ROADMAP FOR SMART ENERGY SOLUTIONS TO REACH A SUSTAINABLE AND SECURE ELECTRICITY SUPPLY IN EUROPE

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Overview

There is a need for major transformations in the energy system and a greater sense of urgency to reach the climate goals. Twenty-first century technologies offer new possibilities for the future of cities. However, the current pace at which these disruptive technologies proliferate rapidly increase, faster than what city leaders could keep up with. Cities need a clear and comprehensive vision to shape their smart energy future, one that is ambitious, grounded to reality, and that leverage unique local assets.

Digitalization offers countless answers and solutions to the increasing challenges of sustainable energy supply. The need for suitable technologies, processes, and business models to cope with the major transformations in the energy system is increasing worldwide. This is due to ongoing megatrends such as urbanization, connectivity, and security. These measures are also intended to counter current crises such as pandemics, energy security and import dependency, climate change and structural change.

One objective is to find out whether there is an intrinsic micro-economic benefit for cities/regions to implement smart energy technologies to enable a shift to carbon-neutral energy consumption. This holds great promise for addressing the vexing challenge of cities to develop a path to carbon-neutrality. This work will envisage a clearer view of the future's potential of the city as well as the today's city-specific challenges.

Methods

The paper introduces a practice-oriented systematic to identify major technological milestones to reach sustainability goals with consideration of city specific circumstances. Reflecting their CO_2-reduction potential the work identifies key technologies, outlines major development milestones, and prioritizes technologies based on their potential to be implemented and upscaled in a particular city/region. The four action lines of the applied systematic guarantee a holistic and sustainable approach to decarbonize the energy system. The paper and presentation will focus on the technology transfer matrix (1), development of the scale-up roadmap (2) and introduce an example of the government decision support model (4).

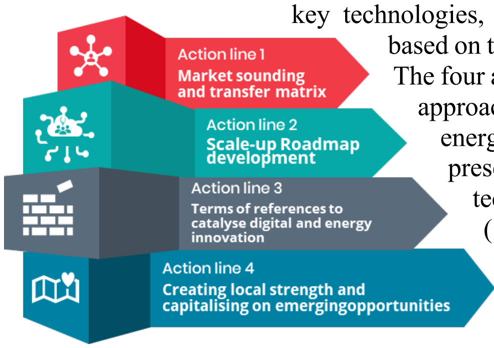

Figure 1: Four action lines of the BABLE decarbonization systematic

The main objective of the transfer matrix is to visualise the assigned rating for each technology based on the described criteria.

		Renewable and sustinable energy generation						
		Biomethan	Mini-CHP for decentral sulutions	Solar thermal generation	Biomass	Wind	Rooftop PV	Large-scale PV
Technology Criteria	Development status	Low	Low	High	Very high	High	High	High
	Conversion efficiency	Medium	Medium	High	Medium	High	Medium	Medium
	Technology potential	Very high	High	High	Medium	High	Very high	Very high
Environmental Criteria	Environmental friendy impact	Medium	Medium	High	Medium	Very high	High	High
	Public acceptance	Very high	High	Very high	High	Medium	Very high	Very high
Economic potential	Status-quo	Low	Low	High	High	Medium	Medium	Medium
	2050	Medium	Medium	High	Medium	High	High	Very high

Figure 2: Example for the technology transfer matrix

For the concept of the scale-up roadmap, the technologies are evaluated based on a Multi-Criteria Assessment (MCA). This analysis highlights the city-specific potential for technologies to decarbonize the energy system considering several key criteria co-identified with the city/region.

Five different sectors for smart energy solutions are analyzed to reflect interdependencies and sector coupling effects:

- Renewable and sustainable energy transition
- Digital & transmission infrastructure
- Balancing and storage
- Climate-neutral end use & energy efficiency
- Sustainable mobility

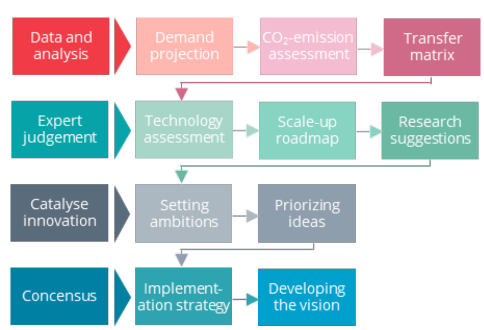

Figure 3: Multi-Criteria Assessment (MCA) for technology evaluation

A cross-sectoral innovative approach is applied to identify the sectors with highest decarbonization potential based on city/region specific circumstances. E.g., the focus to intermittent renewable energy sources of wind and photovoltaics as the main pillars of future electricity generation in Europe comes along with distinctive challenges for technical and market integration. A key issue is to find reasonable use for excess intermittent renewable electricity generation. Hourly specific spread patterns for 22 years for diverse applications in three sectors are processed. For the industrial sector green hydrogen generation and energy efficiency improvements are possible considerations for technology scale-up. For residential and commercial sectors technologies such as building retrofitting, and investments in solar thermal and PV-generation are evaluated.

The introduced methodology of the market analysis demonstrates how the country specific landscape – constituted by market leaders, best-practices, innovation networks and funding instruments - would be decisive to have mass-market adoption of digital energy technologies in the energy system.

Results

The results of the smart energy scale-up roadmap are based on data of a major German city. First a technology transfer matrix (1) is applied, rating available sustainable technologies based on city specific circumstances. For each technology, specific milestones and tipping-points are identified until 2050. Macro-economic consequences and market interaction effects between investigated technologies and sectors are stated. Tangible next steps that need to be undertaken for further scale-up are acknowledged. The smart energy scale-up roadmap (2) demonstrates how investments in research, pilot projects, policy updates and infrastructure in the short and medium-term would be decisive to have mass-market adoption of the technologies in the long-term in a city specific environment.

However, city administration often indicates they have limited capacity and internal structure is not ready for increasingly rapid technologies cycles. To enable city leaders to keep up with disruptive and complex technology a government decision model (4) is introduced. Using a comprehensive up-to-date platform an overview of the full market landscape of use-cases, solutions and products is given. A factsheet review of the market landscape and where technologies have been implemented in the past is done together with city representatives. The city administration refines the scope and makes the decision on best suitable solutions. This is based on the results of the decarbonization roadmap as well as the terms of reference for the procurement method (3) that fits them best. These steps will be presented based on a current project which has proven to accelerate decision making in city administration and help to distribute task to relevant departments overcoming silo thinking.

Conclusions

To achieve the ambitious climate and carbon emission goals, in addition to major infrastructural investments, bottom-up innovations an early engagement of the local ecosystem are crucial. Measures in the energy, building and mobility sectors must significantly reduce carbon emissions immediately. One policy-relevant conclusion is that government intervention has to reach an optimal level to incorporate social limitations of their decarbonization roadmap e.g., address the burden of low-income households. The development of a smart energy scale-up roadmap must bring not only the citizens primary beneficiaries together, but also relevant research and industry partners. In this context, a disruptive development can begin, when some specific digital applications (e. g. ICT, open data, data platforms, security technologies, artificial intelligence, IoT) with relevance to the energy systems become standards.

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