

Energy Applications Within IoT and Digitalisation Strategies

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The Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP), has been supporting governments to co-ordinate effective energy efficiency policies since 2008.

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Current members of 4E TCP are: Australia, Austria, Canada, China, Denmark, the European Commission, France, Japan, Korea, Netherlands, New Zealand, Switzerland, Sweden, UK and USA.

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The EDNA Annex (Electronic Devices and Networks Annex) of the 4E TCP is focussed on a horizontal subset of energy using equipment and systems - those which are able to be connected via a communications network. The objective of EDNA is to provide technical analysis and policy guidance to members and other governments aimed at improving the energy efficiency of connected devices and the systems in which they operate.

EDNA is focussed on the energy consumption of network connected devices, on the increased energy consumption that results from devices becoming network connected, and on system energy efficiency: the optimal operation of systems of devices to save energy (aka intelligent efficiency) including providing other energy benefits such as demand response.

Further information on EDNA is available from: www.edna.iea-4e.org

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Prepared for:

**The Electronic Devices & Networks Annex of
the IEA 4E Technology Collaboration
Programme**



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Acronyms and Abbreviations

ACS	Australian Computer Society
AIOTI	Alliance for Internet of Things Innovation
CCD	Compliance Certification Database
DER	Distributed energy resource
DIGIT	Developing Innovation and Growing the Internet of Things
DOE	US Department of Energy
DSM	Digital Single Market
EDNA	Electronic Devices and Networks Annex
EJ	Exajoules (10^{18} joules)
EU	European Union
FP7	7 th European Research Framework Programme
GDPR	General Data Protection Regulation
GW	Gigawatt (10^9 watts)
ICBM	Internet of Things (IoT), cloud computing, big data analysis, and mobile technologies
ICT	Information and communication technologies
IEA	International Energy Agency
IERC	IoT European Research Cluster
IFD	Innovation Fund Denmark
IoT	Internet of things
ITU	International Telecommunications Union
LPWAN	Low Power Wide Area Network
MIIT	Ministry of Industry and Information Technology
MOST	Ministry of Science and Technology
MSIP	Ministry of Science, ICT, and Future Planning
NB-IoT	Narrowband Internet of Things

OECD	Organization for Economic Cooperation and Development
R&D	Research and development
SGCC	State Grid Corporation of China
SIMIT	Shanghai Institute of Microsystem and Information Technology
SMART	Specific, measurable, attainable, relevant, and timebound
TCP	Technology Collaboration Programme
UK	United Kingdom
US	United States
3GPP	Third Generation Partnership Project
4G LTE	Fourth Generation Long-Term Evolution wireless technology
5G	Fifth Generation wireless technology

Glossary of Terms

Note: Definitions listed here are for the purposes of the EDNA IEA 4E TCP report series on connected devices. Definitions may differ in other contexts or reports.

Connected device	A device with network capability.
Demand Flexibility	Changes in electricity usage by end-use customers from their normal consumption patterns in response to changing market conditions, especially changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.
Digitalisation	The integration of digital technologies (such as IoT) into everyday life by converting non-digital (analogue or physical) mediums, or processes, into digital formats.
Interoperability	The ability of different types of devices, and/or devices from different manufacturers, to connect, communicate, and function with each other.
IoT	A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable ICTs.
Plug-and-play	The ability for a device to function as intended when first used or connected, and without additional user configuration.
Smart Energy Management	The ability for electric grids, consumers, or devices to manage their energy usage based on sensor, pricing, or other types of data.
Smart grid	An electric grid that incorporates digital technologies to enable two-way communication between a utility, or energy-service provider, and the consumer.

Background

The Electronic Devices and Networks Annex (EDNA) is an initiative of the International Energy Agency's (IEA) 4E Technology Collaboration Programme (TCP), which promotes energy efficiency as the key to ensuring safe, reliable, affordable and sustainable energy systems. EDNA specifically focuses on network connected electronic devices and equipment. The objective of EDNA is to: 'provide technical analysis and policy guidance to members and other governments aimed at improving the energy efficiency of connected devices and the systems in which they operate.' The three key areas of focus for EDNA are 1) energy consumption of network connected devices, 2) the increased energy consumption that results from devices becoming network connected, and 3) the optimal operation of systems of devices to save energy including other energy benefits such as demand flexibility.

This EDNA report, 'Energy Applications within IoT And Digitalisation Strategies', is the final report in a series of three reports written by Guidehouse for EDNA. The report 'Policy Guidance for Smart, Energy-Saving Consumer Devices',¹ provides considerations for policy makers to encourage 'smart' consumer devices which save energy and provide demand flexibility. The report 'Roadmap for Consumer Devices to Participate in Demand Flexibility',² provides a roadmap that lays out specific steps needed to achieve widespread demand flexibility of consumer devices in the residential sector. This report provides guidance for policy makers to develop Internet of Things (IoT) and digitalisation strategies for enhancing energy efficiency (including demand flexibility).

The purpose of this report is to provide guiding principles to policy makers for developing and implementing national/regional digitalisation and IoT strategies that emphasise energy applications, including energy efficiency and demand flexibility. Effective guidance will enable governments to include aspects of energy efficiency in the development of their strategies to provide societal and economic benefits. This report is presented in 4 chapters:

- **Chapter 1 (Introduction)** provides background on how digitalisation and IoT strategies can help with intelligent management of energy consumption and presents the report's overall scope and approach.
- **Chapter 2 (Existing IoT and Digitalisation Strategies)** dissects existing digitalisation and IoT strategies for certain nations/regions and analyses their emphasis on energy efficiency, among other key attributes of a strategy.
- **Chapter 3 (Attributes to Develop an IoT and Digitalisation Strategy That Emphasises Energy Applications)** presents several key attributes, including structural frameworks, specific technologies, or government initiatives that a strategy should include to successfully emphasise energy efficiency.
- **Chapter 4 (Execution of an IoT and Digitalisation Strategy)** presents general guiding principles on the process of developing and implementing a digitalisation and IoT strategy.

¹ 4E Electronic Devices & Networks Annex, EDNA, Publications, 'Policy Guidance for Smart, Energy-Saving Consumer Devices', <https://edna.iea-4e.org/library>

² 4E Electronic Devices & Networks Annex, EDNA, Publications, 'Roadmap for Consumer Devices to Participate in Demand Flexibility', <https://edna.iea-4e.org/library>

1. Introduction

According to Cisco, 500 billion devices are expected to be connected to the internet by 2030.³ The rapid innovation in digital technologies will enable the adoption of information and communication technologies (ICT) across the globe. Strategies allow governments to harness digitalisation to develop solutions that benefit society, improve the economy, and ensure a better quality of life for their citizens while also advancing energy efficiency and reducing carbon emissions. This report analyses how digitalisation and Internet of Things (IoT) strategies can harness the power of ICT to realise the benefits of energy efficiency, energy savings, and intelligent energy management in a society.

Currently, there is no universal consensus for defining IoT. While some international organisations such as the International Telecommunications Union (ITU) have attempted to broadly characterise IoT as ‘a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable ICTs’⁴, others including the US National Institute of Standards and Technology have deliberately avoided defining it due to the inherent difficulty in characterizing such a wide scope of applications.⁵ For the purpose of this report IoT refers to the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment.⁶ Digitalisation refers to the integration of digital technologies (such as IoT) into everyday life by converting non-digital (analogue or physical) mediums, or processes, into digital formats. One prominent example of digitalisation in the energy industry is the use of smart meters in the electric grid. Where older meters required a utility worker to periodically read the meter, modern smart meters digitally transmit meter information to utilities via wireless networks. As such, most strategies discussed in this report intertwine the concepts of both IoT and digitalisation.

1.1 Digitalisation/IoT and Energy

Digital technologies have been improving energy systems for decades. Electric utilities were some of the early pioneers of the digital transformation in the 1970s, using IT hardware and data to manage the operation of the grid in real-time. Today, the electric grid produces vast amounts of data that energy providers and distributors use to control pricing signals and the flow of energy, often with extremely complex algorithms and modelling techniques.

According to the IEA, the pace of digitalisation in energy is increasing, with global investment in digital electricity infrastructure growing by over 20% annually since 2014.⁷ Figure 1-1 shows the magnitude of the investments in digital energy solutions broken down by technology type.

³ Cisco, ‘Internet of Things at-a-glance’, 2016, <https://www.cisco.com/c/dam/en/us/products/collateral/se/internet-of-things/at-a-glance-c45-731471.pdf>

⁴ United Nations International Telecommunications Union, ‘Overview of the Internet of Things’, Section 3.2.2, June 2012, https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-Y.2060-201206-!!!PDF-E&type=items

⁵ Chen et al., ‘China’s Internet of Things’, October 2018, https://www.uscc.gov/sites/default/files/Research/SOSi_China's%20Internet%20of%20Things.pdf

⁶ Cisco, ‘Internet of Things at-a-glance’, 2016, <https://www.cisco.com/c/dam/en/us/products/collateral/se/internet-of-things/at-a-glance-c45-731471.pdf>

⁷ IEA, ‘Digitalisation and Energy’, 2017, <https://www.iea.org/reports/digitalisation-and-energy>

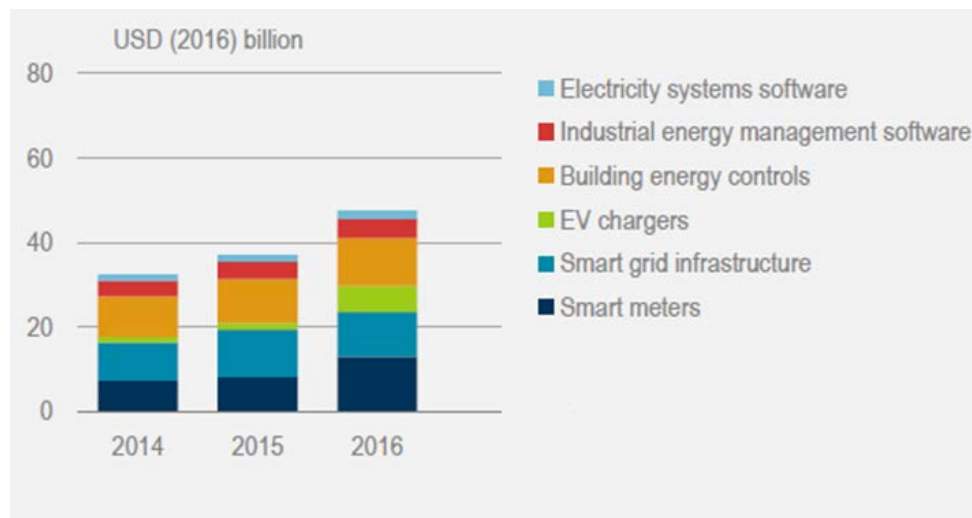


Figure 1-1. Investments in Digital Energy Solutions

Source: IEA

The rapid advances of digitalisation and increasingly large investments in the energy sphere call for a national/regional unified approach to coordinate efforts within a nation/region. Each nation/region's strategy would provide a framework for digitalisation efforts and could establish the development of energy technologies as a primary objective. While the development of digital technologies is not primarily driven by the goal of energy savings, it can offer various benefits to energy systems.

According to the IEA, the impact of technical efficiency improvements has been slowing down since 2017.⁸ From 2015 to 2018, the annual impact of technical efficiency improvements nearly halved from 2.5% to 1.4% of final demand.⁹ One factor contributing to this slowdown is that the levels of investments targeting energy efficiency have begun to plateau since 2014.¹⁰ Digitalisation and IoT solutions can unlock greater efficiency improvements through intelligent management of energy consumption, and demand flexibility in an interconnected IoT ecosystem.

The three fundamental elements of digitalisation are data, analytics, and connectivity. ICT such as sensors and meters gather data that is then analysed by intelligent algorithms which then activate controls or other physical actions. Communication networks connect all these processes together. Figure 1-2 illustrates this ecosystem.

⁸ IEA, 'Energy Efficiency 2019', 2019, <https://www.iea.org/reports/energy-efficiency-2019>

⁹ *Ibid.*

¹⁰ *Ibid.*

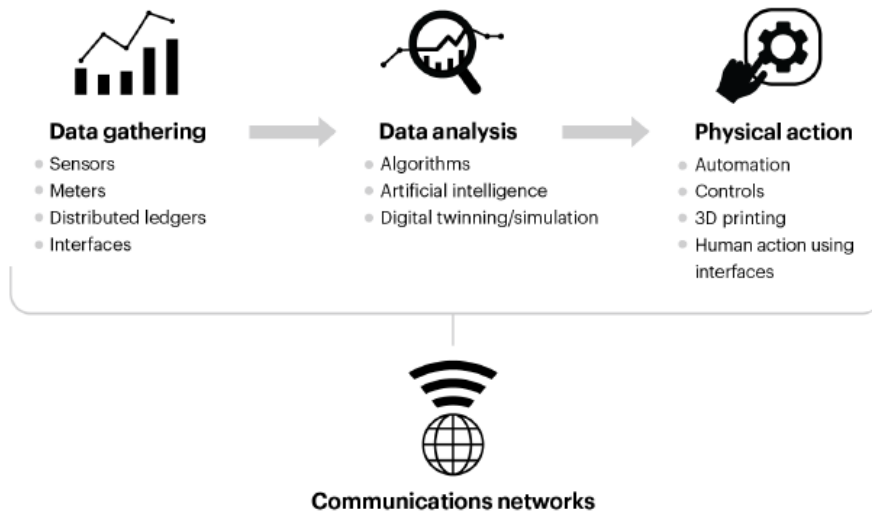


Figure 1-2. Digitalisation in Energy Systems

Source: IEA¹¹

Sensors can detect environmental factors such as daylight, temperature, motion, or pressure. This information can inform technologies such as heating and cooling or lighting applications to more intelligently and efficiently manage their load. Moreover, smart meters enable two-way communication between the grid operator and a building, enabling demand flexibility opportunities to manage consumption and achieve cost savings as well as energy savings. Figure 1-3 illustrates how the interconnectedness of homes, grids, and energy sources can facilitate the interaction of smart energy management.

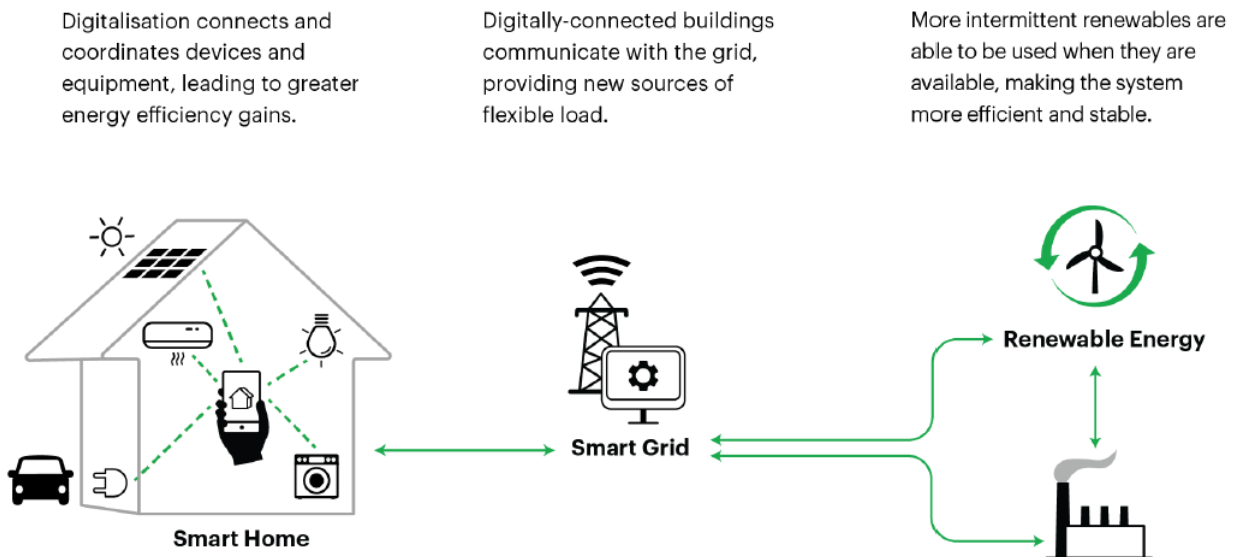


Figure 1-3. IoT in a Smart Energy System

Source: IEA¹²

¹¹ Ibid.

¹² Ibid.

Moreover, by increasing the connectivity of the world's buildings, appliances and equipment, and transport systems, digitalisation can achieve energy savings as more devices can coordinate with each other to increase the intelligence of the system. Digital technologies can increase the flexibility of loads and allow energy operators to monitor energy flows faster and more accurately.¹³ Overall, IEA estimates that digitalisation could reduce global buildings sector energy demand by up to 10% between 2017 and 2040 and could increase demand response capacity by more than ten-fold.¹⁴

In a national/regional strategy, policy recommendations could accelerate the adoption of IoT and digital solutions for energy efficiency. Government needs to play a role in the development of IoT, to create policies that foster innovation, ensure security, and emphasise energy efficiency. The crafting of these policies requires coherent and strategic planning with the involvement of a variety of stakeholders. Failures of governments to facilitate the transition to a new digital environment can have consequences such as poor delivery, privacy and security breaches, loss of citizen trust, and underperformance of technologies.¹⁵ From an energy perspective, lack of government initiative to transition to a digital environment could impact energy grids, particularly if they are unable to maximise their potential energy efficiency, reliability, and security.

The purpose of this report is to help national and regional governments adopt strategic approaches for utilizing digitalisation and IoT to unlock opportunities in energy efficiency improvements and smart energy management. While it's not possible to craft a one-size-fits-all set of guiding principles, these recommendations are intended to apply to all nations/regions regardless of government capacities and social culture.

1.2 Report Scope and Approach

This report analyses the IoT and digitalisation strategies of several EDNA members and regions: Australia, Austria, China, Europe, South Korea, the United Kingdom (UK), and the United States (US). These nations/regions were chosen based on their membership of EDNA, and whether they have a digitalisation or IoT strategy in place. Each nation/region's strategy is analysed in the context of how it emphasises energy applications, its overall structure, and other key attributes of the strategy. Chapter 2 of this report compares the strategies, mainly focusing on the extent to which each strategy emphasises energy applications. Apart from energy applications, other attributes of a strategy taken into consideration include its development process, its participating members, and how it aims to achieve its goals (*i.e.*, through specific, measurable goals, or broad calls to action).

Chapter 3 of the report develops a list of attributes (*i.e.*, key elements of a strategy), including those that are seen in existing strategies discussed in Chapter 2 as well as those that are not part of any existing strategy, but are deemed important to support the advancement of digital energy applications in a nation/region. Chapter 3 also presents potential barriers to drafting a strategy that emphasises energy applications and proposes possible measures to overcome these barriers.

Finally, Chapter 4 of this report presents general guiding principles on the process of developing and implementing a strategy. The discussion in this section is mainly applicable

¹³ *Ibid.*

¹⁴ *Ibid.*

¹⁵ OECD, 'Recommendation of the Council on Digital Government Strategies', July 15, 2014, <https://www.oecd.org/gov/digital-government/Recommendation-digital-government-strategies.pdf>

to the development of an IoT and digitalisation strategy in general, but also includes discussion on energy-specific topics where applicable.

2. Existing IoT and Digitalisation Strategies

This chapter provides an overview of the IoT and digitalisation strategies of certain nations/regions. Each of the strategies were analysed to evaluate their emphasis on energy efficiency, overall structure, and other key aspects. For some nations/regions, a single document that prescribed an overall digital strategy was analysed, whereas for others which did not have such a document, individual digital efforts were examined and evaluated.

Table 2-1 provides the evaluation criteria for evaluating a strategy's emphasis on energy. Table 2-2 summarises the key differences between the various strategies examined as part of this report.

Table 2-1. Scoring a Strategy's Emphasis on Energy

Score	Meaning
High	Establishes energy as a main focus of the strategy and includes specific measures to implement digital/IoT measures to increase energy efficiency in certain applications or improve energy management.
Medium	Includes some mention of energy as a goal of the overall strategy, discusses potential benefits of IoT and digitalisation in certain energy applications.
Low	Includes minimal discussion of energy applications, energy is not established as a focus of the report.
None	Includes no mention of energy applications.

Table 2-2. Comparison of IoT and Digitalisation Strategies

Strategy	Nation / Region	Key Attributes	Emphasis on Energy Applications
'Australia's IoT Opportunity: Driving Future Growth'	Australia	<ul style="list-style-type: none"> • Economic and business-oriented strategy crafted by a private organisation that proposes several policy recommendations for public sector and private-sector players. • Includes some discussion on the potential for energy efficiency opportunities across construction, manufacturing, and agriculture. 	Low
'Digital Austria'	Austria	<ul style="list-style-type: none"> • Establishes a platform for the coordination and implementation of digital solutions. • Flexible strategy, which allows it to be continuously updated and refined, as needed. 	None
'Digital Roadmap Austria'	Austria	<ul style="list-style-type: none"> • Maps the process of driving the transformation of digitalisation. • Includes specific recommendations related to energy such as smart meter rollout programmes, standard development, and demand flexibility. 	High
Various	China	<ul style="list-style-type: none"> • Places a heavy emphasis on the development of technical standards related for communication protocols and smart grid technologies. • Commits to implementing smart grid capabilities by 2021. • Develops a relatively large number of strategies compared to other governments, ensuring the continuous refinement of strategies. 	High
'Digital Single Markets'	European Union	<ul style="list-style-type: none"> • Establishes a single market for IoT devices to ensure that they operate seamlessly and on a plug-and-play basis anywhere in the EU. • Emphasises the need for interoperability, though no mention of energy efficiency. However, interoperability and seamless integration is essential to energy-related IoT applications as well. 	Low

Strategy	Nation / Region	Key Attributes	Emphasis on Energy Applications
'Advancing the Internet of Things in Europe'	European Union	<ul style="list-style-type: none"> • Emphasises the economic benefits of IoT services in reducing energy consumption through intelligent energy management. • Mentions the need for standards to create interoperability through open communication protocols. • Mentions the potential for smart homes to be integrated in the IoT ecosystem. 	High
'Smart Grids Task Force'	European Union	<ul style="list-style-type: none"> • Sets up a task force made up of public and private sector entities to advise on issues related to smart grids such as standards, data protection, and deployment. 	Medium
Alliance for Internet of Things Innovation (AIOTI)	European Union	<ul style="list-style-type: none"> • Builds on the work of the IoT European Research Cluster (IERC), grouping together nation IoT initiatives within the EU. • Publishes recommendations for future IoT research. 	High
'Master Plan in Preparation for the Intelligent Information Society'	South Korea	<ul style="list-style-type: none"> • Outlines the potential negative and positive impacts of IoT/digitalisation. • Outlines short-term and long-term strategies and policies to foster a market conducive to technological innovation. • Describes the potential of improved energy management and includes the ministry of energy as a key player in future policy initiatives. 	Low
'Master Plan for Building the Internet of Things (IoT)'	South Korea	<ul style="list-style-type: none"> • Proposes to create an open IoT platform which can be used by the private sector to develop IoT technologies, which ensures interoperability. • Supports initiatives to encourage the use of smart devices and sensors. • Discusses potential IoT applications in smart infrastructure and the manufacturing industry. 	Low

Strategy	Nation / Region	Key Attributes	Emphasis on Energy Applications
'Innovation Growth Engine'	South Korea	<ul style="list-style-type: none"> Creates 13 'innovative growth engines' to drive the development of IoT/digital solutions in specific technological areas, one of which includes renewable energy and smart management of energy resources. 	Low
'The 5 th Science and Technology Foresight (2016 – 2040)'	South Korea	<ul style="list-style-type: none"> Includes specific timeframes for when policies should be implemented. Discusses the application for AI and data to transform decision-making in the design of buildings. Evaluates the potential for smart grids, which is deemed as a highly-innovative and low-risk venture. 	High
'Industrial Strategy: Building a Britain fit for the future'	United Kingdom	<ul style="list-style-type: none"> Focuses on five goals: innovation, job creation, infrastructure development, business opportunities, and prosperity. The strategy also establishes 'clean growth' as a pillar to achieve these goals, which includes energy applications. Prescribes specific and significant targets for R&D investments. 	Medium
'Upgrading Our Energy System: Smart Systems and Flexibility Plan'	United Kingdom	<ul style="list-style-type: none"> Proposes actions related to regulatory frameworks and market considerations to create a market for the implementation of demand flexibility. Emphasises the importance of smart energy management systems to integrate renewables into the grid. 	High
'Fostering the Advancement of the Internet of Things'	United States	<ul style="list-style-type: none"> Mainly focuses on the role of the government in the digitalisation process to enable infrastructure access, establish policy-making coalitions, promote standards development, and encourage markets to adopt digitalisation. Recognises the potential benefits of IoT in improving energy efficiency in the residential, commercial, and industrial sectors. 	Low

Strategy	Nation / Region	Key Attributes	Emphasis on Energy Applications
'Grid Modernization Multi-Year Program Plan'	United States	<ul style="list-style-type: none"> • Focuses of five key trends: distributed and clean energy, growing demand for reliability and resiliency, growing demand flexibility opportunities, increased availability energy-related data, and an aging electric infrastructure. • Discusses how digital solutions can address or support each of these trends. 	High
'Developing Innovation and Growing the Internet of Things (DIGIT) Act'	United States	<ul style="list-style-type: none"> • Sets forth a collaborative process including governmental and non-governmental players to provide recommendations to the government on how to develop and grow IoT. • Establishes 'sustainable infrastructure' as an area of focus, which implies smart energy infrastructure, though not specifically mentioned. 	Low

2.1 Australia

The report 'Australia's IoT Opportunity: Driving Future Growth'¹⁶ was published by the Australian Computer Society (ACS). ACS is an organisation consisting of more than 42,000 industry professionals in the ICT sector.¹⁷ According to its constitution, its objectives are 'to deliver authoritative independent knowledge and insight into technology' and 'to promote the development of Australian ICT resources.'¹⁸

The main objective of this report is to set out recommendations for both businesses and government to ensure that Australia capitalises on the IoT opportunity, focusing on the economic and business opportunities associated with IoT proliferation. First, the report discusses the need for adoption of IoT, mainly focusing on the economic and productivity benefits of IoT. It assesses the cost implications on several key industries: construction, mining, manufacturing, healthcare, and agriculture. The report also examines the cybersecurity risks prevalent with the increased uptake of IoT technology. Lastly, the report presents several recommendations for public and private-sector players to accelerate the adoption of IoT in Australia.

This report does not include substantial examination of potential energy applications, nor do its final recommendations present any specific proposals related to energy applications. The report includes a brief discussion on the potential for sensors to monitor and provide data to reduce energy consumption in industries that require heavy, energy-consuming machinery such as construction, manufacturing, and agriculture. Overall, however, the emphasis on energy applications is low.

Even though this strategy does not place a heavy emphasis on energy applications, it effectively presents specific and feasible recommendations, which are important for a successful digitalisation strategy. Moreover, its discussion of the cybersecurity risks is a topic which can extend to all industries within IoT, including energy applications.

2.2 Austria

2.2.1 Digital Austria

'Digital Austria'¹⁹ is the Austrian federal government's initiative for successful digitalisation in Austria.²⁰ This strategy was published by the Austrian Research Promotion Agency, a federally-owned research agency whose purpose is to 'promote research, technology, development, and innovation for the benefit of Austria.'²¹ Digital Austria also establishes a platform through which all digitalisation efforts can be coordinated, consisting of federal states, city associations, the chamber of commerce, and business in Austria.²² The platform

¹⁶ Australian Computer Society, 'Australia's IoT Opportunity: Driving Future Growth', September 2018, <https://www.acs.org.au/content/dam/acs/acs-publications/ACS-PwC-IoT-report-web.pdf>

¹⁷ See, generally, <https://www.acs.org.au/home.html>

¹⁸ Australian Computer Society, 'ACS Strategy 2017 – 2022', <https://www.acs.org.au/content/dam/acs/acs-documents/2017-22%20ACS%20Strategy%20FINAL%20-%20Approved%20for%20Release.pdf>

¹⁹ The Austrian Research Promotion Agency, 'Digital Austria', 2019, <https://www.digitalaustria.gv.at/eng/>

²⁰ *Ibid.*

²¹ Austrian Research and Promotion Agency, 'Objectives and Mission', <https://www.ffg.at/en/FFG/objectives-and-mission>

²² Digitales Österreich, 'The Platform Digital Austria', <https://www.digitales.oesterreich.gv.at/plattform-digitales-osterreich>

is managed by the Federal Chancellery of Austria, which also coordinates the implementation process.²³

The main objective of this strategy is to ‘further ensure Austria’s role as a leading digital nation to guarantee and expand prosperity, job opportunities as well as the quality of life in the long term.’²⁴ This strategy is not structured in a typical document format. Rather the strategy is only accessible via web, and the content is displayed across several webpages through which users can navigate and click on individual topics for more information. The bulk of the content is located under three webpages corresponding to three different areas of focus for the strategy: society, the economy, and public administration. Each of these webpages includes several government measures, proposals, initiatives, or programmes that harness digitalisation/IoT to support the objectives of stimulating the economy, enhancing quality of life, and improving government processes. None of the proposals included in this strategy mention energy applications.

Even though Austria’s digitalisation strategy includes no mention of energy applications, there are several aspects that would be useful to incorporate into recommendations for drafting a strategy. First, the overall digitalisation efforts of the Austrian government established a platform, *i.e.* ‘Digital Austria’, which has become the government’s centre point for coordination and strategy implementation.²⁵ As such, all digitalisation projects are coordinated with one another to avoid duplication and ensure interoperability where possible. This platform is made up of both public and private stakeholders, which contributes to the success of the digitalisation measures. Second, the strategy is not a static document; rather, it resides on the web and can be updated when needed. This flexibility can allow lawmakers to adapt strategies as needed and allows citizens to interact with the strategy in a unique, more accessible way. ‘Digital Austria’ also has a Facebook page, where representatives of the platform post opportunities for people to become involved in digitalisation efforts and describe notable accomplishments related to digitalisation efforts.²⁶ The most important takeaways from this strategy are the importance of a platform, lean management, and accessibility.

2.2.2 Digital Roadmap Austria

‘Digital Roadmap Austria’²⁷, submitted in 2016, is based on 12 guiding principles which include inclusivity, digital education, development of communications infrastructure, creating of jobs, and research and development (R&D) among others. Some of its specific recommendations include increasing security and grid stability through flexible control of the energy system. Moreover, the roadmap includes a smart meter rollout to allow consumers and businesses to become more ‘energy aware.’²⁸ Overall, the roadmap contains its own section dedicated to the potential benefits of digitalisation to increase efficiency, conserve resources and minimise environmental impact.

²³ OECD, ‘Digital Government Strategies: Good Practices’, 2014, <http://www.oecd.org/gov/austria-digital-austria.pdf>

²⁴ The Austrian Research Promotion Agency, ‘Digital Austria’, 2019, <https://www.digitalaustria.gv.at/eng/>

²⁵ OECD, ‘Digital Government Strategies: Good Practices’

²⁶ Facebook, ‘Digital Austria’, <https://www.facebook.com/digitalaustria.gv.at/>

²⁷ ‘Digital Roadmap Austria’, 2016, <https://www.digitalroadmap.gv.at/en/>

²⁸ *Ibid.*

2.3 China

China's commitment to becoming a leader in IoT development is driven by the belief that its geopolitical security requires the nation to become a technological power, particularly in emerging technologies.²⁹ IoT is viewed as an important tool to advance China's economy and national strength. Moreover, in a 2011 article in which officials from China's Ministry of Finance discussed IoT, they emphasised the importance of developing China's own technology because they believed that, 'over-dependence on foreign technology is a major risk to Chinese national security.'³⁰ While China's strategy for IoT is not spelled out in a single unified document, its motivations, policy actions, investments, and overall efforts shed light on their approach to accelerating the development of IoT.

In 1999, the Chinese Academy of Sciences Shanghai Institute of Microsystem and Information Technology (SIMIT) and several academic institutions initiated research into IoT, and the government provided roughly the equivalent of 29 million USD for technological and standardisation research.³¹ Since 2009, IoT has become a core component in Chinese development plans and the government has released several development plans and strategies that guide, coordinate, and support IoT development. Table 2-3 presents a list of several IoT-related development plans set forth by the Chinese government.

Table 2-3. Chinese IoT-Related Development Plans, 2010-2017

Issuing Date	Name of Plan	Function and Highlights	Issuing Agency
October 2010	Decision on Accelerating the Cultivation and Development of Strategic New Emerging Industries ³²	Highlighted key industries (including the then emerging IoT industry) and outlined approaches to cultivate and accelerate the development of these industries.	State Council
February 2012	12th Five Year Plan Development Plan for the Internet of Things ³³	Identified IoT as an economic and technological 'strategic high ground' and laid out IoT investment for 2011-2015.	Ministry of Industry and Information Technology (MIIT)

²⁹ Chen et al., 'China's Internet of Things', October 2018, https://www.uscc.gov/sites/default/files/Research/SOSI_China's%20Internet%20of%20Things.pdf

³⁰ Ministry of Industry and Information Technology, 'The Ministry of Finance Answers Questions About the 'Interim Methods for Managing the Special Projects Fund for IoT Development'', April 19, 2011, <http://miit.gov.cn/n1146290/n1146402/n1146455/c3226838/content.html>

³¹ Wu Chengzhi, 'Internet of Things—Building the Engine of the Future Economy, Modern Transmission', no. 6, 2009, www.sheic.gov.cn/res_base/sheic_gov_cn_www/upload/article/file/2011_2/5_31/wscngoc6j6pu.doc

³² State Council of the People's Republic of China, 'Decision on Accelerating the Cultivation and Development of Strategic New Emerging Industries', October 18, 2010, http://www.gov.cn/zwqk/2010-10/18/content_1724848.htm.

³³ Ministry of Industry and Information Technology of the People's Republic of China, '12th Five Year Plan Development Plan for the Internet of Things', February 14, 2012, <http://www.miit.gov.cn/n1146295/n1146562/n1146650/c3074283/content.html>

September 2012	National Broadband Network Technology Development 12th Five Year Special Plan ³⁴	Identified IoT as a 'strategic emerging industry' alongside mobile internet and cloud computing and identified the infrastructure requirements necessary to cultivate those technologies.	Ministry of Science and Technology (MOST)
January 2017	Information and Communications Industry Development Plan (2016–2020) Internet of Things Addendum ³⁵	Guiding document for IoT industry development over a period of five years calling for adjustments to adapt to an Internet of Everything era that had already begun.	MIIT
June 2017	Notice on Comprehensively Advancing NB-IoT ³⁶ Development ³⁷	Calls for relevant provinces and municipalities to prepare narrowband Internet of Things (NB-IoT) ³⁸ for the Fifth Generation wireless technology (5G) era, expanding NB-IoT usage to smart cities, personal and home, and industry.	MIIT

Source: Chen et al., 'China's Internet of Things', October 2018

While this list is not exhaustive, it demonstrates the Chinese government's commitment to continuously refine, and develop IoT strategies. Regarding its emphasis on energy applications, China has focused on standardisation efforts to support the development of smart power grids, drafting 17 standards on smart grid technologies.³⁹ Moreover, in a white paper published by the State Grid Corporation of China (SGCC), the government-owned corporation announced its plans for implementing smart capabilities in the grid system by 2021.⁴⁰ This system will rely on IoT capabilities to improve the efficiency, integration, and

³⁴ Ministry of Science and Technology of the People's Republic of China, 'National Broadband Network Technology Development 12th Five Year Special Plan', September 18, 2012, <http://www.most.gov.cn/tztq/201209/W020120918518757509871.doc>

³⁵ Ministry of Industry and Information Technology of the People's Republic of China, 'Information and Communications Industry Development Plan (2016–2020) Internet of Things Addendum'

³⁶ Narrowband Internet of Things (NB-IoT) is a Low Power Wide Area Network (LPWAN) radio technology standard. For more information, visit <https://www.gsma.com/iot/narrow-band-internet-of-things-nb-iot/>

³⁷ Ministry of Industry and Information Technology of the People's Republic of China, Notice on Comprehensively 'Advancing NB-IoT Development', June 16, 2017, <http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757020/c5692719/content.html>

³⁸ Narrowband Internet of Things (NB-IoT) is a low power radio technology.

³⁹ Chen et al., 'China's Internet of Things', October 2018

⁴⁰ Xinhua, 'China to establish ubiquitous power IoT within 2 years', October 15, 2019, http://www.xinhuanet.com/english/2019-10/15/c_138473855.htm

utilisation of different types of energies.⁴¹ Smart meters have already proliferated in the Chinese grid; in 2018, 200 million smart meters were purchased in China, the highest penetration in the world.⁴² Additionally, China is currently in the early stages of installing second-generation smart metering systems⁴³, which enables compatibility across various energy suppliers⁴⁴. These network-connected devices will also support the development of smart grid capabilities to manage energy more efficiently.

Overall, China's approach to developing its IoT and digitalisation capabilities can be characterised as active and robust. China has published dozens of white papers, roadmaps, and strategies to develop and implement IoT. Their efforts span across various industries such as telecom, utilities, and device manufacturers, as well as federal and local governments, which are often intertwined with many of these industries. From 2010 to 2018, China's IoT industry more than quadrupled in size,⁴⁵ demonstrating the effectiveness of its approach. Its IoT efforts also include the development of smart grid capabilities which can optimise energy management and increase energy efficiency. Moreover, China's policies and standardisation efforts have proven to be an effective first step in national digitalisation efforts. It is also important to note that China's government has considerable influence over its national industries. Therefore, these digitalisation efforts measures may be coordinated and implemented more easily than in other nations/regions without the same cohesion between state and private industry.

2.4 Europe

2.4.1 Digital Single Markets

In Europe, the 'Digital Single Market' (DSM) strategy aims to unlock digital opportunities for people and businesses and enhance Europe's position as a world leader in the digital economy.⁴⁶ This strategy is meant to leverage digitalisation technologies to tackle a wide variety of economical, societal, and environmental issues. DSM is built on the following three pillars⁴⁷:

1. 'A single market for the IoT: IoT devices and services should be able to connect seamlessly and on a plug-and-play basis anywhere in the European Union (EU), and scale up across borders.
2. A thriving IoT ecosystem: open platforms used across vertical silos will help developer communities to innovate. As a kick-start, IoT deployments in selected lead markets will be supported.
3. A human-centred IoT: the IoT in Europe is to respect European values, empowering people along with machines and businesses, thanks to high standards for the

⁴¹ *Ibid.*

⁴² Research and Markets, 'The Smart Meter Industry in China to 2025: Analysis on Electric, Gas, Water and Heat Meters', March 14, 2019, <https://www.globenewswire.com/news-release/2019/03/14/1753138/0/en/The-Smart-Meter-Industry-in-China-to-2025-Analysis-on-Electric-Gas-Water-and-Heat-Meters.html>

⁴³ Nhede, Nicholas, 'China maintains lead in global smart meter market', July 12, 2018, https://www.smart-energy.com/industry-sectors/data_analytics/global-smart-meter-market-navigant/

⁴⁴ uSwitch, 'Smart meter FAQs', 2020, <https://www.uswitch.com/gas-electricity/guides/energy-smart-meters-faqs/>

⁴⁵ Chen et al., China's Internet of Things, October 2018

⁴⁶ See, generally, <https://ec.europa.eu/digital-single-market/en>

⁴⁷ European Commission, 'Advancing the Internet of Things in Europe', April 19, 2016, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016SC0110&from=EN>

protection of personal data and security, visible notably through a “Trusted IoT” label.’

The three pillars are applicable across various sectors such as construction, public administration, security, and education, among others. In this way, the European Commission can ensure seamless integration among individuals, businesses, and the various governments that make up the EU.

An important aspect of these efforts is the development of technical standards. In April 2016, the European Commission proposed concrete measures to speed up the standard setting process for five priority areas: 5G, cloud computing, IoT, data technologies, and cybersecurity. The European Commission continues to monitor the standardisation process and collaborate with standard development organisations through its multi stakeholder platform. Moreover, the European Commission also aims to hold a process of international dialogue between other nations with heavy IoT development such as the US, South Korea, Japan, and China.⁴⁸ International collaboration on standards can ensure that the best practices are implemented in a strategy. A dialogue and exchange of ideas on challenges, best practices, and technical knowledge would aid the development of standards.

2.4.2 Advancing the Internet of Things in Europe

The European Commission’s staff working document, ‘Advancing the Internet of Things in Europe’,⁴⁹ emphasises the economic benefits of IoT services in reducing energy consumption through intelligent energy management. The document describes how a digital single market can facilitate the management and transmission of data in smart home energy systems to ensure interoperability across devices through open communication protocol standards.

Moreover, the document discusses various areas in which IoT can spur innovation, including smart homes and smart energy. For smart homes, digital solutions can be implemented to improve climate control and heating, ventilation, and air-conditioning methods to lower energy usage. In the future, the document describes the increasing number of smart appliances that will be present in smart homes, and how these devices can participate in demand response programmes to optimise energy management. For smart energy, the roll-out of smart meters and IoT sensors will produce a wealth of data that will allow smarter management of energy systems and the development of optimised decentralised solutions that could potentially achieve energy savings. For example, in Barcelona a smart streetlights programme achieved at least 30% energy savings per year through optimised use based on sensor data.⁵⁰

2.4.3 Smart Grids Task Force

The European Commission also set up a smart grids task force in 2009 to advise on issues related to smart grid deployment and development.⁵¹ This task force comprises various expert groups who are each tasked with an issue related to smart grids, such as standards, data protection, and smart grid deployment. Smart grids are intimately intertwined with

⁴⁸ *Ibid.*

⁴⁹ *Ibid.*

⁵⁰ European Commission, ‘Advancing the Internet of Things in Europe’

⁵¹ European Commission, ‘Smart grids task force’, <https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force>

digitalisation capabilities and can lead to energy savings in power generation, transmission, and buildings.⁵²

In sum, the European Commission's digitalisation strategy relies on three pillars to ensure seamless interoperability across devices and industries. These pillars set up a foundational platform on which IoT and digital solutions can be built. Moreover, the European Commission has set forth various strategies and programmes that utilise digital solutions to achieve improved energy efficiency and smart energy management. With such a heavy emphasis on both interoperability and energy management, manufacturers and policy makers can work together to implement successful digital solutions for energy applications.

2.4.4 Alliance for Internet of Things Innovation (AIOTI)

Alliance for Internet of Things Innovation (AIOTI) was established with support from the European Commission to foster the creation of an innovative and industry-driven European Internet of Things ecosystem.⁵³ The AIOTI builds on the work of the IoT European Research Cluster (IERC)⁵⁴, grouping together the IoT projects funded by the 7th European research framework programme (FP7)⁵⁵, as well as national IoT initiatives and has links with all the EU funded projects. Moreover, addressing challenges like energy efficiency, climate change, and carbon-neutral smart cities is listed as a vision of AIOTI.⁵⁶

In August 2018, the Alliance published its recommendations⁵⁷ for the future IoT research priorities under Horizon Europe and Digital Europe programmes in period 2021-2027. This work continues by publishing the vision on Future Networks⁵⁸, Services and Applications under Horizon Europe and priorities for the new political cycle in the EU (2019-2024).⁵⁹

2.5 South Korea

South Korea is a global leader of telecommunication infrastructure development with some of the world's fastest internet speeds, and the highest internet penetration rate, with nearly every South Korean household online.⁶⁰ As such, its government is strongly committed to the development of ICT through strategic policies. This section presents a discussion from four different strategies published by the South Korean Ministry of Science, ICT and Future Planning (MSIP) related to the development of a digital and intelligent economy.

⁵² CE Delft, 'The social costs and benefits of Smart Grids', https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group3_cost_benefits.pdf

⁵³ For more information, visit <https://aioti.eu/>

⁵⁴ For more information, visit <http://www.internet-of-things-research.eu/>

⁵⁵ European Commission, 'FP7 - Seventh framework programme of the European Community for research and technological development including demonstration activities(FP7)', <https://cordis.europa.eu/programme/id/FP7>

⁵⁶ 'AIOTI Vision and Recommendations: European IoT challenges and opportunities 2019 – 2024', <https://aioti.eu/aioti-vision-and-recommendations-european-iot-challenges-and-opportunities-2019-2024/>

⁵⁷ AIOTI, 'AIOTI position paper on Horizon Europe and Digital Europe', August 2018, https://aioti.eu/wp-content/uploads/2018/09/AIOTI_Position_Paper_HEU_2018_for_publishing.pdf

⁵⁸ AIOTI, '5GIA-AIOTI Vision on Future Networks, Services and Applications, March 2019, <https://aioti.eu/5gia-aioti-vision-on-future-networks-services-and-applications/>

⁵⁹ AIOTI, 'European IoT challenges and opportunities 2019–2024', 2019, <https://aioti.eu/wp-content/uploads/2019/09/AIOTI-Priorities-2019-2024-Digital.pdf>

⁶⁰ ITUNews, 'How the Republic of Korea became a world ICT leader', February 12, 2018, <https://news.itu.int/republic-korea-leader-information-communication-technologies/>

2.5.1 Master Plan in Preparation for the Intelligent Information Society

The first report, titled the ‘Master Plan in Preparation for the Intelligent Information Society’⁶¹ outlines the potential negative and positive impacts of intelligent ICT, which refers to technology that is capable of performing the highly complex functions of human intelligence by combining the ‘intelligence’ of artificial intelligence (AI) with the information provided by data-processing and network technologies, such as IoT, cloud computing, big data analysis, and mobile technologies (referred to collectively as ‘ICBM technologies’). The report then outlines short-term and mid to long-term strategies and policies that the government can implement in order to establish a business and society-friendly technological ecosystem. A final section also discusses an implementation framework with specific roles and responsibilities for businesses, citizens, government, and experts and academia. With regard to energy applications, this plan mainly describes the potential positive impacts of improved energy management through smart ICT. In its proposed implementation framework, the plan includes the Ministry of Energy in various committees tasked with coordinating policy issues. In this capacity, the Ministry of Energy can include energy applications in future policy recommendations.

2.5.2 Master Plan for Building Internet of Things (IoT)

The second report, titled the ‘Master Plan for Building the Internet of Things (IoT)’⁶², focuses on the development of the IoT ecosystem. One important aspect of this report is its emphasis on an open IoT platform created by the government which can be used by private sector companies to implement digital solutions. This type of platform maximises interoperability, streamlines the exchange of data, and ensures flexibility. Other policy tasks include investments in telecommunication infrastructure, and the promotion of smart devices and sensors. The report cites smart streetlight programmes and energy efficient manufacturing processes as potential energy applications.

2.5.3 Innovation Growth Engine

The ‘Innovation Growth Engine’⁶³ policy creates 13 ‘innovative growth engines’ dedicated across different government ministries to find solutions to future challenges associated with a digitalised society. The 13 engines are classified into four areas: intelligent infrastructure (telecom infrastructure, AI, big data), smart moving objects (autonomous vehicles, unmanned drones), technological convergence (smart cities), and the industrial base (manufacturing, energy). Each of these engines has a variety of ministries in charge of their coordination. Renewable energy and the integration of these energy sources are directly mentioned as an area of key focus of the industrial base engine.

⁶¹ Government of the Republic of Korea, ‘Master Plan in Preparation for the Intelligent Information Society’, July 2017, <http://english.msip.go.kr/english/msipContents/contentsView.do?catelId=msse56&artId=1352869>

⁶² Ministry of Science, ‘ICT and Future Planning, Master Plan for Building the Internet of Things (IoT)’, May 8, 2014, [www.iotkorea.or.kr/2013_kor/uploadFiles/board/KOREA-%20IoT\(Internet%20of%20Things\)%20Master%20Plan%20-%202014.pdf](http://www.iotkorea.or.kr/2013_kor/uploadFiles/board/KOREA-%20IoT(Internet%20of%20Things)%20Master%20Plan%20-%202014.pdf)

⁶³ Ministry of Science and ICT, ‘The INNOVATION GROWTH ENGINE: Leading preparations for the Fourth Industrial Revolution’, February 9, 2018, https://www.msit.go.kr/cms/english/pl/policies2/_icsFiles/afieldfile/2018/04/06/%ed%98%81%ec%8b%a0%ec%84%b1%ec%9e%a5%ec%98%81%eb%ac%b8-%ec%9d%b8%ec%87%84%eb%b3%b8.pdf

2.5.4 The 5th Science and Technology Foresight (2016 – 2040)

The final report, titled ‘The 5th Science and Technology Foresight (2016 – 2040)’,⁶⁴ has three main objectives. The first is to predict how future technologies will impact society; the second is to contribute to science and technology planning; and the third objective is to predict the tipping point of societal adoption for certain technologies. One distinct feature of this report is that its policy recommendations include information about when each policy measure should be implemented based on current technological and societal aspects. Furthermore, in identifying future technologies, the report mentions energy efficiency several times. In particular, the report mentions the ability of software tools to support the design of energy efficient buildings. With the support of IoT and behavioural data, these software tools can intelligently optimise heating and cooling systems to minimise their energy use without compromising occupant comfort. Of all the strategies discussed in this report, this is the only one which mentions the innovative use of digitalisation to optimise energy management in this manner. The report also discusses the development of smart energy grid construction technology, which it ranks highly in innovativeness and low in uncertainty, making it an attractive technology option to pursue. In the area of manufacturing, the report also identifies autonomous energy management systems which can prove to be cost-effective and energy efficient for manufacturers. Each of these technologies relies on digital capabilities to realise its full potential.

In addition to these strategies, South Korea has already implemented policies related to the development of smart grids. In one such policy measure, the ‘Smart Grid Construction and Utilization Act’,⁶⁵ defines a smart grid as a ‘power grid for maximizing the efficiency in the use of energy by supplying electric power by means of ICT applied thereto, through which suppliers and users of electric power can exchange information on a real-time basis.’ Defining a smart grid as a grid that maximises the efficiency of energy use ensures that all future developments of smart grids achieve energy savings.

The South Korean strategies and reports related to digitalisation efforts, particularly ‘The 5th Science and Technology Foresight (2016 – 2040)’, place a relatively heavy emphasis on potential energy saving applications. In addition, South Korea’s ‘Smart Grid Construction and Utilization Act’ outlines the development of intelligent energy grids. By focusing on specific technologies that can increase energy efficiency and codifying energy efficiency into law, South Korea’s places a high emphasis on energy applications in their IoT and digitalisation efforts.

2.6 United Kingdom

2.6.1 Industrial Strategy: Building a Britain fit for the future

The UK strategies presented in this section were developed by and for Great Britain. Britain’s first digitalisation strategy, titled ‘Industrial Strategy: Building a Britain fit for the future’⁶⁶ focuses on five foundations: creating an innovative economy, creating more jobs,

⁶⁴ Republic of Korea, ‘The 5th Science and Technology Foresight (2016-2040)’, April 2017, [https://www.msit.go.kr/cms/english/pl/publications/_icsFiles/afieldfile/2017/10/31/The%205th%20Science%20and%20Technology%20Foresight%20\(2016-2040\).pdf](https://www.msit.go.kr/cms/english/pl/publications/_icsFiles/afieldfile/2017/10/31/The%205th%20Science%20and%20Technology%20Foresight%20(2016-2040).pdf)

⁶⁵ Republic of Korea, ‘Smart Grid Construction and Utilization Act’, January 27, 2016, <http://extwprlegs1.fao.org/docs/pdf/kor169184.pdf>

⁶⁶ Secretary of State for Business, Energy and Industrial Strategy, ‘Industrial Strategy: Building a Britain fit for the future’, November 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730048/industrial-strategy-white-paper-web-ready-a4-version.pdf

upgrading infrastructure, enhancing business environment, and creating more prosperous communities across UK. The strategy aims to harness AI and data to maximise the advantages for clean growth, shape the future of mobility, and address issues of an ageing society.

One distinct feature of this strategy is its mention of specific investment amounts into certain areas. Some investments that would be of interest to energy technologies include raising total research and development to 2.4% of GDP by 2027 and investing over £1 billion in digital infrastructure.

2.6.2 Upgrading Our Energy System: Smart Systems and Flexibility Plan

As part of Britain's overall industrial strategy, the British government also published a plan that focuses solely on digitalisation within the energy system, titled 'Upgrading Our Energy System: Smart Systems and Flexibility Plan'.⁶⁷ This plan proposes actions to deliver a smarter, more flexible energy system by: 'removing barriers to smart technologies, including storage; enabling smart homes and businesses; and, making markets work for [demand] flexibility.' Some of these barriers include licensing and regulatory burdens, which inhibit the adoption of smart devices that can participate in demand flexibility. Other issues include the encouragement of residential participation in demand response programmes, seeking standards to encourage the usage of smart appliances, and how to spur the innovation of storage technologies. The plan also proposes to develop smart systems for more cost effective and clean energy across power, heating, and transportation applications. With the promised integration of an increasing number of renewable resources, a key challenge is for the grid to intelligently manage the distribution and demand of energy.

Overall, Britain has placed a heavy emphasis on the importance of smart energy management and clean growth. Its industrial strategy includes clean growth as one of its pillars. Further, the dedicated strategy related to the development of the energy system includes various specific measures that directly address barriers to the development of smart energy systems and proposes solutions to overcome these barriers. These aspects also mention how the market should adapt to facilitate the participation of demand flexibility technologies, which is unique to Britain's strategy.

2.7 United States of America

The US does not have a unified approach for developing IoT and digitalisation. Rather, individual departments, such as the Department of Commerce and the Department of Energy, have released their own plans on developing IoT and digitalisation development for their specific goals and capabilities. However, in May 2019, the US Senate introduced a bill which would attempt to craft a national IoT strategy through a multi-collaborative approach of various government and industry stakeholders⁶⁸ (discussed in further detail in Section 2.7.3). The bill has yet to be signed into law as of May 2020, and the publication of a final national strategy can be expected 1-2 years following the signing of the bill into law.

⁶⁷ Secretary of State for Business, Energy and Industrial Strategy, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan', July 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/633442/upgrading-our-energy-system-july-2017.pdf

⁶⁸ United States Congress, 'Developing Innovation and Growing the Internet of Things (DIGIT) Act', S. 88/H.R. 686, January 9, 2020, <https://www.fischer.senate.gov/public/cache/files/ae48cc18-a6a3-4d4e-b4bb-f7f7fabf899/digit-act-of-2019-final-.pdf>

2.7.1 Fostering the Advancement of the Internet of Things

In January 2017, the US Department of Commerce released a report titled 'Fostering the Advancement of the Internet of Things'⁶⁹ which reviews the current technological and policy landscape relating to IoT technologies and discusses what role the Department of Commerce should play in evolving this landscape. The report recognises the potential benefits of IoT capabilities in improving energy efficiency in the residential, commercial, and industrial sectors. However, due to the report's limitation on developing practices that fall under the jurisdiction of the Department of Commerce, energy applications are not mentioned to a great extent. Rather, this report focuses on how the Department of Commerce can develop IoT by enabling infrastructure availability and access, establishing policy-making coalitions, promoting technological standards advancement, and fostering friendly market conditions for the development of IoT. This type of siloed approach could provide useful recommendations for a specific entity, but since digitalisation and IoT are such cross-cutting technologies, a national strategy requires the collaboration of numerous government entities.

2.7.2 Grid Modernization Multi-Year Program Plan

Similar to the Department of Commerce's report, the US Department of Energy published its own 'Grid Modernization Multi-Year Program Plan'⁷⁰ in November 2015 which discusses how digital and IoT solutions could be implemented in a grid of the future. In particular, the plan focuses on five key trends that are driving the transformation, such as: distributed and clean energy, growing demands for grid resiliency and reliability, growing demand flexibility opportunities, emergence of interconnected electricity information and control systems, and an aging electricity infrastructure. The plan also discusses in detail how digital solutions can help support these transformations and alleviate certain issues, proposing specific actions and recommendations within the department's capabilities.

2.7.3 Developing Innovation and Growing the Internet of Things (DIGIT) Act

In an effort to coordinate the development strategy in a more holistic approach, the US Senate introduced the 'Developing Innovation and Growing the Internet of Things (DIGIT) Act' in May 2019⁷¹, which sets forth a collaborative process for developing a national IoT strategy. Specifically, it would require the government to convene a working group made up of federal entities and industry stakeholders to provide recommendations to Congress on developing and growing IoT in the US. The DIGIT Act also recognises sustainable infrastructure as an area of focus, which could benefit from the development of IoT. While sustainable infrastructure could also include the sustainable management of waste, water, and land use, it is likely that the national IoT strategy will include aspects of smart energy management. The strategy is set to be published 18 months after the bill is signed into law.

While the individual-department approach allows a more detailed and tailored discussion of the development of IoT, the successful implementation of actions would require a collaborative approach across multiple government entities to ensure interoperability and avoid conflicting approaches. One approach to mitigate conflicting approaches while

⁶⁹ US Department of Commerce, 'Fostering the Advancement of the Internet of Things', January 2017, https://www.ntia.doc.gov/files/ntia/publications/iot_green_paper_01122017.pdf

⁷⁰ Department of Energy, 'Grid Modernization Multi-year Program Plan', November 2015, <https://www.energy.gov/sites/prod/files/2016/01/f28/Grid%20Modernization%20Multi-Year%20Program%20Plan.pdf>

⁷¹ United States Congress, 'Developing Innovation and Growing the Internet of Things (DIGIT) Act'

maintaining detailed strategies is to have an overall national policy, and the individual entities' strategies must conform to this national policy.

3. Attributes to Develop an IoT and Digitalisation Strategy That Emphasises Energy Applications

This section considers key attributes and guidance to developing an IoT and digitalisation strategy that emphasises energy applications. Based on the analysis of various strategies in Section 2 of this report, Figure 3-1 illustrates key attributes that should be included in an IoT or digitalisation strategy: an overall objective, a defined role of government, specific targets, presentation of challenges, and action items to meet the targets and address challenges. Generally, the overall objective of a strategy defines the ‘why’, or purpose, of a strategy. The role of government defines the ‘who’, *i.e.*, who will be the key stakeholders involved, and the role of the government in the development and implementation process. The specific targets define the ‘what’ of a strategy, *i.e.*, what steps need to be taken. And the action items define the ‘how’, *i.e.*, how policy makers will achieve the specific targets.



Figure 3-1. Key Attributes of an IoT and Digitalisation Strategy with an Emphasis on Energy Applications

These key attributes define the overall structure of a strategy, and the objective of energy applications should act as an overarching element that is considered as part of every other key attribute. The elements discussed in this chapter are grouped into these key attributes. Many of these elements are commonly found in existing strategies that emphasise energy applications as a goal.

3.1 Overall Objective

The overall objective of a strategy is the foundation for a strategy’s structural framework. This structural framework shapes the overall focus of a strategy and the goals of any recommendations or policies presented in the strategy. In the analysed strategies, these

overall objectives usually include economic goals, societal benefits, or advancing a nation/region's digital capabilities. A strategy that emphasises energy applications can be effective in setting forth specific actions to reduce energy consumption and encourage adoption of programmes that promote energy savings such as demand flexibility.

3.1.1 Energy Efficiency as an Overall Objective

In the UK's strategy, 'Industrial Strategy: Building a Britain fit for the future', 'clean growth' is one of the foundational pillars, or overall objectives, of the strategy. This approach allows the strategy and its proposed recommendations to maintain a focus on environmental considerations alongside the development of a digital economy. In the context of the UK's strategy, clean growth is referred to as the use of 'low carbon technologies, systems, and services that cost less than high carbon alternatives.'⁷² The reduction of carbon emissions is correlated directly with improvements in energy efficiency.

Overall objectives provide a structure to the strategy and set the focus of a strategy's proposed action items. With many EDNA members committed to lowering their carbon emissions through international agreements, IoT and digitalisation strategies should emphasise the opportunity for ICT solutions to achieve energy savings, improve energy efficiency, and further develop intelligent energy management, including demand flexibility. Austria's 'Digital Roadmap Austria' and the EU's 'Advancing the Internet of Things in Europe' provide an in-depth analysis for energy savings through intelligent efficiency and demand flexibility. Energy applications should be a primary focus of policy recommendations. An IoT and digitalisation strategy can have additional objectives, but these should be developed and evaluated with respect to energy applications that save energy and improve energy management.

3.1.2 Flexibility of a Strategy

Another attribute to consider in the development of a strategy's objective is its flexibility in the context of its ability to adapt to a rapidly innovating technological landscape. Even though energy infrastructure can be expected to last decades, software, applications, and ICT hardware can have a much shorter lifespan.⁷³ Strategies and policies must be able to deal with new developments in these technologies. Moreover, strategies should not be too rigid on their specific goals, but instead should be able to adapt based on the technological landscape and the effectiveness of the existing strategy. This idea is discussed in more detail in Chapter 4 of this report, regarding the implementation of a strategy.

3.2 Role of Government

The role of government in a strategy can take various shapes. A strategy may emphasise the need for the government to adopt a less involved approach, instead encouraging industry to spearhead the digitalisation of a nation/region. Another approach may be for policy makers to be more involved, where the government implements policies and regulations to stimulate digitalisation. A middle ground between those contrasting approaches is a mixed approach, in which the government coordinates alongside a variety of non-governmental stakeholders to develop and implement digital solutions. The involvement of government is crucial for the development of a unified strategy because policy makers can bring together stakeholders with varying interests for dialogue and discussion. Policy makers

⁷² Secretary of State for Business, Energy and Industrial Strategy, 'Industrial Strategy: Building a Britain fit for the future'

⁷³ IEA, 'Digitalisation and Energy'

can effectively stimulate digitalisation through policies, investments, and by fostering favourable market conditions.

3.2.1 Collaborative Development Process

The involvement of a wide range of entities representing various areas and interests is necessary for the development of a strategy on a topic as broad as digitalisation. South Korea's 'Innovation Growth Engine' policy emphasises the need for a wide representation of industries by assigning ministries to each 'innovation growth engine' which is tasked with the development of a specific area within IoT and digitalisation. Some of the ministries involved include the Ministry of Science and ICT; the Ministry of Culture, Sports and Tourism; Ministry of Land, Infrastructure and Transport; and the Ministry of Health and Welfare. An IoT and digitalisation strategy, even one that focuses on energy applications, can impact several different areas of governance. For example, one facet of the strategy may be to reduce energy consumption in the transportation section. The success of this goal would be dependent on the collaboration between policy makers in transportation and energy. Section 3.3.5 discusses applications across industries in more detail.

Moreover, successful strategies often require government bodies and private-sector entities working closely together. By working together, both the private sector and government can effectively craft strategies that take into consideration industry capabilities, limitations, needs, and consumer impacts while achieving the goals set forth by the government in a strategy.

Finally, while international partners are usually not directly involved in the development of a national/regional strategy, international collaboration is especially beneficial for the development of standards for communication protocols and smart grid technologies. One example is the European Commission's commitment to hold a process of international dialogue between other nations such as the US, South Korea, Japan, and China. For a more detailed discussion on the development of standards, see Section 3.5.3.

3.3 Specific Targets

The specific targets of a strategy refer to specific aspects, measures, or benefits that a strategy aims to implement or achieve. These can range from digitalised public administration functions, telecommunication infrastructure developments, or enhanced education through digitalisation. This section will frame the discussion around aspects, measures, or benefits as related to improved energy efficiency through IoT and digitalisation.

3.3.1 Open Platform

Open access to energy-related data is vital for interoperability efforts and the effectiveness of energy-saving measures. According to the IEA report, 'Energy Efficiency 2019',⁷⁴ in a digitalised nation/region, a wide range of data are created every second that are directly related to energy applications. These include energy consumption data as well as data that correlates with energy consumption, such as weather conditions, consumer behaviour, and smart meter data. For example, the energy consumption of heating and cooling equipment is heavily dependent on weather conditions and consumer behaviour and preferences. With intelligent algorithms and software processing, these data can be used to unlock even more

⁷⁴ IEA, 'Energy Efficiency 2019'

energy saving opportunities. Further, South Korea's report on 'The 5th Science and Technology Foresight (2016 – 2040)'⁷⁵ mentions the potential application of intelligent modelling tools to utilise data related to energy consumption behaviours to aid in construction designs that maximise potential energy savings while minimizing impacts on the comfort of inhabitants.

Moreover, policy-making processes can also benefit from the sophisticated collection and publication of key energy data.⁷⁶ Tools such as online registries of products, and their performance can aid the development of more targeted policy approaches. The EU⁷⁷, Canada⁷⁸, and the US⁷⁹ have online databases of products with detailed performance-related characteristics and features, including energy-performance data.

South Korea's 'Master Plan for Building the Internet of Things (IoT)'⁸⁰ discusses how the government can provide an open platform environment on which the private sector can develop IoT technologies. Figure 3-2 illustrates how such a platform would operate. Service providers would access IoT data through an open platform which is accessible to everyone. This measure would also increase the interoperability among devices and services.

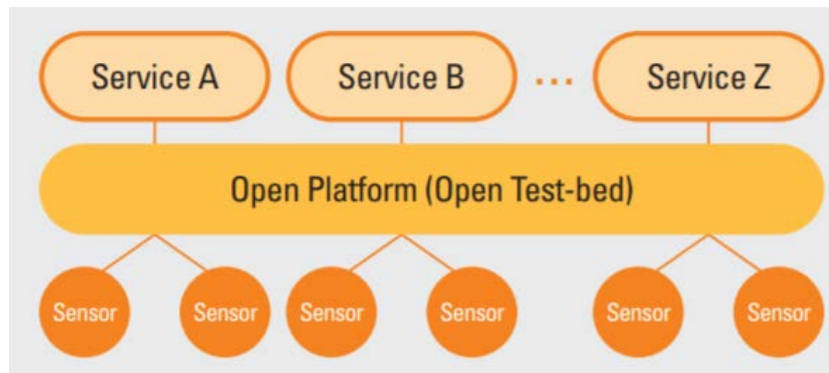


Figure 3-2. Illustration of an Open Platform IoT Ecosystem

Source: 'Master Plan for Building the Internet of Things (IoT)'

With open access to data, components within an IoT ecosystem could communicate with each other to identify new ways to work together to increase end-use efficiency.⁸¹ For example, a large number of connected energy-using devices, vehicles, and buildings can provide significant opportunities for demand flexibility measures. The report titled 'Policy Guidance for Smart, Energy-Saving Consumer Devices' from this series of three reports discusses in more detail how device and overall system functionality can benefit from open access environments.⁸²

⁷⁵ Republic of Korea, 'The 5th Science and Technology Foresight (2016-2040)'

⁷⁶ IEA, 'Energy Efficiency 2019'

⁷⁷ See, generally, https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/product-database_en

⁷⁸ See, generally, <http://oee.nrcan.gc.ca/pmi-lmp/index.cfm?action=app.welcome-bienvenue>

⁷⁹ See, generally, https://www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*

⁸⁰ Ministry of Science, ICT and Future Planning, 'Master Plan for Building the Internet of Things (IoT)'

⁸¹ IEA, 'Energy Efficiency 2019'

⁸² EDNA, 'Policy Guidance for Smart, Energy-Saving Consumer Devices'

3.3.2 Demand Flexibility and Intelligent Management

With digital strategies and smart infrastructure, demand response capacity could increase to 450 gigawatts (GW) globally, more than 10 times the capacity available today.⁸³ Digitalisation can enable consumers from all demand sectors to participate in energy system operations. By 2040, 1 billion households and 11 billion smart appliances could actively participate in electricity systems, allowing them to participate in demand flexibility activities.⁸⁴ Demand flexibility can reduce peak demand and as a result reduce strain on the grid while reducing electricity prices for consumers. Moreover, digitalisation alongside demand flexibility can help integrate variable renewables and intelligently manage a variety of energy sources on the grid by shifting demand to times of the day with high renewable energy supply.⁸⁵ The report titled 'Roadmap for Consumer Devices to Participate in Demand Flexibility' from this series of three reports discusses how nations/regions can develop a roadmap to develop demand flexibility and unlock these benefits.⁸⁶

3.3.3 Smart Grids and Infrastructure

Smart grids and infrastructure work hand-in-hand with other attributes discussed in this section, and it is important to emphasise the development of smart infrastructure to unlock energy efficiency opportunities from demand flexibility, smart meter data, and other grid initiatives. For example, the city of Barcelona's smart street light programme uses sensors to detect movement and dim lighting to achieve energy savings.⁸⁷ Similar streetlight initiatives have been implemented in Copenhagen, Chicago, and London.⁸⁸ Of the strategies analysed in Chapter 2 of this report, China, South Korea, and the US have dedicated committees, task forces, or plans for the modernisation of the electricity grid. National/regional strategies should aim to provide funding or implement policies to support the development of infrastructure and grid-related technologies that can achieve energy savings.

Telecommunication infrastructure must be capable to handle the growing number of IoT devices that connect to a network now as well as in the future. Some nations, such as China and South Korea, emphasise the importance of 5G wireless technology in enabling IoT. 5G is especially useful in applications where real-time network performance is critical, such as remote control of heavy machinery in hazardous environments.⁸⁹ While an emphasis on 5G is not required for a digitalisation and IoT strategy, it can improve the reliability and function of an IoT ecosystem. The development of a ubiquitous 5G network would require large investments in new telecommunication infrastructure.

Moreover, some strategies analysed in Chapter 2 set forth by various nations/regions, including China, the EU, and South Korea, also emphasise the importance of smart meters in enabling demand flexibility. Smart meters provide two-way communication between the meter and the utility to provide data on electricity consumption in time intervals ranging from

⁸³ IEA, 'World Energy Outlook 2018', 2018, <https://doi.org/10.1787/weo-2018-en>

⁸⁴ IEA, 'Digitalisation and Energy'

⁸⁵ Goldenberg, Cara; Dyson, Mark; 'Pushing the Limit: How Demand Flexibility Can Grow the Market for Renewable Energy', February 14, 2018, <https://rmi.org/demand-flexibility-can-grow-market-renewable-energy/>

⁸⁶ EDNA, 'Roadmap for Consumer Devices to Participate in Demand Flexibility'

⁸⁷ Fuldauer, Esther, 'Lighting the road to smart cities and sustainability', August 23, 2019,

<https://www.smartcitylab.com/blog/urban-environment/lighting-the-road-to-smart-cities-and-sustainability/>

⁸⁸ *Ibid.*

⁸⁹ Collela, Paolo, '5G and IoT: Ushering in a new era', March 30, 2017, <https://www.ericsson.com/en/about-us/company-facts/ericsson-worldwide/india/authored-articles/5g-and-iot-ushering-in-a-new-era>

minutes to one hour. These connected devices can also support the development of smart grid capabilities to manage energy more intelligently and efficiently.

3.3.4 Smart Devices

The IEA estimates that, under some scenarios, 11 billion smart appliances could be deployed by 2050, meaning these devices will make up a large share of the global demand response capacity.⁹⁰ Furthermore, IEA estimates that the implementation of smart devices can achieve energy savings of up to 10% between 2019 and 2040, equivalent to 234 exajoules (EJ) in energy savings.⁹¹ Thus, a national/regional strategy should emphasise the importance of policies for encouraging the adoption of smart appliances, and smart, energy-saving devices in general. This includes setting up favourable market conditions and implementing regulations to stimulate the uptake of smart, energy-saving devices. The UK's strategy 'Upgrading Our Energy System: Smart Systems and Flexibility Plan' includes a commitment for the government to work with industry on standards to ensure that smart functionality allows customers to participate in demand side response.

For more information on smart, energy-saving devices, the report 'Policy Guidance for Smart, Energy-Saving Consumer Devices' from this series of three reports includes considerations for policy makers to encourage the adoption of smart, energy-saving devices.⁹² These include technical considerations that policies should address, such as communications protocols, usability, and data privacy and security as well as the types of policies that are available, such as mandatory requirements, voluntary measures, incentive programmes, and industry self-regulation.

3.3.5 Applications Across Industries

Another important attribute of digitalisation strategies is that they should emphasise how ICT can improve processes as well as energy performance across a variety of industries. The Australian report, 'Australia's IoT Opportunity: Driving Future Growth', emphasises how sensor data can improve energy performance process in industries that require heavy, energy consumptive machinery such as construction, manufacturing, and agriculture. Moreover, South Korea's digital strategy 'The 5th Science and Technology Foresight (2016 – 2040)' discusses how data gathered by IoT on temperature, consumer behaviour, and the performance of machinery can be analysed by software and AI tools to provide insights on how to design buildings to achieve maximum energy performance while minimizing comfort impact for consumers. The transportation sector is another area not frequently discussed in the analysed strategies that can reduce energy consumption through ICT solutions.⁹³ In order to encourage the participation of as many industries as possible and achieve the most energy savings, IoT/digitalisation and energy applications should be discussed in the context of as many sectors as feasible.

3.4 Challenges

Nations/regions seeking to implement a national/regional strategy on digitalisation and IoT development that emphasises energy applications face a number of barriers. This section

⁹⁰ IEA, 'Energy Efficiency 2019'

⁹¹ *Ibid.*

⁹² EDNA, 'Policy Guidance for Smart, Energy-Saving Consumer Devices'

⁹³ IEA, 'Energy Efficiency 2019'

presents various challenges that digitalisation/IoT strategies with an emphasis on energy applications need to address and how to overcome them.

3.4.1 Uncertainty in Energy Efficiency Benefits

The IEA report, 'Energy Efficiency 2019' estimates that digitalisation can reduce global buildings sector energy demand by up to 10% between 2017 and 2040.⁹⁴ However, the report also recognises that the exact scale of these impacts is uncertain and depends heavily on industry responses to policies. Additionally, one potential side effect of digitalisation is the increased energy use of devices that are network-connected. The energy consumption of these new features in devices has the potential to offset energy savings, but further research is needed to determine the true scale of such impacts.

In order to minimise the standby energy consumption of connected devices, governments could implement minimum energy performance standards. Various nations/regions around the globe⁹⁵ prescribe minimum energy efficiency levels, maximum no-load/standby energy consumption requirements, or a maximum unit energy consumption based on a combination of design factors. However, the current frameworks for standard implementations need to adapt to the rapid change of pace at which IoT devices evolve. For traditional plug-loads such as refrigerators, freezers, air conditioners, and televisions, policy makers are able to study stable markets and implement informed energy performance standards.⁹⁶ In contrast, the rapid evolution of IoT devices may hinder policy-making efforts to establish informed regulations, and could consequently impose energy standards that are not stringent enough to achieve maximum energy savings, or too stringent to hinder innovation in this area.

3.4.2 Data Privacy/Security

Data privacy and security are becoming major concerns as more data are gathered on consumers through the use of network-connected devices. Digital consumers may face challenges related to information disclosure, misleading and unfair commercial practices, confirmation and payment, and fraud and identity theft.⁹⁷ These challenges could inhibit the adoption of IoT technologies if consumers do not trust the responsible handling of their data. Moreover, the growing concept of data ownership could hinder open access and interoperability efforts. Technological standards with privacy and cybersecurity requirements could mitigate such concerns while maximizing interoperability. In North America, Europe, China, and India, governments have already put in place legal frameworks for cybersecurity.⁹⁸ For example, the EU's General Data Protection Regulation (GDPR) aims to give control to users over their personal data by requiring controllers and processors of the data to adhere to security and privacy measures. Data controllers must enable the highest-level privacy settings by default, and personal data may only be processed under certain lawful bases, one of which is user consent.

Further, the Organization for Economic Cooperation and Development's (OECD) report, 'Going Digital: Shaping Policies, Improving Lives' suggests that the most effective way to deal with uncertainties is to manage digital risks.⁹⁹ This involves characterizing the risks

⁹⁴ *Ibid.*

⁹⁵ For more information on which nation/regions have energy efficiency regulations, see <https://aceee.org/research-report/i1801>

⁹⁶ IEA, 'Digitalisation and Energy'

⁹⁷ OECD, 'Going Digital: Shaping Policies, Improving Lives'

⁹⁸ IEA, 'Energy Efficiency 2019'

⁹⁹ OECD, 'Going Digital: Shaping Policies, Improving Lives'

associated with the open access of data, including consumer privacy risks, malware risks, and general improper use of data. These risks need to be reduced to an acceptable level for policy makers to implement certain digital measures.

The report “Policy Guidance for Smart, Energy-Saving Consumer Devices’ from this series of reports also discusses the impact of data and privacy concerns on the use of smart technologies, and how to alleviate these concerns.¹⁰⁰

3.4.3 Demand Flexibility Electricity Market Barriers

Regulations and incentives in the electricity markets are important for increasing the participation of demand flexibility opportunities. In general, the absence of markets and incentives for participating in demand flexibility is the greatest implementation barrier. The UK strategy, ‘Upgrading Our Energy System: Smart Systems and Flexibility Plan’,¹⁰¹ outlines various measures to support the development of a smart, flexible energy system by alleviating regulatory burden, and transforming the market to work for demand flexibility. These measures include assessing existing tariff schemes, investments, and incentives to ensure that distribution network operators are harnessing demand flexibility technologies. Through these measures, the strategy aims to upgrade the regulatory framework, and its electricity market structure to allow for innovation in demand flexibility technologies to flourish. The report ‘Roadmap for Consumer Devices to Participate in Demand Flexibility’ from this series of three reports also offers various initiatives to fostering favourable market conditions such as liberalizing markets, developing ancillary services aimed at renewable energy integration, and implementing policies for minimum demand flexibility capacity requirements.¹⁰²

For any nation/region to develop a successful IoT and digitalisation strategy, it is important to understand and assess the prevalent market conditions. These would help determine how to prioritise, develop, and implement the IoT and digitalisation strategy.

3.4.4 Interoperability

In the IoT world, interoperability generally refers to the ability of different types of devices, and/or devices from different manufacturers, to connect, communicate, and function with each other. Interoperability between connected devices is important for the successful implementation of an IoT ecosystem, and the maximum realisation of energy efficiency opportunities. Interoperability can also increase the simplicity of the technology for users, further increasing the chance of adoption of IoT technologies. A fragmented ecosystem with non-interoperable systems could undermine the effectiveness of technologies and increase complexity for consumers. One effective approach to combat this problem is to foster the development of global, voluntary standards by development organisations made up of policy makers and industry stakeholders, such as manufacturers.

Additionally, it is important for the federal government to not adopt new, unnecessary regulations where existing standards and/or best practices already exist. The ‘National IoT Strategy and Dialogue’ report published by industry associations, corporations, and the US Chamber of Commerce Technology Engagement Center, stresses the need for the federal

¹⁰⁰ EDNA, ‘Policy Guidance for Smart, Energy-Saving Consumer Devices’

¹⁰¹ Secretary of State for Business, Energy and Industrial Strategy, ‘Upgrading Our Energy System: Smart Systems and Flexibility Plan’

¹⁰² EDNA, ‘Roadmap for Consumer Devices to Participate in Demand Flexibility’

government to coordinate across federal agencies to prevent inconsistent, duplicative, or unnecessary IoT regulations to avoid creating barriers for the integration of IoT across all industry sectors.¹⁰³

The report 'Policy Guidance for Smart, Energy-Saving Consumer Devices' from this series of reports also discusses the importance of interoperability for the performance of IoT systems and smart devices.¹⁰⁴

3.4.5 Infrastructure and Technological Limitations

The successful implementation of an IoT strategy relies on various infrastructure pre-conditions such as broadband requirements, and smart grid developments. These elements require costly investments by the government and can be especially difficult to implement in rural areas. According to the OECD, rural areas usually lag urban and other areas in their access to fixed broadband access with a minimum download speed of 30 megabits per second, the speed required to use advanced connected devices and services.¹⁰⁵ To address these challenges in strategies, policy makers can set national/regional targets for broadband availability in terms of the speed of service and percent of population under coverage.¹⁰⁶ Additionally, policy makers must promote competition to positively influence private investment in rural areas and improve pricing decisions.¹⁰⁷ The more devices that communicate within an IoT system and share data, the more effective and useful the system becomes.

3.5 Action Items

The following section presents various action items, or specific goals, that IoT and digitalisation strategies can include to emphasise energy applications. These recommended actions include investments, infrastructure development, government investments, and other measures to promote reliability and security in a digitalised society.

3.5.1 Investment Opportunities in R&D

The IEA's 'Efficient World Strategy' suggests that to achieve the full potential of energy efficiency, global investments would need to double by 2025.¹⁰⁸ This includes, investments into efficient technologies, project investments by energy service companies, and climate mitigation investments by financial institutions.¹⁰⁹ In China, the government has provided millions of dollars in technological and standardisation research and is leading the world in these areas. About 60% of patents granted in China from 2013 to 2016 were related to digital technologies, compared to about one-third of granted patents in OECD nations.¹¹⁰ In the UK, its industrial strategy commits to raising total research and development to 2.4% of its GDP by 2027 and investing over £1 billion in digital infrastructure.

¹⁰³ Intel, Samsung, ITI, 'National IoT Strategy and Dialogue', June 2016, <https://www.itic.org/dotAsset/bdce6de4-8a00-49c5-a7a9-4dfb95609a76.pdf>

¹⁰⁴ EDNA, 'Policy Guidance for Smart, Energy-Saving Consumer Devices'

¹⁰⁵ OECD, 'Going Digital: Shaping Policies, Improving Lives'

¹⁰⁶ *Ibid.*

¹⁰⁷ *Ibid.*

¹⁰⁸ IEA, 'Energy Efficiency 2019'

¹⁰⁹ *Ibid.*

¹¹⁰ OECD, 'Going Digital: Shaping Policies, Improving Lives'

The investment opportunities should target both the public and private sectors. For the public sector, investment money can be funnelled directly into researching agencies' budgets. For the private sector, incentives can be implemented in the form of R&D tax credits as well as open business plan competitions related to the promotion of energy-related IoT technologies.

3.5.2 Smart Infrastructure Development

Depending on a nation/region's needs, the development of smart infrastructure may be a crucial first step that needs to be emphasised in a digitalisation/IoT strategy. To enable reliable communication between devices and users, telecommunication infrastructure needs to be developed such that it can handle a large number of devices on a network and reach as many people as possible. Europe's 'Digital Single Market' strategy prioritises the development of 5G infrastructure to meet the demands of a robust IoT ecosystem. Additionally, China's 'Notice on Comprehensively Advancing NB-IoT Development' calls for the development of IoT technologies with 5G capabilities.

As discussed in Section 3.3.3 of this report, an important step in the development of smart infrastructure is the roll-out of smart meters. In China, government plans and policies have led to one of the highest rates of smart meter adoption in homes.¹¹¹ Smart meters are becoming more prevalent, with nearly 950 million smart meters installed globally in 2019 and an estimated 1.5 billion that will be installed by 2028.¹¹² These devices capture high resolution information on real-time energy use, faults, reverse flow, and other factors and allow for detailed analyses of energy demand efficiency opportunities. The adoption of smart meters go hand in hand with the implementation of demand flexibility and intelligent energy management. Various strategies analysed in Chapter 2 of this report, such as the EU's 'Advancing the Internet of Things in Europe', and South Korea's 'Master plan for Building the Internet of Things', discuss the benefits of smart metering and why digitalisation strategies should aim to increase the adoption of smart meters.

3.5.3 Development of Technical Standards

The interoperability of different data types, devices, and applications allow systems to operate in a reliable, streamlined, and secure manner. To ensure that systems operate smoothly in this manner, it is necessary for the development of technical standards, especially for communication protocols. These standards can include requirements for the openness of data and flow of information as well as for the implementation of cybersecurity by design, among other requirements. The development of technical standards can be spearheaded by the government, international organisations, or industry. The European Committee for Electrotechnical Standardization brings together national standardisation organisations of 34 European nations which include industry stakeholders, trade unions, and environmental groups.¹¹³ The inclusion of a variety of groups is key to ensure that standards do not impose unnecessary burden on manufacturers, do not overlap with other existing standards, and focus on the goal of energy efficiency.

¹¹¹ Cision PR Newswire, 'China Smart Meter Industry Report, 2019-2025', <https://www.prnewswire.com/news-releases/china-smart-meter-industry-report-2019-2025-300839055.html>

¹¹² Navigant Research, 'Market Data: Smart Meter Global Forecasts', 3Q 2019, <https://www.navigantresearch.com/reports/market-data-smart-meter-global-forecasts>

¹¹³ IEA, 'Digitalisation and Energy'

Moreover, the international collaboration on standard development can further increase interoperability and alleviate burden on manufacturers who sell their products in different areas. An example of such an approach is the development of Fourth Generation Long-Term Evolution communication (4G LTE) through the Third Generation Partnership Project (3GPP) which has successfully implemented 4G LTE capability in various nations/regions with a high degree of compatibility with smartphones.¹¹⁴ Governments should follow a similar approach for the development of IoT communication protocols.

3.5.4 Cybersecurity Measures

In order to foster trust and participation in digitalisation measures, policy makers should include security considerations in all aspects of an IoT ecosystem. The development of consensus standards or labelling programmes can ensure that all technologies which use standardised technology comply with a set of security requirements that protect consumer privacy and the overall reliability of the system. In the US, the Department of Energy is the lead for cybersecurity in the energy sector. The Department of Energy has published a series of industry-led roadmaps that propose frameworks for resilient energy systems which include specific cybersecurity measures.¹¹⁵ In Finland, the Finnish Transport and Communications Agency, Traficom, launched a cybersecurity label in November 2019.¹¹⁶ This label can be awarded to networking smart devices if they meet the certification criteria of an industry standard, ETSI EN 303 645.¹¹⁷ The emphasis of cybersecurity measures is key to encouraging consumers to participate in the IoT ecosystem as well as maintaining overall system resiliency and security.

3.5.5 Increased Digital Literacy and Education

Digital literacy and education are important for both policy makers and consumers. Energy policy makers need to make sure they are informed about the latest developments in the digital world, its trends, and future implications.¹¹⁸ This can be achieved through the recruitment of digital experts in energy policy-making agencies, as well as conferences, workshops, and exercises. For consumers, education on how to appropriately install, operate, and secure devices is crucial for the adoption of digital technologies. Policy makers can assist to develop certification programmes for installers of services related to digitalisation and/or IoT.¹¹⁹ These certifications could be coordinated alongside technical standards for security protocols, IoT ecosystem structures, or other areas related to IoT use in the residential or commercial sector. Another important education opportunity is the education of consumers on the benefits of participating in intelligent energy efficiency or management programmes, or demand flexibility opportunities both, in terms of impact on the environment as well as potential cost savings for consumers.

¹¹⁴ Lee, Gwanhoo, 'IoT Innovation and Deployment: A Blueprint for U.S. and Korean Leadership'

¹¹⁵ US Department of Energy, 'Roadmap to Achieve Energy Delivery Systems Cybersecurity', September 2011, https://www.energy.gov/sites/prod/files/Energy%20Delivery%20Systems%20Cybersecurity%20Roadmap_finalweb.pdf

¹¹⁶ Traficom, Finnish Transport and Communications Agency, 'Finland becomes the first European country to certify safe smart devices – new Cybersecurity label helps consumers buy safer products', November 26, 2019, <https://www.traficom.fi/en/news/finland-becomes-first-european-country-certify-safe-smart-devices-new-cybersecurity-label>

¹¹⁷ CYBER, Cyber Security for Consumer Internet of Things, Draft 'ETSI EN 303 645', V2.0.0, 2019-11

¹¹⁸ IEA, 'Digitalisation and Energy'

¹¹⁹ IEA, 'Energy Efficiency 2019'

4. Execution of an IoT and Digitalisation Strategy

Well-developed and implemented strategies are fundamental for effective coordination and the realisation of benefits associated with a digitalised society. Due to the differences in socio-economic priorities as well as differing cultures in various nations/regions, there is no one-size-fits-all approach when it comes to developing a national/regional strategy. This section discusses general guiding principles for governments to consider when developing and implementing a strategy with an emphasis on energy applications. Usually, the process to develop and implement a strategy requires three basic steps, as illustrated in Figure 4-1.



Figure 4-1. Execution of a Strategy

While these three steps are applicable to any type of national/regional digitalisation or IoT strategy, the discussion in this section will focus on how energy applications can be integrated into a strategy through various procedural aspects of a strategy.

4.1 Planning and Preparation

The planning and preparation stage for the development of a strategy establishes clear goals and identifies key stakeholders to include in the development process.

4.1.1 Establishing the Overall Objective

The first step in developing a strategy that has an emphasis on energy applications is establishing energy applications as an objective among other broad objectives. One example of a strategy that accomplishes this is the UK's 'Industrial Strategy: Building a Britain fit for the future', which includes 'clean growth' as a fundamental pillar of the strategy. While the strategy can have additional aims or objectives, such as promoting economic growth, improving society, or generally harnessing the power of AI and data, these must tie in with the overall objective of energy applications. The overall objective of a strategy must

be defined and communicated clearly to all stakeholders before any other steps are taken in the development of a strategy. This will ensure that the specific targets and action items included in a strategy are crafted with energy applications, or another similar objective, in mind. However, it's also important to note that the overall strategy should avoid making these measures too rigid, detailed, or precise. Digital initiatives must be nimble, flexible, and quick to pivot if it fails to deliver real-world impact.¹²⁰

4.1.2 Identifying Key Stakeholders

The next crucial step is the establishment of a multi-stakeholder approach to develop a strategy in coordination with public and private entities. Digital transformation policies need to be coordinated with all actors affected by digital transformation.¹²¹ In the area of energy, these actors can range from manufacturers, utilities, energy-efficiency advocates, standards organisations, energy policy makers, telecommunication industry stakeholders, consumers, and any other stakeholders that play a prominent role in energy applications in a given market. These stakeholders can be assembled into coalitions, or task forces, that are assigned to tackle specific areas of a strategy. One example of this approach is the US 'DIGIT Act', which requires the government to convene task forces made up of governmental as well as non-governmental stakeholders to provide policy recommendations to support the development of IoT in the US.¹²² Another approach would be to set up a standalone organisation which oversees the development and execution of the strategy. The key is to involve actors at multiple levels of government as well as non-governmental stakeholders in the process.

Once the key stakeholders are identified, according to the OECD, the government must first establish effective organisational and governance frameworks that coordinate the implementation across all levels of government through:

- i) 'Identifying clear responsibilities to ensure overall coordination of the implementation of the digital government strategy
- ii) Establishing a system for "checks and balances" of governments' decisions on spending on technology to increase the level of accountability and public trust, and to improve decision-making and management to minimise risks of project failures and delays.'¹²³

The first approach to implement a strategy involves the head of the government as the primary leader, developer, and supporter of the strategy, in conjunction with ministerial agencies and other stakeholders. However, the head of the government is often also the overall coordinating lead. Figure 4-2 illustrates this approach.

¹²⁰ Mourtada, Rami; et al., 'How to Supercharge Your National Digital Transformation', July 25, 2018, <https://www.bcg.com/publications/2018/how-supercharge-your-national-digital-transformation.aspx>

¹²¹ OECD, 'Going Digital: Shaping Policies, Improving Lives'

¹²² United States Congress, 'Developing Innovation and Growing the Internet of Things (DIGIT) Act'

¹²³ OECD, 'Going Digital: Shaping Policies, Improving Lives'

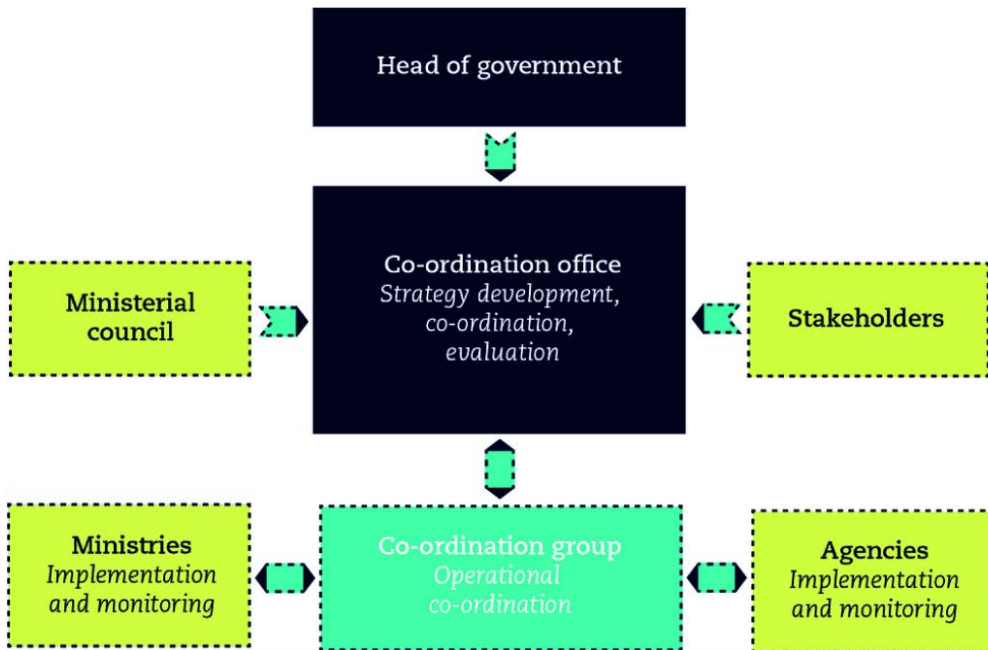


Figure 4-2. High-Level Centralised Approach to Implementing a Strategy

Source: OECD¹²⁴

The second approach, illustrated by Figure 4-3, utilises a ministry-led approach where a ministerial council made up of staff from all types of ministries lead the overall development, implementation, and coordination process.

¹²⁴ *Ibid.*

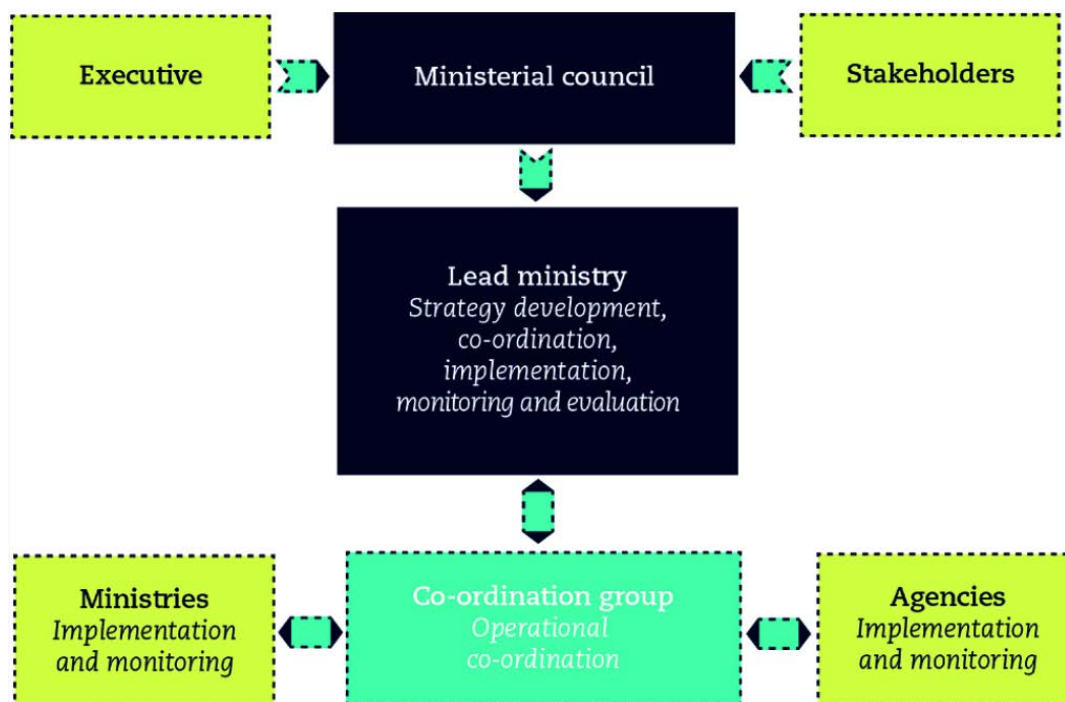


Figure 4-3. Ministry-led Approach to Implement a Strategy

Source: OECD¹²⁵

This decentralised approach places the responsibility of the overall efforts in the hands of various government entities. The key difference in these two approaches lies in which players are implementing the strategy, either the head of the government, or a ministerial council. In some nations/regions, the head of the government may have more power to implement measures, which could benefit the speed of the process. In a ministry-led approach, the ministries that make up the ministerial council would coordinate with each other instead of the head of government. This approach could result in longer implementation timeframes but could also benefit aspects of interoperability and increased collaboration. In Denmark, the Agency for Digitisation and the UK's Government Digital Service are examples of organisations comprised of government players that are responsible for driving digital transformation.¹²⁶ Whichever approach, or combination of approaches, is taken, the secure commitment of leadership is essential to the development of a strategy.¹²⁷

4.2 Development of Strategy

The development stage of a strategy includes the creation of a document and its implementation, which consists of the steps identified in Section 4.2.1 through Section 4.2.3 of this report.

4.2.1 Identifying Specific Targets

The first step in developing a strategy is identifying the areas on which the strategy should focus. These specific targets should directly relate to the overall objective established in the

¹²⁵ *Ibid.*

¹²⁶ Mourtada, Rami, et al., 'How to Supercharge Your National Digital Transformation'

¹²⁷ OECD, 'Recommendation of the Council on Digital Government Strategies'

Planning and Preparation stage of a strategy. To ensure consistency, a nation/region should also examine which other strategies are in place.¹²⁸ As discussed in Chapter 2, nations/regions can have various digitalisation strategies set in place, each focusing on a different topic. A unified digitalisation/IoT strategy should consider the objectives and goals of existing strategies and attempt to avoid conflicting goals or objectives.

Moreover, the selected specific targets could vary based on an individual nation/region's needs for realizing digitalisation. For example, aspects such as telecommunication infrastructure, investments into digital solutions, and policy measures can vary depending on the governmental structure of a nation/region and its socioeconomic status. Therefore, nations/regions need to determine the areas of focus of a digitalisation/IoT strategy. Section 3.3 of this report enlists the specific targets of a strategy that emphasises energy applications.

4.2.2 Identifying Challenges and Infrastructure Needs

The next step is to identify the challenges and infrastructure needs associated with digitalisation. Some potential challenges associated with digitalisation, such as data and privacy challenges, market considerations, and interoperability are discussed in Section 3.4 of this report. The collaboration of a wide variety of stakeholders is also crucial in identifying challenges that may not be obvious to policy makers.

As discussed in Section 3.4.5, a digitalisation strategy should also identify infrastructure needs before implementing digitalisation measures. Specifically, whether the existing telecommunication infrastructure provides sufficient coverage for the benefits of digitalisation to impact a large portion of the population, or whether the strategy should focus on developing telecommunication infrastructure before implementing digital solutions. An effective characterisation of the current state of infrastructure will require collecting relevant data such as:

- Percentage of households connected to the internet;
- Percentage of households with smart meters installed; and,
- Residential electricity data use.

4.2.3 Action Items

After identifying the specific targets a strategy should focus on, and the challenges that the strategy should address, policy makers need to develop a set of action items. Generally, action items should be specific, measurable, achievable, realistic, and timebound (SMART). Crafting action items in this manner clearly defines the scope of an action item and increases the chance of it being implemented successfully. Table 4-1 lists some examples of guiding questions for policy makers to draft SMART action items.

¹²⁸ OECD, 'Going Digital: Shaping Policies, Improving Lives'

Table 4-1. Guiding Questions for Drafting SMART Action Items

Aspect	Guiding Questions
Specific	Who is involved in the development and implementation processes? What is the purpose of this action item? What is the timeline of this action item? Where will it happen?
Measurable	Which indicators/data can evaluate the effectiveness of the action item? Do policy makers need to develop measures to gather this data (e.g., surveys, focus groups, measuring equipment)? How can policy makers know if the goal has been accomplished?
Attainable	Is the action item economically and technologically feasible? What other types of resources do policy makers need to develop and implement the action item (e.g., personnel, capital, technology, equipment)?
Relevant	Why is the action item significant? Is it worthwhile? Does it align with a strategy's overall objective? Is this the right time?
Timebound	What are the development and implementation timelines for this action item? When can policy makers and/or stakeholders expect to see results?

The various types of action items that a strategy with an emphasis on energy applications needs to address are listed in Section 3.5 of this report. Similar to the identification stages in Sections 4.2.1 and 4.2.2, the action items should be developed in collaboration with a variety of stakeholders.

4.2.4 Implementation Timeline

Without successful implementation, the main benefits of a digitalisation and IoT strategy may not be realised. Each action item should have assigned a specific implementation timeline based on its priority, magnitude, and cost among other factors. The implementation timeline should specify and designate tasks that should be accomplished by specific stakeholders such as government agencies, organisations, or manufacturers, and when they should be accomplished by.

4.2.5 Establishing Metrics to Measure Success

To evaluate the effectiveness of a strategy, nations/regions should establish clear metrics to measure the success of action items. For example, these metrics can include the number of households connected to the internet, or the number of households that participate in demand flexibility. Such quantifiable metrics will allow policy makers to receive continuous feedback on the effectiveness of their approaches, which is crucial for the next stage, continued monitoring, of a digitalisation/IoT strategy.

4.3 Continued Monitoring and Revising

With a framework in place, the next steps would involve monitoring efforts to examine the effectiveness of the strategy. These monitoring efforts would involve market assessments to evaluate the progress in the uptake of digital solutions, monitoring standard development, or evaluating the effectiveness of financial investments. In Denmark, the Innovation Fund Denmark (IFD) initiative follows projects funded by the government from start to finish to ensure that it is creating knowledge, growth, or employment to benefit society.¹²⁹ If overall efforts are not producing results as expected, then the strategy can be modified with new measures that would alleviate certain issues.

Based on the progress made towards goals, policy makers can revise and adjust their strategies. As discussed in Section 3.1.2 of this report, a constantly evolving technological landscape can pose challenges to maintaining the rigidity of a strategy. An easy approach to overcome this is to maintain the strategy in a digital format so that it can be easily and regularly updated. The 'Digital Austria' platform is an example of a strategy that lives online for easy modification and leverages social media to spread awareness.

¹²⁹ Mourtada, Rami, et al., 'How to Supercharge Your National Digital Transformation'