“well below 2 degrees”: The potential role of novel demand-side approaches in deep mitigation

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Overview

- Introduction: emerging literature on non-mainstream options
- Challenging the role of demand-side efforts in IAMs:
  - What is not covered by scenarios but could make a difference
- Highlights from non-technological and/or non-price opportunities from AR5
- Further novel demand-side approaches and opportunities…?

Acknowledgments to: Elisabeth Boles, MIT, Souran Chatterjee, CEU 3CSEP
The “other side” of AR5 pathways
New U.N. Climate Report, in Brief

YOUR GOOSE IS COOKED.
Figure 6.35. Direct emissions in 450 ppm CO$_2$eq scenarios with and without using CCS

Source: IPCC AR5 WGIII
Challenged by Creutzig et al. 2016

- Of the 400 scenarios reviewed in AR5 that limit warming to 2°C, 344 (86%) rely on negative emission technologies, in particular on BECCS.
- Several of these imply massive changes in land use patterns and have raised many concerns since AR5.
- Could the demand-side fill the gap?
- The AR5 also showed that the solution space is much more flexible if demand is kept at bay or reduced.

Supply or demand-side problem?
Baseline Scenarios: Direct vs. Indirect Emission Accounting

Source: Volker Krey, using IPCC AR5 Figure SPM.10,
Figure 9.1 | Direct and indirect emissions (from electricity and heat production) in the building subsectors (IEA, 2012a; JRC/PBL, 2013; see Annex II.9).

Source: IPCC AR5 WGIII
Energy efficiency in buildings can substantially lower sectoral energy use; thermal uses are most reducible.

For further details on mitigation options and potentials, see Chapter 9.

Source: IPCC AR5 WGIII

3CSEP
Source: IPCC AR5 WGIII, Chapter 9
Figure 9.21 Building final energy use in EJ / yr in 2050 (2030 for BUENAS and WEO’10) for advanced scenarios, modelling four groups of building end-uses as compared to reference.

Integrated Models (480-580 ppm CO₂eq)
- Difference Baseline to Mitigation Scenario
- Mitigation Scenario

Sectoral Models
- Difference Baseline to Advanced
- Advanced

Source: IPCC AR5 WGIII, Chapter 9
Challenging energy models regarding their ability to show deep opportunities in the building sector

- Do models covering the building sector really understand the frontiers of know-how in architecture? (such as nearly-zero and passive buildings)?

- Proposal: move away from modeling building COMPONENTS to building SYSTEMS (i.e. better to use performance-based approaches to building energy modeling, at least for heating/cooling)

- How are we projecting the building energy future?
55,000 Passive Houses exist in 28 European member countries.
Historic building Eberlgasse
Retrofit to Passive House
Net floor area 668.3 m²
Wall U-value 0.089 W/m²K
Heating demand from 178 kWh/m²a to 15 kWh/m²a
Primary energy demand: 108 kWh/m²a for heating, hot water, household electricity
Owner: Andreas Kronberger Unternehmensberatung
Building physics: Schöberl & Pöll GmbH

Heat Energy kWh/(m²a)

Before retrofit

After retrofit

Solar Energy

- 92%

178

15

2
First retrofit to Passive House Plus
Office building Technical University Vienna
Architect: Arch. DI Gerhard Kratochwil
Building physics: Schöberl & Pöll GmbH
Owner: BIG Bundesimmobilien gesmbH

Treated floor area: 7,322 m² = 80,000 ft²
Heating demand: 14 kWh/m²a = 4.4 kBTU/ft²a
Heat load: 9 W/m² = 2.85 BTU/ft²
Primary energy: 56 kWh/m²a = 17.75 kBTU/ft²a

Primary Energy kWh/(m²a)

Before retrofit: 803 kWh/m²a
After retrofit: 56 kWh/m²a
Renewable Energy: 61 kWh/m²a

- 94%
World’s largest Passive House city district
Zero-Emission-City areal Heidelberg-Bahnstadt
116 ha, 1,700 flats
Passive House as Standard for urban development

www.heidelberg-bahnstadt.de
Belgian Energy provider Elia

Brussels mandated Passive House in January 2015

High rise renovation to full PH

Brussels Environnement Ministry
New York City may go Passive

A Roadmap for New York City’s Buildings:

“The City Government will implement leading edge performance standards for new construction that cost effective achieve highly efficient buildings, looking to Passive House to inform the standards”
The Lock-in Risk: global heating and cooling final energy in two scenarios

- Lock-in Effect 80%
- Moderate Efficiency
- Deep Efficiency

Global heating and cooling final energy in two scenarios.
The lock-in risk: heating and cooling energy demand by two scenarios

Source: IPCC AR5 WGIII, Chapter 9

*Lock-in Risk of Sub-Optimal Scenario Realative to Energy Use in 2005.
Further questioning energy modeling: working in traditional silos vs allowing for different systemic approaches

- Sectoral breakdown – inherited from economic statistics; is this still the best (or at least only) way to organize energy (end) use?

- E.g. urban systems
  - The role of urban planning, interactions between buildings and transport; role of density
  - Eliminating UHI – effect on emissions/energy use?

- ICT
  - 10% of global electricity consumption is for IT
  - If the cloud were a country, it would have the 5th largest electricity demand in the world.
  - “Information efficiency”?

- E.g. food systems
Food systems

- The industrial food system is responsible for 44 to 57% of all global GHG emissions (Grain, 2011)
  - Agriculture, industry, transport, buildings, services

- In EU, transport of food accounts for at least 6% of global GHG emissions. (Grain, 2011)

- processing and packaging of food accounts for between 10-11% of GHG emissions, while refrigeration of food accounts for 3-4% of total emissions and food retail another 2%. (Grain, 2011)

- In North America, 42% of food was wasted
  - But cross-sectoral savings often remain uncaptured
    - Reducing food waste
    - Dietary shifts
    - ?
Figure 6. Part of the initial production lost or wasted at different stages of the FSC for fruits and vegetables in different regions

Food losses - Fruits and vegetables

Source: FAO
Further challenging integrated energy modeling 2: technology vs. behavior/culture/values

- Factors of 3 to 10 differences in residential energy use for similar dwellings with same occupancy and comfort levels (Zhang et al., 2010), and up to 10 times difference in office buildings with same climate and same building functions with similar comfort and health levels.

- The use of 'part-time' and 'part-space' indoor climate conditioning, using mechanical systems only for the remaining needs when passive approaches cannot meet comfort demands can reach energy use levels below 30 kWh e / m² / yr as a world average (TUBESRC, 2009; Murakami et al., 2009), as opposed to the 30 – 50 kWh e / m² / yr achievable through fully automatized full thermal conditioning (Murakami et al., 2009; Yoshino et al., 2011).
Figure 9.10 | Annual total electricity use per unit of floor space of buildings on a university campus in Beijing, China, 2006 (Zhang et al., 2010).

Source: IPCC AR5 WGIII, Chapter 9
Figure 9.9 | Annual measured electricity per unit of floor space for cooling in an apartment block in Beijing (Zhang et al., 2010).

Source: IPCC AR5 WGIII, Chapter 9
Behaviour, lifestyles vs technology cont.

- Dress codes: AC thermostat setting from 28 to 24 will more than triple AC power use in Zurich and double in Rome. “Cool Biz” of Japan enables the higher setting.
- Many more examples – point is to go beyond price-driven demand changes as sole behavioural option, as well as purchasing behavior to increase penetration of advanced technologies.
- E.g. Lord Stern’s example: average car in the city is utilized less than 8% of the time; with less than a third of seat occupancy – i.e. just above 2% average utilization factor. Using parking space, urban space, resources to manufacture, dispose of, etc. Is really the winning strategy to optimize the fuel/efficiency of this vehicle, rather than incentivising shared ownership/use systems?
Challenging the frontiers of demand-side energy modeling 3.

- In general, are the effects of the shared economy captured? Future opportunities?
- Driverless mobility?
- Driverless smart/intelligent transport and shipping systems, replacing even public transport systems?
- In general, how much are we capturing the gigantic optimization opportunities through IOT, Big Data, Web 2.0, ubiquitous remote sensors, etc….?
- Information efficiency?
- CDRU?
Further non-technological, non-price opportunity examples
based on Creutzig et al 2016, Annual Reviews
Demand side measures | Examples
--- | ---
Semi-detached and three story buildings have been shown to be significantly more efficient in terms of operational energy than single-story freestanding units. | In Sydney, Australia, low-rise attached housing has 15-20% lower energy use than detached housing with the same number of bedrooms.

Behavioral changes, depending on the type of end use | Savings from heating loads of 10–30% are possible for changes in thermostat setting.

| Cooling savings of 50–67% are recorded with measures such as substituting air conditioning with fans in moderately hot climates with tolerable brief heat exposures. |

Increasing the thermostat setting from 24°C to 28°C reduces annual cooling energy use by more than a factor of three for a typical office building in Zurich, by more than a factor of two in Rome and by a factor of two to three if increased from 23°C to 27°C for the night-time in residential Hong Kong.

Source: Creutzig et al 2016 Annual Reviews
<table>
<thead>
<tr>
<th>Demand side measures</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>By shorter showers, switch from bathing to showering</td>
<td>Hot water savings of 50%</td>
</tr>
<tr>
<td>By turning off not needed lights</td>
<td>Lighting energy savings of 70%</td>
</tr>
<tr>
<td>Smaller fridge/fridge-freezer volumes and elimination of a second fridge</td>
<td>Refrigerator energy savings of 30-50%</td>
</tr>
<tr>
<td>With cold compared to hot water washing</td>
<td>Clothes washers energy savings of 60–85%</td>
</tr>
<tr>
<td>Dishwasher (by fully loaded operation versus typical part-load operation)</td>
<td>Dishwashers energy savings of 75%</td>
</tr>
</tbody>
</table>

Source: Creutzig et al 2016 Annual Reviews
Summary points

- For WB2C scenarios it is crucial that energy modeling is advanced to better integrate:
  - Frontiers of technologies and know-how
    - E.g. passive buildings
  - Frontiers of 21st century opportunities for optimization and service provision
    - IOT, web 2.0, big data, ubiquitous sensors, etc.
  - The increasing opportunities through the shared economy
  - Opportunities through behavior, lifestyle change, cultural change
  - Analyse also in other systemic frameworks than traditional economic sectors; e.g. food systems and urban systems
  - The quantification (and minimization?) of the lock-in risk

- Other: emission reporting (modeling) and attribution need to reflect both “extreme” attribution approaches
Thank you for your attention

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Supplementary slides
IPCC AR5: Substantial reductions in emissions will require large changes in investment patterns

Based on Figure 16.3
New business models are needed

- What we really need are ingenious **new business models** whose profits are not from converting raw natural resources to sellable consumer goods; but rather decouple (or minimize the link between) well-being from more resource consumption.

- Recent ideas that come close but are not quite what I mean are:
  - Social media – replacing much travel? (good or bad…?)
  - Airbnb, Uber, etc – the sharing economy?

- More business platforms needed for utilizing unwanted, grown-out, etc products that have not reached the end of their lifetimes but cannot easily find their new owner
  - Also needs a cultural change, but partially ongoing

- More business profiting form repair and good maintenance, lending, rather than selling new and encouraging early breakdown or replacement

- Business ideas utilizing or miniising waste streams – such as the 50% of the food in the EU that we ends up as waste
  - are there solutions that still supply the choice of fresh food an hour before closure but eliminate waste? Could we better predict demand?

- More utilization of IT for more optimization (such as traffic jams, unnecessary trips to where we do not want to go but have to; more teleworking, teleeducation; more optimization in transport and aviation)

- Can businesses profit from a more quality spending of time rather than consumption? (community-building, family, local travel, eco-tourism, etc)
2015 was the warmest year ever recorded on Earth
Annual Temperature vs 1951-1980 Average (°C)

- All years
- El Niño years
- La Niña years

+0.87 °C New record
Estimates for mitigation costs vary widely.

- Reaching 450ppm CO$_2$eq entails consumption losses of 1.7% (1%-4%) by 2030, 3.4% (2% to 6%) by 2050 and 4.8% (3%-11%) by 2100 relative to baseline (which grows between 300% to 900% over the course of the century).

- This is equivalent to a reduction in consumption growth over the 21$^{st}$ century by about 0.06 (0.04-0.14) percentage points a year (relative to annualized consumption growth that is between 1.6% and 3% per year).

- Cost estimates exclude benefits of mitigation (reduced impacts from climate change). They also exclude other benefits (e.g. improvements for local air quality).

Source: IPCC 2014, AR5 WGIII
AR5: the largest assessment in human history

1 Summary for Policymakers
   1 Technical Summary

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