the supply side which requires a detailed representation of demand-supply linkages in policy and Integrated Assessment models. With recent advances, these linkages can now be represented much better and confirm the fundamental nature of changing demand as driver of supply side systems transformations.

Plenary Session III: Young Demand Researchers Poster Session

[This session](#) was devoted to up and coming demand researchers presenting their research to workshop participants. They presented their research in a poster session format on the following illustrative topics:

- Conceptual/theoretical work that furthers a deeper understanding of determinants of energy and other resource (water, food, materials) service demands
- Empirical work that describes and explains heterogeneity of service demands across different social groups and cultures
- Research exploring linkages between service levels and structure and human wellbeing (incl., sufficiency and decent living standards concepts)
- Research on novel business and organizational models with a focus on 'usership' rather than ownership
- Modeling applications to simulate policy interventions in service demand
- Studies that explore the interlinks between various resource services (e.g., energy and water, food, materials)

Each of the 14 poster presenters gave a 5-minute ‘snapshot’ presentation of their poster, followed by poster visits and discussion. A list of the posters is given in Appendix 3 and copies of the posters and accompanying presentations are available on the workshop [website](#).

A committee reviewed all posters and the following day awards recognition awards were presented to the five best posters (see Appendix 3).

Plenary Session IV: Transport Demand, New Business Models, and Modeling

Luis Martinez explored the question of how shared mobility can help address the challenges of urban mobility by exploring recent technologies, governance and societal trends. He compared conventional modes with three different modes of shared mobility, viz. shared taxi, taxi buses, and platform carpooling (Figure 7), across five cities (Auckland, Dublin, Helsinki, Lisbon, and Lyon).

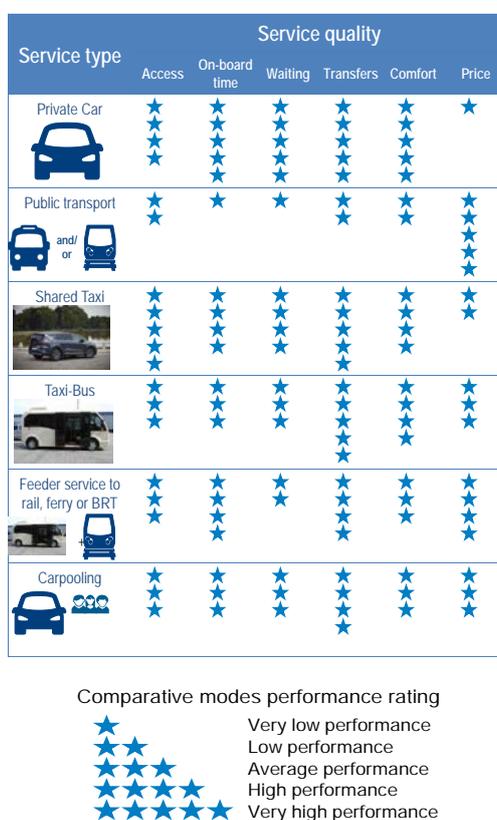


Figure 7. Comparative performance ranking of urban transport modes incl. shared mobility concepts.

Using a modeling approach, and based on current transport modes and surveys on future mode choices in the respective cities, he was able to show that the potential impact on future urban mobility patterns and emissions reductions was dependent on the current modal share, the quality of public transport, population density, and trip patterns. Surveys showed that there were significant differences between cities in people’s willingness to use shared mobility services. The modeling tested various policy options to promote greater use of shared mobility services such as low-emissions zones within cities, electrification of the fleet, and greater

integration with existing and future public transport services. He concludes that optimized shared mobility can provide significant benefits. Replacing private car trips in areas currently not well served by public transport and using flexible, on-demand taxi buses and shared taxis as feeder services for existing public transport services could result in better and more equitable access to opportunities, improved service quality and a reduction of CO₂ emissions. Emissions could be further reduced if a shared mobility approach is complemented with support for the use of electric vehicles in the fleet. In all cases, transition will require the alignment of other policy tools, such as pricing, regulation, land-use and infrastructure design. The benefits of on-demand shared mobility services depend on creating the right market conditions and operational frameworks and therefore need to be introduced at sufficient scale to be effective. Shared mobility services have maximum positive impact when they are adopted by private car users, therefore policy measures, new services and information campaigns should specifically target potential early adopters among this group, particularly those currently not well served by public transport services.

[Tiejun Ma](#) presented the results of modeling work to estimate future diffusion rates of electric vehicles in Shanghai. Strong policy incentives have led to a rapid early uptake of electric vehicles in Shanghai (Figure 8), but are unlikely to be maintained.

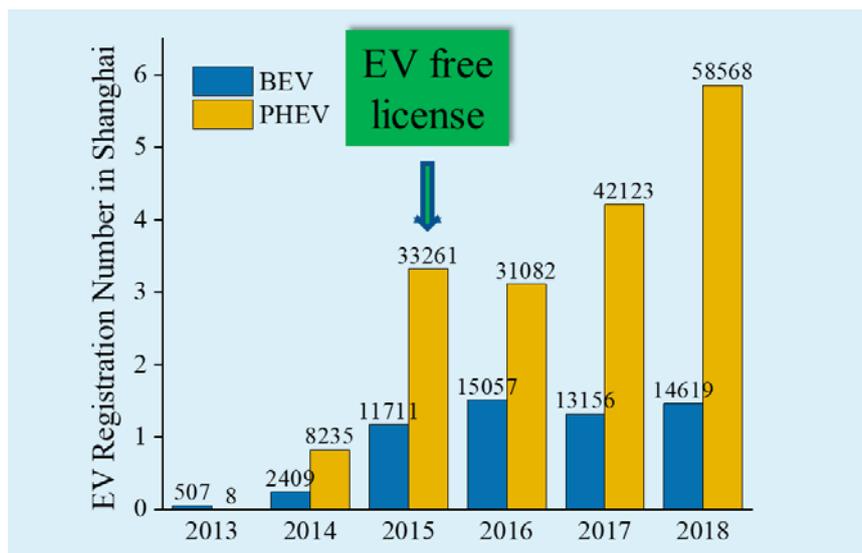


Figure 8. Diffusion of electric vehicles (BEV=battery powered, PHEV=plug-in hybrid vehicles) in Shanghai, China. Note in particular the impact of the introduction of free registration licenses (a subsidy equivalent to approx. 10,000 Euro) for electric cars in 2015.

Hence, projecting future diffusion patterns of electric vehicles requires to consider a comprehensive set of variables and drivers. Ma reported on extensive empirical surveys of current owners of conventionally powered vehicles, EV owners, and non-car owners that were conducted in order to be able to simulate possible diffusion patterns in Shanghai. The surveys identified a number of factors influencing consumer choice of purchasing EVs, including demographics (income, age, education level, family size, location), external factors such as technological maturity and the accessibility of free registration and licenses, as well as the number of peers with EVs and the total level of EV ownership. Using current data for these demographic factors and projections to 2060, early modeling results suggest that the

proportion of EVs in the total Shanghai fleet (which has a cap on total car ownership of around 4.5 million) will increase from approximately 8% in 2018 to approximately 45% in 2060. Of particular interest was the impact of the peer effect on total EV ownership, which when included in the model, increases the proportion of EVs in 2060 to around 55%.

Keiji Gi presented preliminary modeling analyses of the impacts of increased shared mobility beyond the transport sector. The underlying assumption in the model is that increased car- and ride-sharing will lead to an overall reduction in the total number of vehicles. This will have significant spillover effects in the energy, iron and steel, and plastics sectors. Increased electrification and automation of the remaining fleet will further enhance these co-benefits resulting in significant emissions reductions, particularly as primary energy supply moves to low-carbon sources.

Gi then went on to discuss a novel bottom-up approach for estimating end-use energy demand based on people's daily behaviors and specifically their time budgets. With specific reference to the transport sector the model assumes that total passenger distance travelled, and the mode of transport chosen (and therefore energy consumption) is determined by the time available for different types of travel (e.g., commuting, business travel and private leisure travel). Modeling scenarios based on changing demographics (e.g., aging population, gender equity, etc.) and changing transport system (e.g., shared mobility, improved infrastructure, etc.) for Japan, shows that for most scenarios overall passenger transport demand decreases while the share of public transportation increases (Figure 9). Also, as a proportion of total travel time future scenarios show an increase in leisure travel time through concomitant reductions in commuting time and business-related travel.

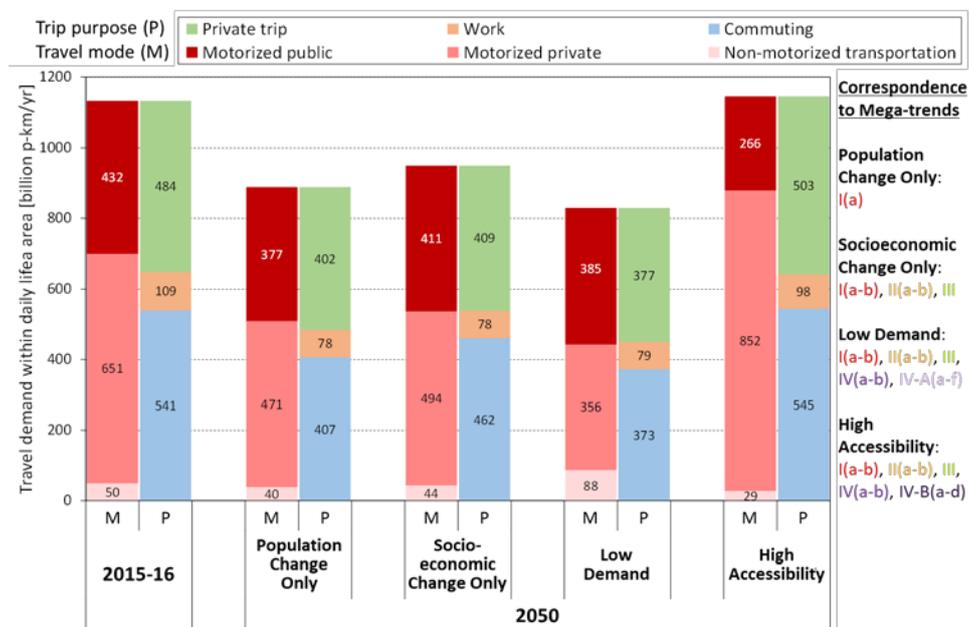


Figure 9. Passenger travel demand in Japan 2015/16 and four scenarios for 2020, projected using a model that includes time budget allocations.

Gi then outlined how existing integrated assessment models cannot adequately estimate changes in transport demand brought about by behavioral changes and disruptive mobility

service developments. He called for better integration between IAMs and service demand scenarios obtained from sectoral transport demand models and/or agent-based models which consider potential disruptive changes in mobility service as a way of better understanding of future transport energy demand.

Bianka Shoai presented a French government hourly model for energy demand and supply. The French government has a goal of carbon neutrality by 2050 primarily through reducing consumption, electrification of energy and biomass. Bianka explained how hourly energy demand is modeled with particular reference to the transport sector. Hourly demand modeling is critical to efficiently match demand with supply with future hourly demand scenarios enabling better supply infrastructure and primary source mix, under different climate scenarios. Of particular interest is the potential impact of electrification of the transport sector on hourly demand and associated CO₂ emissions (interestingly the model is able to ascribe hourly CO₂ emissions per end use based on the supply mix at the time) under different EV diffusion and climate scenarios. However, how to model new electricity uses such as EVs and their interaction with other energy uses (e.g., charging EVs at home) and their integration into the broader energy system presents large uncertainties and modeling challenges. Results show low-carbon mobility scenarios (primarily high diffusion of EVs) could reduce direct and indirect CO₂ emissions by approximately 40% in 2035 compared to scenarios without EVs and by around 65% in 2050 compared to 2017.

Discussion

The discussion started with the observation that much of the current work on transport sector demand was based on incrementalism with a call for a greater focus on truly disruptive transformations, that is, low-energy demand scenarios with zero emissions. However, it was argued that a challenge for such demand scenarios is the lack of ability of policy makers to implement such disruptive changes, particularly in developing countries. Counter to this argument, it was highlighted that the Global South has a long history of shared mobility from which lessons could be learned. It was agreed that better narratives are needed to educate not only policy and decision makers but also the general consumer (and voter) of the types of radical changes required.

Of particular note was the general omission of the freight sector in the models presented, which primarily focused on local passenger travel (even excluding air travel). The transportation of people and goods accounts for approximately 25% of global energy consumption. Of this, approximately 40% is associated with freight (i.e., approximately 10% of global energy consumption). There is considerable potential for demand reductions through electrification of the freight sector from low-carbon energy sources – these potentials are currently underrepresented in existing models.

Also of note was the challenge presented by not explicitly singling out policy scenarios for reducing transport energy use in the United States, which accounts for approximately 25% of global transport sector energy use.

Plenary Session V: Energy Access, Efficiency, and Demand for Sustainable Development

[Jay Taneja](#) began this session discussing energy access and demand for productive use in the developing world. He argued that small-scale electricity grids operate through a system of inequality where a small number of customers drive a large proportion of the load which subsidizes a large number of small consumers. The commercial success of these grids depends on the ability to stimulate demand among customers once access has been established. Demand stimulation comes in two forms: broad-based (e.g., for domestic appliances for cooking, cooling, and entertainment) and productive use (e.g., for supporting commercial activity). However, it has been shown that estimating demand for electricity is especially challenging among consumers who have not previously had access, with some survey-based demand estimates significantly overestimating actual consumption. Empirical data (Figure 10) show both large dispersion as well as a dynamic demand response that increases over time after people gain access to electricity.

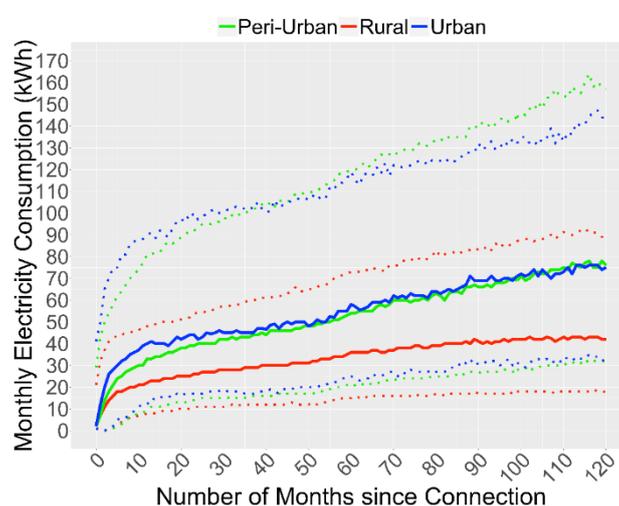


Figure 10. Rural household electricity use (mean and 10th and 90th percentiles) in Kenya by location in time after grid connection.

Big data sources, such as the number of mobile phones, have been shown to be a better predictor of consumer demand in the developing world. Household consumer demand can be stimulated by offering incentives, such as low-cost appliances. A further challenge of estimating, and therefore stimulating, demand is the limited understanding of the interplay between price, reliability, and quality of the energy services, that is, how much are different types of customers willing to pay for different levels of power reliability and quality. Stimulating demand for productive use is particularly challenging as productive use value chains are complex and identifying where potential energy access related bottlenecks occur is difficult. However, it is important to be able to identify enough high-use individual customers to justify a grid connection as low-use customers can rarely afford the initial connection fee, even if heavily subsidized.

[Narasimha Rao](#) discussed energy demand in the context of minimum decent living standards (DLS) for all. Previous top-down estimates of minimum energy needs for development or

human wellbeing range from 10-100 GJ/capita and are typically based on aggregate indicators such as the human development index or life expectancy (Figure 11).

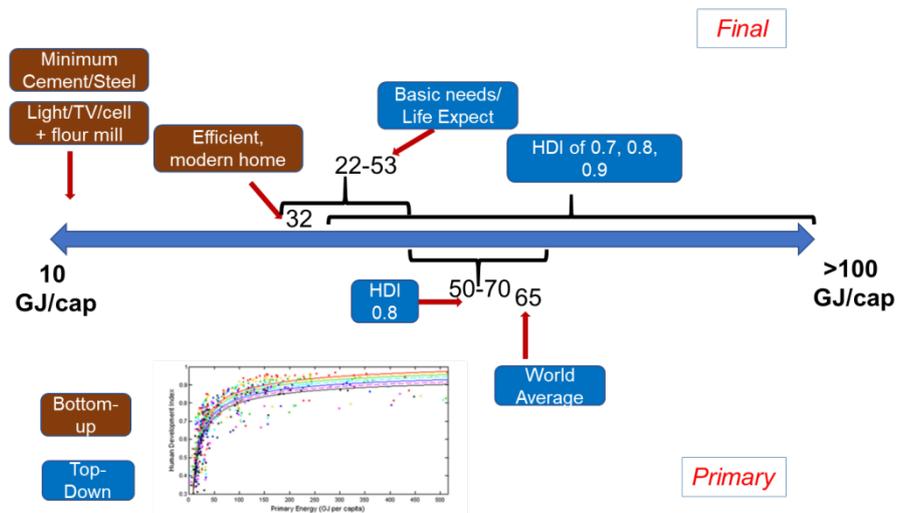


Figure 11. Final and primary energy per capita for Decent Standards of Living, a comparison of literature estimated according to method.

In contrast, Rao uses a bottom-up approach based on DLS to estimate demand. Decent living standards include adequate nutrition, safe shelter with minimum space and thermal comfort, sufficient in-house water for drinking and basic ablutions, improved sanitation, lighting, clean cooking fuels, cold storage, internet and broadcast access, and the use of motorized transport including public transport. In addition, it includes at the national level the provision of health care services and education facilities to support both physical and social wellbeing. Using this approach, estimates of total energy needs to meet these standards, including both operation and the necessary up-front infrastructure construction demands, lie at the lower end of the 10-100 GJ/capita range but show significant differences between countries. The majority of this energy demand is for mobility, production and preparation of food and housing, including thermal comfort. It has previously been argued that the increased energy demands needed for global human development are inconsistent with climate policies that require drastic energy reductions; however, Rao argues that the energy requirements to meet DLS fall well within the range of energy demand estimates in most 2°C climate scenarios, for the countries studied. The underlying reason for this difference is that most climate mitigation models, and underlying shared socioeconomic pathways, use a certain level of affluence, and therefore energy demand, for development which are significantly higher than the demand required for achieving DLS. As an example, the energy consumption of home air-conditioning associated with such affluence is up to five times higher than that required to provide the thermal comfort and reduced heat stress associated with DLS. A key takeaway from this study is the significant heterogeneity of energy requirements for meeting DLS between countries: ~12 GJ/capita for India compared with ~22 GJ/capita for Brazil. Furthermore, the gap between DLS energy needs and those estimated under various climate mitigation models differs between countries (~10 GJ/capita gap for India compared with 50 GJ/capita gap for South Africa) which holds important implications for climate policies within countries and globally.

[Shonali Pachauri](#) closed this session by discussing direct household energy access and demand. Currently around one billion people still lack access to electricity. However, access should be viewed more broadly than simply having a connection. There are many dimensions of access on the both the supply side (availability, affordability, quality, quantity, reliability, sustainability) as well as the demand for end-use services provided (cooking, heating/cooling, lighting etc.). Pachauri argues that there is a general lack of consumer-centric planning when it comes to providing access. There are no reliable estimates of the latent demand of those currently without access, or of consumption patterns of users once a connection is established – both of which have been shown to be highly heterogenous among different income groups within and between countries. For example, adoption rates for household appliances differs significantly at the same income level in different countries: at \$10/day (PPP) only 11% of South African households have washing machines compared with 81% in Mexico, while 70% have refrigerators compared with 95% respectively (Figure 12).

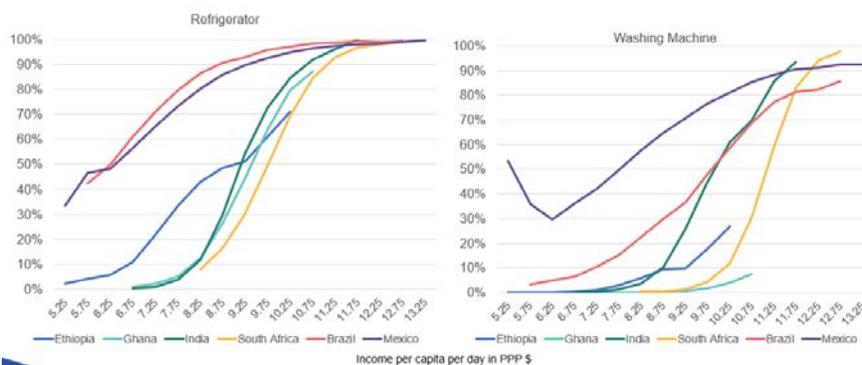


Figure 12. Diffusion of household appliances (refrigerators and washing machines) in selected developing countries as a function of income.

Historically it has been shown that electricity consumption increases with income however, there are differences in the income elasticity of demand between countries. These factors are critically important for estimating latent demand and therefore for energy access policies. There is also a general failure to account for consumer’s culture, behavior and aspirations in estimating demand and consumption in energy access policies. For example, despite improvements in the share of the population using modern cooking energy technologies, the global population still dependent on solid fuels remains around 3 billion and is still rising in some countries. Although there is increasing evidence and awareness of the adverse health and environmental impacts of solid fuel use, policies focus more on electrification, rather than health, and despite years of improved stove projects and subsidies on cleaner fuels, fuel stacking remains the norm in many rural regions in developing countries. Part of the reason for the general policy failure is the fact that if solid fuels are locally available and free (do not have alternative uses) and the opportunity cost of women’s time is low, alternatives can’t compete to completely displace solid fuels: that is, behaviors, traditions and social norms matter. Pachauri finished by discussing the need for residential demand modelling to take into consideration the multidimensionality of the drivers of that demand, including demographics, socioeconomics, behaviors, norms and lifestyles, climate and weather, the characteristics of building stock and appliances as well as energy pricing, policies, infrastructure and supply. Models should also account for the different end-use services provided.

Discussion

The final discussion of the meeting was a general 'call to arms' for participants.

There was a real sense of urgency for action to be taken now using the plethora of information and knowledge we have at hand, rather than being too cautious and arguing for more research and more data. There is a need for large-scale case studies to act as exemplars as to what can be achieved in the near term. The use of stylized facts was argued to be a good approach and called for activism, particularly with national government implementation agencies who are typically more amenable to action and change. Identification of effective incentives will be critical.

It was also stated that it would be beneficial to have policy makers at future workshops to discuss first-hand the barriers to implementation. Any transition to a low demand future needs to focus on protecting people and their wellbeing during that transition rather than stranded capital assets. Arguably the greatest challenge facing such a transition is understanding how to elicit the necessary widescale behavioral change, which will require a greater integration of social and physical sciences.

Appendix 1: List of Participants

Keigo Akimoto

The Research Institute of Innovative
Technology for the Earth (RITE)
Japan

Geoff Clarke

International Institute for Applied Systems
Analysis (IIASA)
Australia

Talita Borges Cruz

Instituto Alberto Luiz Coimbra de Pós-
Graduação e Pesquisa de Engenharia (COPPE)
at Universidade Federal do Rio de Janeiro
Brazil

Simone Fobi Nsutezo (remote)

Columbia University
United States

Keii Gi

The Research Institute of Innovative
Technology for the Earth (RITE)
Japan

Chioke Harris

National Renewable Energy Laboratory (NREL)
United States

Kejun Jiang (remote)

National Development and Reform
Commission, China
China

Jaewan Kim

Yonsei University
Korea

Benigna Boza-Kiss

International Institute for Applied Systems
Analysis (IIASA)
Hungary

Felix Creutzig

Mercator Research Institute on Global
Commons and Climate Change (MCC)
Germany

Simon De Stercke

Imperial College London
Belgium

Atsuko Fushimi

The Research Institute of Innovative
Technology for the Earth (RITE)
Japan

Arnulf Grubler

International Institute for Applied Systems
Analysis (IIASA)
Austria

Kinga Horváth

EnergSys
Hungary

Miho Kamei

Institute for Global Environmental Strategies
(IGES)
Japan

Yong Gun Kim

Korea Environmental Institute
South Korea

Osamu Kimura

Central Research Institute of Electric Power Industry(CRIEPI)
Japan

Abhishek Kumar

Population Council, India
India

Tieju Ma

East China University of Science and Technology (ECUST) and International Institute for Applied Systems Analysis (IIASA)
China

Eric Masanet

Northwestern University
United States

David McCollum

Electric Power Research Institute (EPRI)
United States

Shusuke Mori

JST Center for Low Carbon Society Strategy
Japan

Sumie Nakayama

J-Power
Japan

Leila Niamir

Mercator Research Institute on Global Commons and Climate Change (MCC)
Germany

Paul Kishimoto

International Institute for Applied Systems Analysis (IIASA)
Canada

Benjamin Leibowicz

University of Texas at Austin
United States

Luis Martinez

International Transport Forum at Organisation for Economic Co-operation and Development (OECD)
France

Alessio Mastrucci

International Institute for Applied Systems Analysis (IIASA)
Italy

Sergi Moles-Gruoso

Central European University
Hungary

Takahiro Nagata

The Research Institute of Innovative Technology for the Earth (RITE)
Japan

Nebojsa Nakicenovic

International Institute for Applied Systems Analysis (IIASA)
Austria

Yannick Oswald

University of Leeds
United Kingdom

Shonali Pachauri

International Insitute for Applied Systems
Analysis (IIASA)
Austria

Keywan Riahi

International Insitute for Applied Systems
Analysis (IIASA)
Austria

Joyashree Roy (remote)

Asian Institute of Technology (AIT)
Thailand

Rami Shabaneh

King Abdullah Petroleum Studies and Research
Center (KAPSARC)
Saudi Arabia

Bianka Shoai

RTE-France (DSO Regulator)
France

Julia Steinberger (remote)

University of Leeds
United Kingdom

Bin Su

National University of Singapore(NUS)
Singapore

Jay Taneja (remote)

University of Massachusetts
United States

Diana Urge-Vorsatz

Central European University
Hungary

Narasimha Rao (remote)

School of Forestry and Environmental Studies,
Yale University
United States

Michaela Rossini

International Insitute for Applied Systems
Analysis (IIASA)
Austria

Alessandro Sanches

Instituto 17
Brazil

Yoshiyuki Shimoda

Osaka University
Japan

Linda Steg

University Groningen
Netherlands

Erich Streissnig

International Insitute for Applied Systems
Analysis (IIASA)
Austria

Masa Sugiyama

Tokyo University
Japan

Fei Teng

Tsinghua University
China

Bas van Ruijven

International Insitute for Applied Systems
Analysis (IIASA)
Netherlands

Jefim Vogel
Univeristy of Leeds
United Kingdom

Pat Wagner
International Insitute for Applied Systems
Analysis (IIASA)
Austria

Charlie Wilson
Tyndall Centre for Climate Change Research
and International Institut for Applied Systems
Analysis
United Kingdom

Kenji Yamaji
The Research Institute of Innovative
Technology for the Earth (RITE)
Japan

Ju Yiyi
University of Tokyo
Japan

Xingrong Zhao
East China University of Science and
Technology (ECUST)
China

Caroline Zimm
International Insitute for Applied Systems
Analysis (IIASA)
Austria

Appendix 2: Meeting Agenda

Monday, 11 November

11:30	<i>Mondial Shuttlebus Transportation leaves from Vienna meeting place (see Logistics Note) to IIASA (Schlossplatz 1, Laxenburg)</i>
12:00	<i>Arrival at IIASA and Registration (Conference Secretariat next to the Wodak Room)</i> <i>Sandwich lunch</i>
13:00-13:30	Opening Session Welcome, and Framing Introduction to Workshop <i>Arnulf Grübler (IIASA, 5 min) and Keigo Akimoto (RITE, 15 min)</i> Short greeting address <i>Kenji Yamaji (RITE)</i>
13:30-15:30	Plenary Session I: Energy Demand - An Evolving Landscape (30 mins each incl. Q/A) Chair: Kenji Yamaji (RITE) <ul style="list-style-type: none">• Outcomes of the Nara Workshop <i>Charlie Wilson (University of East Anglia, Tyndall Center and IIASA)</i>• The World in 2050 Initiative: TWI2050 Digitalization Report <i>Nebojsa Nakicenovic (IIASA)</i>• Demand, efficiency, lifestyles: Perspective from the Global South (via WebEx**) <i>Joyashree Roy (Asian Institute of Technology)</i>• Megatrends in energy systems <i>David McCollum (Electric Power Research Institute)</i>
15:30-16:00	<i>Coffee Break</i>
16:00-17:30	Parallel Sessions:
Gvishiani Room	Parallel Session I: Break-out group on “What do we know and what we need to know” (demand research needs) Moderator: Charlie Wilson (University of East Anglia, Tyndall Center and IIASA)
Wodak Room	Parallel Session II: Break-out group on Digitalization Moderator: Nebojsa Nakicenovic (IIASA)
17:45	<i>Adjourn - Mondial Shuttlebus Transportation leaves from IIASA to dinner</i>
18:00-20:30	<i>Social Event at Klostergasthaus Thallern (Thallern 2, 2352 Gumpoldskirchen)</i>
ca. 20.30	<i>Mondial Shuttlebus Transportation from Klostergasthaus Thallern to Vienna</i>

Tuesday, 12 November

- 08:30 *Mondial Shuttlebus Transportation leaves from Vienna meeting place (see Logistics Note) to IIASA (Schlossplatz 1, Laxenburg)*
- 9:00-9:30 *Morning coffee and snacks*
- 09:30-11:00 **Plenary Session II: Demand, Lifestyles, Social Aspects of Mitigation in AR6 (20 min each)**
Chair: Keigo Akimoto (RITE)
- Overview of IPCC AR6 Chapter 5
Felix Creutzig (Mercator Research Institute on Global Commons and Climate Change)
 - Social science aspects in IPCC AR6
Linda Steg (University of Groningen)
 - History and assessment of mitigation potential assessments in IPCC, the case of buildings sector (Q/A session)
Diana Urge-Vorsatz (Central European University)
- 11:00-12:00 **Round Table Discussions, Kick-off Statements**
Moderator: Keywan Riahi (IIASA)
(5-minutes statements per intervention, followed by general discussion)
- 12:00 *Walk over to the IIASA Schloss Restaurant*
- 12:00-13:30 *Lunch – Oval Room - Schloss Restaurant*
- 13.30-14.00 *Coffee break*
- 14:00-16.00 **Plenary Session III: Young Demand Researchers Poster Session (5 minutes-presentation by “next generation” researchers)**
Chair: Arnulf Grübler (IIASA)
- 16:00-17:30 **Poster visits and discussions**
- 18:00 *Walk over to the IIASA Restaurant*
- 18:00-20:30 *Social Event / Reception – IIASA Schloss Restaurant – Oval Room*
- 20:30 *Mondial Shuttlebus Transportation from IIASA to Vienna*

Wednesday, 13 November

- 08:30 *Mondial Shuttlebus Transportation leaves from Vienna meeting place (see Logistics Note) to IIASA (Schlossplatz 1, Laxenburg)*
- 9:00-9:30 *Morning coffee and snacks*
- 09:30-11:00 **Plenary Session IV: Transport Demand, New Business Models, and Modeling (25 min. each)**
Chair: Paul Kishimoto (IIASA)
- Shared mobility: concepts and modeling
Luis Martinez (OECD)

- Modeling new mobility concepts for Shanghai
Tiejun Ma (School of Business, East China University of Science and Technology)
 - Preliminary modeling analyses on global impacts of sharing mobility beyond transportation sector
Keiji Gi (RITE)
- 11:00-12:30 **Round Table Discussions, Kick-off Statements**
Moderator: *David McCollum (Electric Power Research Institute)*
(5-minutes statements per intervention, followed by general discussion)
- 12:30 *Walk over to the IIASA Schloss Restaurant*
- 12:00-13:50 *Lunch – Oval Room*
- 14:00-15:30 **Plenary Session V: Energy Access, Efficiency, and Demand for Sustainable Development (20 mins each)**
Chair: *Linda Steg (University of Groningen)*
- Energy access and demand for productive purposes (businesses and agricultural activities) (via WebEx**)
Jay Taneja (University of Massachusetts)
 - Energy demand for decent living (infrastructure build out and operation) (via WebEx**)
Narasimha Rao (IIASA and Yale University)
 - Direct household energy access and demand
Shonali Pachauri (IIASA)
- 15:30-16:00 *Coffee break*
- 16:00-17:00 **Round Table Discussions, Kick-off Statements**
Moderator: *Shonali Pachauri (IIASA)*
(5-minutes statements per intervention, followed by general discussion)
- 17.00** **Closing Remarks & Outlook:** *Arnulf Gröbler (IIASA) and Keigo Akimoto (RITE)*
- 17.15** **End of Workshop**
(Upon request – transfers to hotel or airport will be arranged)
- 17:30 *Mondial Shuttlebus Transportation from IIASA to Vienna*
- 18:30 *Optional private dinner or evening event (TBD)*

Appendix 3: List of Posters

Poster Awards

Best Poster with Distinction

Simone Fobi, Quadracci Sustainable Engineering Lab, Columbia University, USA. [Using remote sensed data to predict residential electricity demand in Kenya.](#)

Citation: The research presented is an ingenious combination of using empirical data and remote sensing information to study the electricity demand response after gaining access in Kenya. The clearly structured poster was complemented by an excellent presentation.

Leila Niamir, Mercator Research Institute on Global Commons and Climate Change, Germany. [Behavioral climate change mitigation from individual energy choices to demand-side potential.](#)

Citation: The research presented is original and highly relevant to understanding service demands. The work is both conceptually and analytically interesting, integrating bottom-up heterogeneous agent-level processes with the macro-effects of climate change, employing a highly appropriate methodological approach. The research was presented in a very clear presentation.

Best Poster

Yannick Oswald, Sustainability Research Institute, University of Leeds, UK. [International inequality in energy footprints.](#)

Citation: The research presented is of high quality and highly relevant to energy demand services in comparing energy footprints across countries. The work looks at embedded energy related to the production of goods and services, which is an important topic that is often still overlooked in studies. The results show that inequality differs across different types of services. The poster and presentation were very clear.

Simon De Sterke, Department of Civil and Environmental Engineering, Imperial College London, UK. [Modeling the dynamics of the water-energy nexuses of London and Mumbai from an end-use perspective.](#)

Citation: The research presented is novel and highly relevant to understanding service demands in connecting different service sectors and comprehensively investigating feedbacks of different sectors at an urban scale, including resource flow connections between the city and its hinterland. The animated presentation provided a novel experience, telling a real story.

Xingrong Zhao, East China University of Science and Technology, [China. Are transport users willing to share? Stated preference study on shared mobility in Shanghai.](#)

Citation: The research presented is interesting and relevant to energy service demands both in content and methods. The work investigated shared mobility in Shanghai using survey data to understand heterogeneous human preferences, actions, rebound effects, and related energy demand. The presentation was clear and well-structured.

Other Posters

- **Talita Cruz**, Energy Planning Program, COPPE/UFRJ, Brazil.
[*Modeling social heterogeneity: How does a better representation of income inequality affect energy choices in Brazil?*](#)
- **Kinga Horváth**, EnergoSys Inc., Hungary.
[*Improving indoor comfort while being energy efficient.*](#)
- **Miho Kamei**, Institute for Global Environmental Strategies, Japan.
[*Urbanization, carbon neutrality, and gross national happiness: Sustainable development pathways for Bhutan.*](#)
- **Jaewan Kim**, Yonsei University, South Korea.
[*Multilevel analysis on effectiveness of energy transition policy in Seoul: the Seoul Eco-mileage program.*](#)
- **Abhishek Kumar**, Population Council, New Delhi, India.
[*Understanding contribution of women's education on marriage age and use of maternal healthcare services in India, 2005-2016.*](#)
- **Benjamin Leibovitz**, Operations Research and Industrial Engineering, University of Texas, USA.
[*Urban land use and transportation planning for climate change mitigation: A theoretical framework.*](#)
- **Sergi Moles-Gruoso**, Department of Environmental Sciences and Policy, Central European University, Hungary.
[*Harnessing the exemplary role of the public sector: Conceptual and epistemological issues.*](#)
- **Jefim Vogel**, Sustainability Research Institute, University of Leeds, UK.
[*Gatekeepers of low-energy wellbeing: Provisioning systems as intermediaries between energy use and basic needs satisfaction.*](#)
- **Ju Yiyu**, Institute of Future Initiative, University of Tokyo, Japan.
[*Optimal technology combination under national mitigation and energy service demand scenarios: the cement industry in Japan and China.*](#)