IRENA
International Renewable Energy Agency

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Background Note

Artificial Intelligence (AI), Emerging Technologies and Electrification for an Accelerated Energy Transition

Background

1. The global energy transition is entering a more complex and uncertain phase. While renewable energy deployment and energy efficiency improvements have accelerated, progress remains insufficient. At the same time, energy demand continues to rise, driven by economic development, urbanisation, industrialisation, and emerging uses such as AI and digitalisation, data centres, and space cooling. These trends, combined with geopolitical tensions and market volatility, are reshaping national policy priorities. Renewable energy offers a means to address many of these challenges.

2. In this context, Artificial Intelligence (AI) and other emerging technologies are becoming central to the energy transition. As energy systems become more distributed and decentralised, with increasing contributions from variable renewable generation, AI and other digital solutions provide the intelligence and control needed to manage complexity by enabling real-time optimisation, predictive planning, and more resilient and efficient operations.

3. Innovations such as AI-driven forecasting, digital twins for system planning, and IoT-enabled smart devices are already transforming how energy is produced and consumed. From optimising electric vehicle charging and smart building energy use to improving control systems in industrial processes, these technologies are enabling more adaptive and responsive energy systems.

4. IRENA's analysis shows that electrification is a key pathway to a secure, resilient and low-emission energy system across transport, buildings and industry. By shifting end-use sectors toward electricity, particularly from renewable sources, electrification can reduce emissions, improve efficiency, and strengthen energy security. Combined with renewable energy and energy efficiency, it could deliver one-third of cumulative CO2 emissions reductions over 2026–2050. Realising this potential will require expanded renewable power, grids and system flexibility, with AI and digital technologies playing an important role in enabling smarter demand, better system planning and improved integration of renewables.

5. Therefore, in all these domains, innovative solutions offer exciting opportunities to transform the way energy is produced, transmitted and used. However, progress remains uneven across regions and sectors, and efforts are often fragmented.

6. In this context, this programmatic discussion aims to position AI and digital solutions, as well as other innovative enabling solutions as key enablers to unlock an accelerated and competitive energy transition. This session will offer the opportunity for an exchange of country experiences on best practices and strategies to accelerate the deployment and adoption of relevant solutions across energy generation, and in the transport, buildings and industry end-use sectors.

Guiding questions

The discussion will invite Members to share their national strategies and priorities across three dimensions: regional context, sectoral implementation and enabling innovations and measures.

1. Transport sector

- **Scaling electrification and digitalization**

  What strategies are being implemented to accelerate the uptake of electric mobility (including public transport), and how are charging infrastructure needs and system integration are supported through digitalisation?

- **System integration, AI and planning**

  How is transport electrification being paired with broader power system planning (e.g. smart charging, vehicle-to-grid), and what role does AI and digital solutions play in enhancing efficient deployment?

2. Buildings sector

- **Deployment of smart electrified solutions**

  Which policies and measures are being implemented to scale up electrification in buildings (e.g. heat pumps, smart appliances), particularly in rapidly growing urban areas?

- **Affordability and efficiency**

  How are countries using digital technologies to ensure that electrification in buildings remains affordable (e.g., connected devices leveraging Time of Use tariffs) and are they combined with energy efficiency improvements to manage demand growth?

3. Industry sector

- **Electrification of industrial processes**

  What approaches are being pursued to electrify industrial processes, and how are emerging solutions such as green hydrogen, heat pumps and AI-based automations being integrated to enhance processes and optimise energy use in industrial applications?

- **Investment and competitiveness**

  What policy frameworks and financial mechanisms are being used to support industrial electrification while maintaining competitiveness and a level playing field with new energy-intensive sectors including AI data centres (AI factories)?

Implementation and enabling measures (Cross-cutting)

Across all sectors, Members are also invited to reflect on:

- How are national electrification strategies adapted to regional contexts, resource endowments and development priorities?
- Which policy, regulatory and financial measures are most effective in accelerating electrification?
- Is digitalisation being prioritised to take advantage of technologies such as AI to mitigate bottlenecks such as those in power infrastructure, use of grid enhancing technologies and system management to cope with the long lead time of grid expansion and present grid connection queues?
- How is integrated planning being ensured between electrification, renewable energy deployment, grid expansion and system flexibility?

Expected outcome of the Programmatic Discussion

- IRENA will introduce insights regarding electrification and the use of AI and emerging technologies to support an accelerated energy transition.
- The discussion with Members will provide insights into practical pathways to accelerate smart electrification across sectors, identify common challenges and enabling conditions such as AI adoption.
- The exchanges will inform how IRENA can further support Members in developing integrated digitally based electrification strategies aligned with renewable energy and energy efficiency goals.

Associated publications

- Digitalisation and AI for Power System Transformation: Perspectives for the G7 (2025)
- Beyond Tripling: A TAFF Roadmap for a Global Electrification Target 2026 *(forthcoming)*
- World Energy Transition Outlook 2026 *(forthcoming)*
- Digitalisation Case Studies *(forthcoming)*