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Impacts and Value Chains of the Cloud-Edge-IoT Continuum in the Energy Sector

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Why is the CEI continuum important for the Energy sector?

The ongoing energy transition is essential for mitigating climate change. The transition causes major changes from the traditional linear value chain towards an integrated energy ecosystem. Due to the decentralisation, the weather-dependency of renewables and the energy flow in several directions, the energy sectors digitalisation and CEI solutions are an inherent necessity for the transition.

As part of its efforts to promote the CEI Continuum, the EUCEI initiative has carried out a series of industry focused surveys on current and planned adoptions. The Energy sector sees a lot of yet-untapped potential for CEI development. Whilst Cloud is already present in almost 70% of the surveyed companies, Edge and IoT are projected to reach above 50% and 70% presence over the next few years, highlighting the transformation that is taking place across the Computing Continuum in Europe (see percentages for usage and plans for uptake by 2025).

Cloud computing:

- **34%** Extensive use
- **34%** Limited use
- **21%** Plan to use

Edge:

- **4%** Extensive use
- **24%** Limited use
- **25%** Plan to use

IoT:

- **18%** Extensive use
- **33%** Limited use
- **19%** Plan to use

In the Energy Sector, the demand for a CEI Continuum is primarily governed by the need to mitigate climate change and not necessarily by industry needs. Hence, the energy transition and digitalisation of the energy sector is mainly driven by various regulations at the national and international levels, including the European Green Deal. e.g. reform of the EU electricity market design.

What are the CEI opportunities in the Energy sector?

The energy transition comes with new roles in the energy system, new regulations and new possibilities, but also with stability and security concerns and additional challenges, such as decentralisation, dependence on weather-dependent renewable energy sources, and energy flow in multiple directions. The digitalisation of the energy sector using CEI solutions for Smart Grid and Energy Management have become essential for a successful transition. Digitalisation needs to penetrate the energy system at all levels. As a result, the boundaries between specific and more defined CEI use cases and approaches that contribute to the overall challenges are often blurred.

Other use cases like **Drone-based observation for remotely monitoring and maintaining infrastructure**, particularly powerlines and Employee safety monitoring for powerline repair and oil rig operations are additional CEI opportunities in the energy sector.

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What is the challenge of Smart Grid and Energy Management?

In the past, the energy value chain was linear, moving from energy generation to transmission network to distribution network and finally to energy use/consumers. Now, the energy ecosystem needs the efficient and resilient integration of flexible energy generation sources and storage solutions.

To meet the overall challenges:

Flexibility: Integration of flexible energy sources +

Stability/resilience: Network observability, automation and controllability +

Efficiency: Efficient use of energy

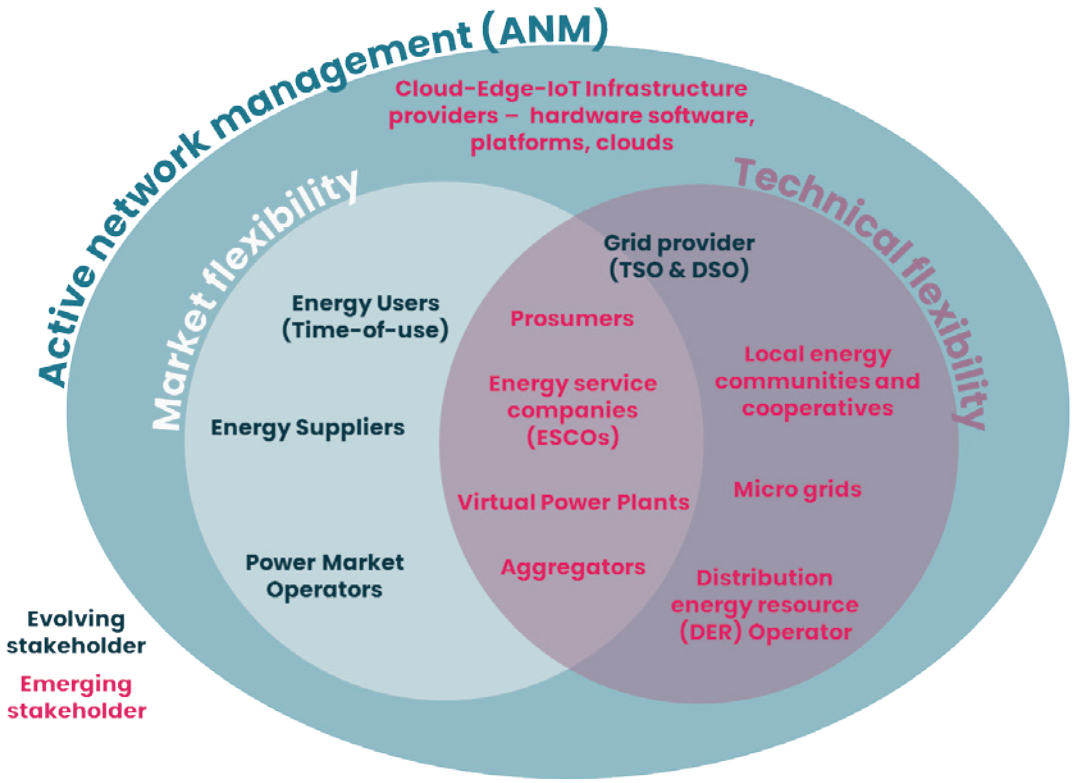
The energy consumption/generation has to be flexibly shifted to another moment (e.g. from day to nighttime) and/or location.

This can be achieved mainly by the following approaches:

Market flexibility **Technical flexibility** **Active network management**

Efficient and stable integration of flexibility sources into the energy system requires active grid management, observability, automation, and controllability of the grid and/or energy generation and/or consumption and/or storage with different temporal and spatial granularity. To achieve this flexibility, the roles of existing stakeholders in the energy system need to evolve, while a range of new market opportunities and demands are created.

The following figure shows the non-linear value network with evolving stakeholders that successfully operate on the existing energy market and new emerging stakeholder who disrupt the old business relations in the existing value network.



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On one hand, the evolution of old stakeholders' roles is necessary, presenting various challenges for grid providers. On the other hand, new stakeholders have emerged in the energy landscape. E.g. Prosumers, who are able to generate, consume, and/or store energy simultaneously, now play a major role. Another example of an emerging stakeholder are energy aggregators. These entities collect small amounts of energy from multiple sources, combine them and sell the resulting energy in larger quantities to wholesale buyers or grid operators.

What are the key service requirements for the energy sector?

Design

- **Regulatory Framework** for:
  - Alignment and harmonisation on the local, national and European level.
  - Collaboration along the value chain, force implementation of EU Regulation on the national levels.
  - Definition of standards for successful interoperability and new value chain adopter models.
  - Incentivise grid flexibility by CEI updates and improvements of the existing infrastructure.
- **Interoperability** of infrastructure and platforms;
- **Standardisation** of sensors, data formats, platforms, grid signals and communication standards to enable integrations of CEI infrastructures into existing IT systems
- **IT Infrastructure for Active Network Management:**
  - open source IoT platforms are needed that serve as Control Room Architecture for Future Grids, overcome traditional SCADA systems (Supervisory Control and Data Acquisition) and can handle large volumes of data and serve to reduce inertia.
  - For active network management (ANM), IoT platforms need to enable observability, controllability and automation depending on location and time (granularity close to real-time) of the grid.
  - ANM can then be used for e.g. voltage control, congestion management (demand/capacity exceeds the transfer capabilities), demand response, digital twins for load prediction or distribution energy resource (DER) management.
  - Needs to meet cybersecurity standards and should be able to make use of Artificial Intelligence.

Installation

- Infrastructure: hardware basis for the observability, controllability, and automation of the grid is needed in the form of additional sensors.
- At the secondary substation level (medium to low voltage) for control of temperature, equipment status and status of the grid for real-time monitoring for power quality and load prediction as well as edge analytics for predictive maintenance.
- on the consumer/prosumer side, smart meters are needed for flexible tariffs and additional devices for bidirectional integration of electricity and information are needed.
- Edge intelligence can facilitate more energy efficiency, e.g. through smart home solutions.
- Installation of energy accumulation resources, e.g. batteries or hydrogen can be used for smart energy management, and the large-scale introduction of EVs and charging infrastructure is one aspect.

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Operation

- Data privacy of the consumers, e.g. IoT sensors and edge computing applications must be ensured.
- Cybersecurity the energy sector is critical infrastructure which means that high requirements on safety and security for reliable electricity distribution apply during design and operation.

Maintenance

- Degradation of meters, infrastructure as well as treatment of batteries and accumulators have to be considered.

Upgrade

- For the planning and design of future grids, IT Infrastructure in the form of open source IoT platforms is required for data exchange management across key actors.

What are the value chain catalysts for CEI adoption?

The energy transition adds complexity and the need to monitoring and controlling a well-established system with high safety and security requirements and long lifespan of its components, such as the grid and conventional power plants. There are different ways to advance with their benefits and challenges. Due to the complexity of the system, there is no one-fits-all solution. The following points are key to accelerate the transition and for CEI adoption:

- Aligning the regulatory framework with the right technical and financial incentives to allow existing stakeholders to develop and new businesses to become value chain adopters.
- Achieving the right balance between market flexibility, technical flexibility, and active network management will be essential.
- Finding the optimal sweet spot between infrastructural changes in the grid or at the consumer/prosumer level and management optimisation, which can be achieved by leveraging technologies such as artificial intelligence to predict and manage the system with minimal additional hardware.
- A variety of European research Lighthouse Projects with regard to the digitalisation of the energy sector already exists. The success of the uptake of CEI technologies strongly depends on the business models of the resulting pilot solutions.

If you're interested in growth opportunities in this sector or want to learn more, contact us at: info@eucloudedgeiot.eu