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POLICY BRIEF: DIGITALISATION AND THE ENERGY TRANSITION

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Digital solutions can provide numerous benefits to energy systems by improving the flow of information, improving monitoring and operational capabilities, and creating new modes of engagement for users, communities, and governments. This relationship is not one-sided: as our world becomes increasingly interconnected, energy demand for digitalization is only bound to grow, requiring proactive measures to improve efficiency and increase security. The city of Kochi provides an example of the benefits that greater digitalization can bring.

INTRODUCTION

There exists a strong link between energy and digitalization. Digital monitoring systems have always been critical to ensuring the functioning of electricity grids, but over the past decade, 'smart' technologies have enabled new, more decentralized models of electricity generation and consumption that are particularly relevant to communities and local and regional governments (LRGs). Enhanced digital capabilities have helped improve the overall efficiency of our energy systems, but these in turn also consume energy, and bring with them various trade-offs in terms of technical capacity, ethical concerns, as well as new vulnerabilities [1].

Still, increased digitalization can generate several benefits for LRGs and their local energy systems (including in terms of governance, information access, and overall functioning), provided they are well-managed and with adequate foresight and safeguards in place. This policy brief explores how digital solutions can be deployed in the local energy transition, highlighting the efforts of the city of Kochi, India.

DEFINING DIGITALISATION

Digitalisation, or digital transformation, broadly referes to the integration of information and communication technology (ICT) or digital tools and solutions into processes or structures. By easing communication and coordination between 'operations and operators' , digitalization can create new avenues to increase productivity, reduce inefficiencies, improve security, enhance sustainability, and reduce costs for existing systems [2].

LOCAL GOVERNMENTS & DIGITALISATION

Greater digitalization can be particularly beneficial to LRGs as they manage various municipal services, including local water or energy utilities, lighting, transportation networks, as well as general administrative tasks. Buildings and transport in particular make up a significant share of energy consumption in urban areas, and digitalization can help reduce and enable more efficient energy consumption across these two sectors.

Digital solutions can help improve the flow of information, for example by providing access to real-time data or facilitating access to important sources of information. This can help consumers adapt their behaviour, for example by reducing consumption when electricity prices are high. It can also allow them to access benefits more easily, such as financial support for installing solar panels on rooftops or similar mechanisms.

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By allowing for the generation of new data points, digitalization can help drive data-driven decision-making, provided the available data is analyzed and insights are integrated into existing structures. This can help improve planning, including local climate action plans, by identifying priority areas. Better monitoring and verification, aided by digital tools, can help cities test out new solutions and course-correct as needed, improving overall implementation and accountability.

'SMART' CITIES

Countries around the world have seen a lot of potential in the 'smart city' concept that aims to leverage digitalization to improve service delivery and improve citizen engagement [3]. For example, the European Union as well as India instituted national-level programs that support cities in their digital transformation. Typically these programs focus on transport and the built environment, but the challenges they address can also vary. For example, for some cities, expanding access to internet services and increasing digital literacy might be a top priority, while for other advanced cities, smart traffic and transport management might possess a greater scope for emissions reduction and well-being.

DIGITAL SOLUTIONS FOR THE ENERGY SECTOR

There are myriad solutions that can be deployed to help improve the functioning of the energy system and help integrate renewable energy (RE) and improve energy efficiency (EE), either by improving computing power, connectivity, data processing and modelling capabilities, and accessibility.

Smart meters and grids: In the context of electricity, smart meters can actively send and receive information on consumption and other parameters, including in real time. This functionality is derived from the broader 'internet of things (IoT)' concept. Traditional meters only provide information on total consumption and must be physically monitored. The increased connectivity and monitoring capabilities of smart meters can help users identify potential areas for energy savings and adapt accordingly, reducing energy consumption and therefore costs [4].

They are essential for the eventual expansion of **smart grids**, allowing for effective management of the system and offering benefits such as dynamic pricing (where electricity price changes are reflected in the electricity bill) and greater flexibility. The increased flow of information and management capabilities allow for the integration of renewables-based electricity generation, increased automation, and improved fault detection and recovery. More novel functions, such as vehicle-to-grid (V2G) are also enabled through such 'smart' features, allowing the grid to tap into a range of sources for flexibility [5].

Cloud computing: Given the massive amounts of data and information generated through smart grids and systems, there is an equally great need for computing power. Cloud computing can enable the 'remote' processing of this data, through cloud platforms i.e. a network of servers, storage, etc., that are able to access computing power without requiring on-site infrastructure [6].

Blockchain: Essentially a secure, decentralized digital 'ledger' for recording market transactions, including in electricity markets, blockchain can allow for secure decentralized transactions between RE producers and consumers through peer-to-peer transactions [7, 8]. This can be particularly useful in community energy setups or microgrids. It can also help verify information, such as renewable energy certificates (RECs) as well as carbon credits to ensure there is no double counting [9].

Artificial intelligence (AI) and automation: While a broad term, the use of AI in the energy sector typically refers to automated processes assisting in or taking over tasks that typically require human input. AI, with proper input and 'training', can assist in processing vast volumes of data in order to create better models and forecasts (for example, forecasting variable solar and wind generation), identify patterns, and generally improve efficiency in operations [10]. One of the key advantages is of AI is that through the use of machine learning, the more high-quality data is fed into an AI system, the better it can become at its tasks [11].

Digital twins: Digital twins are virtual recreations of existing physical systems, such as cities or electricity grids [12, 13]. Given the vast expansion of computing power and data capabilities, digital twins can aid planning, for example in the electricity grid, by providing almost real-time information on grid dynamics, allowing operators to address faults and even predict or prevent them [12].

Digital dashboards and platforms: These can ease access to information by providing information from a variety of sources in a centralized, user-friendly manner. Such platforms can be useful for policymakers, researchers, and community members to understand the dynamics of the energy transition. They can also help provide access to information related to support mechanisms such as tax breaks or subsidies that can help finance the implementation of RE/EE solutions.

Building energy management systems (BEMS): This is a software- and sensor-based system that helps monitor and adjust the energy use of a building, be it a large commercial building or a home [14]. It is a critical solution for improving energy efficiency in the built environment as it can automate decision-making related to building heating, ventilation, and air conditioning (HVAC) units, or lighting, or the integration of on-site RE sources such as rooftop solar panels.

Virtual power plants (VPP): A VPP is a system that aggregates small-scale resources (i.e. across energy consumers and suppliers) in order to provide the electricity grid a range of services, similar to a physical power plant. These resources can include electric vehicles and chargers, home appliances and HVAC units, industrial equipment, etc. As these are generally flexible resources i.e. can be turned on and off on demand, they can provide the grid with services include balancing grid capacity, voltage management, and so on [15].

The above mentioned digital solutions are some of the more common ones and most relevant to cities, but several others exist that are suited to specific sectors and applications.

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CHALLENGES IN ADOPTING DIGITAL SOLUTIONS FOR THE ENERGY SECTOR

While digital solutions do provide numerous benefits in terms of improved efficiency and RE integration, they do carry a number of downsides that must be accounted for and managed to ensure a well-functioning system.

- **High costs:** Integrating digital tools into existing systems can incur high upfront costs, both in terms of the infrastructure itself as well as developing appropriate skill sets to securely operate and maintain such systems [16]. This is not always feasible even for developed countries, making it even more challenging for smaller cities, particularly in developing countries. Moreover, investment needs for the energy and digital sectors are substantial, creating the risk of competition between the two [18].

- **Energy consumption and environmental impacts:** Vast amounts of computing power is required for digital technologies to provide their stated functions. This in turn requires large amounts of electricity to power servers and other technologies. Such systems often require continuous power and cooling, and this electricity demand is only likely to grow. AI has been a key driver of data centre energy demand—by some projections, this is likely to double to 945 TWh by 2030, roughly the equivalent of Japan's present-day electricity consumption [10]. In an ideal scenario, this excess electricity demand could be met with renewable energy sources (and in many cases are key drivers of RE supply), but this is not always the case [19]. Moreover, data centers typically require large volumes of water for cooling. Digital technologies also require the use of large amounts of raw material and generate electronic waste that is typically harder to dispose of [20].

- **Data privacy:** Given the granular level of data that can be collected through smart energy devices, without strong privacy protections, such data is prone to misuse. Moreover, in the event of breaches, personal data can also be compromised.

- **Security and resilience:** Relying on digital technologies can also create vulnerabilities, especially in terms of cybersecurity. Such attacks can compromise personal information as well as larger systems, such as electricity grids [1]. Moreover, given how critical energy and electricity infrastructure is, outages can have cascading effects on other systems such as payments, communications, healthcare, etc. Investments in adequate backup systems, preparedness, and 'digital resilience', both in terms of technology as well as human capital, are critical.

- **Equity concerns:** Digital technologies may not be affordable for low-income communities. This can often widen the digital access gap, creating inequities in accessing the benefits of greater energy efficiency and climate. This is also true for communities that may lack digital literacy. Vulnerable communities may also face the worst impacts during outages, as they may lack access to backup systems or alternatives. In addition, with increased automation, this may create the risk of job losses and require significant re-skilling, which may not be feasible for everyone and once again disproportionately impact low-income or vulnerable communities.

MAIN INSIGHTS AND RECOMMENDATIONS

For local and regional governments

- Prioritize the digital solutions according to community needs and the local context. For example, online platforms that facilitate access to energy-related information, including the kinds of support available for RE/EE solutions, may be more relevant in developing country contexts.
- Pilot projects in order to test their efficacy and user-friendliness while allowing for community feedback. For example, smart meters can be installed in certain neighbourhoods before wider expansion.
- Emphasize social inclusion when deploying smart energy solutions, such as by piloting projects in low-income housing, or ensuring solutions are accessible through technologies that are widely available, such as smartphones.
- Leverage partnerships with the private sector and academia to access resources and expertise when implementing digital solutions, including for capacity building for government officials and technicians.

For national governments and agencies

- Develop digitalization programs and provide appropriate financial resources to LRGs to enable them to undertake such a transformation. This can be done while investing in relevant infrastructure on a national scale.
- Invest in capacity building for government staff to enable the implementation of digital solutions, with the aim of improving service delivery, cybersecurity, and policymaking. Encouraging collaboration with existing energy utilities and government departments, for example, can help with developing technical expertise and common data management practices.
- Set adequate national-level policies and standards regarding interoperability, data security, and privacy standards in order to enable the secure and smooth flow of information across systems.

For private sector and financial institutions

- Work with LRGs and local communities to ensure digital solutions and associated infrastructure, such as data centers, are socially accepted.
- Both the private sector and financial sector entities can support pilot projects through grants or corporate social responsibility (CSR) funds.
- Financial institutions can help deploy innovative financing mechanisms, such as blended finance, for projects that integrate digital solutions in the service of RE/EE expansion.

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GET TO KNOW: KOCHI, INDIA

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Kochi has been implementing its smart city program since 2017, under the umbrella of India's Smart City Mission. To this end, the Cochin Smart Mission Limited (CSML) special purpose vehicle was set up in order to plan, approve, fund, implement, and monitor related development projects [21].

One of its core features has been its 'Integreated Command and Control Centre' (IC4), asystem that integrates data from various sources in the city—such as the water supply or health services—and allows for enhanced data-driven decisionmaking [22, 23]. This is particualrly useful in cases of extreme weahter and other systemic shocks.

Such a system has involved the installation of smart meters, both for water and electricity. Kochi's IC4 has also facilitated improved traffic management and more efficient street lighting through improved data gathering and analysis capabilities. A better monitoring system for its streetlights, combined with the switch from sodium vapour to more energy-efficient LED bulbs, Kochi was able to realize significant energy and cost savings [23].

Moreover, Kochi also takes advantage of digital tools to enable the integration of renewable energy. The rollout of smart meters has enabled households to install their own solar panels, primarily for the purpose of realizing cost savings and improving supply reliability [24].

Kochi's transport system is also the site of major transformations, showcasing the potential of aligning energy and mobility goals through increased digitalization. Kochi's public transportation systems—buses, metro rail, and its water metro—collectively operate under Kochi Metro Rail Limited (KMRL). Solar panels have been integrated throughout this system—for example, solar panels installed on metro stations and bus depots supply a significant share of the eneryg required for land transport [25, 26]. Similarly, the water metro fleet is comprised of battery-powered hybrid boats that are primarily charged through solar-powered installations. Kochi has also made efforts to expand the share of e-rickshaws (three-wheelers, powered by batteries) in freight transportation within the city.

In addition to its physical infrastructure, the city has also integrated the K-SMART system to ease governance and community engagement across a number of parameters, such as permits, tax filing, and bill payments [a]. Kochi is an example of how a growing city, through forward-looking policies, can create the structures necessary to take advantage of the opportunities under the energy transition as well as the broader digital transformation.

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