ANNEX **81**

EBC
Energy in Building and
Communities Programme

International Energy Agency

Opportunities for Government Leadership on Data-Driven Smart Buildings

IEA Annex 81 'Data-Driven Smart Buildings'

Energy in Buildings and Communities Technology Collaboration Programme

August 2024

Technology Collaboration Programme
by iea

ANNEX **81**

International Energy Agency

Opportunities for Government Leadership on Data-Driven Smart Buildings

Energy in Buildings and Communities Technology Collaboration Programme

August 2024

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Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 30 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes (TCPs). The mission of the IEA Energy in Buildings and Communities (IEA EBC) TCP is to support the acceleration of the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge, technologies and processes and other solutions through international collaborative research and open innovation. (Until 2013, the IEA EBC Programme was known as the IEA Energy Conservation in Buildings and Community Systems Programme, ECBCS.)

The high priority research themes in the EBC Strategic Plan 2019-2024 are based on research drivers, national programmes within the EBC participating countries, the Future Buildings Forum (FBF) Think Tank Workshop held in Singapore in October 2017 and a Strategy Planning Workshop held at the EBC Executive Committee Meeting in November 2017. The research themes represent a collective input of the Executive Committee members and Operating Agents to exploit technological and other opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy technologies, systems and processes. Future EBC collaborative research and innovation work should have its focus on these themes.

At the Strategy Planning Workshop in 2017, some 40 research themes were developed. From those 40 themes, 10 themes of special high priority have been extracted, taking into consideration a score that was given to each theme at the workshop. The 10 high priority themes can be separated in two types namely 'Objectives' and 'Means'. These two groups are distinguished for a better understanding of the different themes.

Objectives - The strategic objectives of the EBC TCP are as follows:

- reinforcing the technical and economic basis for refurbishment of existing buildings, including financing, engagement of stakeholders and promotion of co-benefits;
- improvement of planning, construction and management processes to reduce the performance gap between design stage assessments and real-world operation;
- the creation of 'low tech', robust and affordable technologies;
- the further development of energy efficient cooling in hot and humid, or dry climates, avoiding mechanical cooling if possible;
- the creation of holistic solution sets for district level systems taking into account energy grids, overall performance, business models, engagement of stakeholders, and transport energy system implications.

Means - The strategic objectives of the EBC TCP will be achieved by the means listed below:

- the creation of tools for supporting design and construction through to operations and maintenance, including building energy standards and life cycle analysis (LCA);
- benefitting from 'living labs' to provide experience of and overcome barriers to adoption of energy efficiency measures;
- improving smart control of building services technical installations, including occupant and operator interfaces;
- addressing data issues in buildings, including non-intrusive and secure data collection;
- the development of building information modelling (BIM) as a game changer, from design and construction through to operations and maintenance.

The themes in both groups can be the subject for new Annexes, but what distinguishes them is that the 'objectives' themes are final goals or solutions (or part of) for an energy efficient built environment, while the 'means' themes are instruments or enablers to reach such a goal. These themes are explained in more detail in the EBC Strategic Plan 2019-2024.

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*) and joint projects with the IEA Solar Heating and Cooling Technology Collaboration Programme by (☼):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: ☼ Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: ☼ Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: ☼ Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: ☼ Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO_2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO_2 Equivalent Emissions for Building Construction (*)

Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
Annex 60: New Generation Computational Tools for Building and Community Energy Systems (*)
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings (*)
Annex 62: Ventilative Cooling (*)
Annex 63: Implementation of Energy Strategies in Communities (*)
Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles (*)
Annex 65: Long-Term Performance of Super-Insulating Materials in Building Components and Systems (*)
Annex 66: Definition and Simulation of Occupant Behavior in Buildings (*)
Annex 67: Energy Flexible Buildings (*)
Annex 68: Indoor Air Quality Design and Control in Low Energy Residential Buildings (*)
Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings (*)
Annex 70: Energy Epidemiology: Analysis of Real Building Energy Use at Scale (*)
Annex 71: Building Energy Performance Assessment Based on In-situ Measurements (*)
Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings (*)
Annex 73: Towards Net Zero Energy Resilient Public Communities (*)
Annex 74: Competition and Living Lab Platform (*)
Annex 75: Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables (*)
Annex 76: ☼ Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emissions (*)
Annex 77: ☼ Integrated Solutions for Daylight and Electric Lighting (*)
Annex 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications (*)
Annex 79: Occupant-Centric Building Design and Operation
Annex 80: Resilient Cooling (*)
Annex 81: Data-Driven Smart Buildings
Annex 82: Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems
Annex 83: Positive Energy Districts
Annex 84: Demand Management of Buildings in Thermal Networks
Annex 85: Indirect Evaporative Cooling
Annex 86: Energy Efficient Indoor Air Quality Management in Residential Buildings
Annex 87: Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems
Annex 88: Evaluation and Demonstration of Actual Energy Efficiency of Heat Pump Systems in Buildings
Annex 89: Ways to Implement Net-zero Whole Life Carbon Buildings
Annex 90: EBC Annex 90 / SHC Task 70 Low Carbon, High Comfort Integrated Lighting
Annex 91: Open BIM for Energy Efficient Buildings
Annex 92: Smart Materials for Energy-Efficient Heating, Cooling and IAQ Control in Residential Buildings
Annex 93: Energy Resilience of the Buildings in Remote Cold Regions
Annex 94: Validation and Verification of In-situ Building Energy Performance Measurement Techniques
Annex 95: Human-centric Building Design and Operation for a Changing Climate
Annex 96: Grid Integrated Control of Buildings

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - HVAC Energy Calculation Methodologies for Non-residential Buildings (*)
Working Group - Cities and Communities
Working Group - Building Energy Codes

Summary

At COP28, jurisdictions committed to double the global average annual rate of energy efficiency improvements.

Non-residential buildings can use up to 40% more energy than needed. Existing and emerging digital technologies can cost-effectively reduce this waste. Digitalisation enables energy waste to be identified and rectified. It also enables more sophisticated building controls, that optimise energy use.

In the short term, digitalisation is an underutilized energy efficiency technology that governments can support, as part of a no-regrets (positive benefit to cost) policy approach for reducing greenhouse gas emissions.

In the medium term, digitalisation becomes a critical tool for enabling the clean energy transition. Vast amounts of new variable renewable electricity resources will need to be backed up with controllable (dispatchable) resources to maintain electricity system reliability, and to avoid discarding unusable renewable energy production. Dispatchability and electricity system coordination requires digitalisation.

Critically, navigating the clean energy transition will require zero-carbon-ready buildings to be 'digital ready'.

It is no surprise then, that the IEA identifies '*Leveraging digital innovation to enhance system-wide efficiency*' as one of its ten strategic principles for achieving the COP28 goals.

The International Energy Agency (IEA) Annex 81, "Data-Driven Smart Buildings", is an international collaborative project of the Energy in Buildings and Communities (EBC) Technology Collaboration Programme. Annex 81 specialises in understanding and growing the role of digitalisation, as an enabling tool for improving energy performance in non-residential buildings.

Annex81 considers digitalisation to include a suite of existing and emerging digital technologies that bring together **(i) real time data** (eg Internet of Things (IoT) technology for situational awareness), **(ii) advanced analytics** (eg Machine Learning technology to forecast events and select an optimal course of action) and **(iii) connectivity** (eg internet and cloud technology to ensure information flows are automated and information is accessible to remote users).

This report brings together expert knowledge, literature synthesis and feedback from industry interviews, with a focus on providing governments with guidance on actions that they can take to accelerate adoption of digital energy performance technologies.

Despite the existence of highly cost-effective digitalisation solutions, various barriers impede rapid adoption of the technology. Some well documented barriers include (i) interoperability (ii) data access, (iii) privacy and (iv) cybersecurity. More generally, industry interviews expressed the adoption challenge in terms of two core (but connected) themes. These themes were:

- Uncertain Return on Investment: The cost of digitalisation retrofits (for existing buildings) can vary significantly due to interoperability barriers, skills gaps and other supply chain issues. Benefits can also be muted by a lack of fair access to energy markets.
- Complexity and Trust: Digitalisation is perceived as a complex product to purchase, requiring careful consideration of software and hardware functionalities, as well as work-force practices (to take advantage of the insights obtained from the technology).

Both themes highlight industry uncertainty (consistent with the current immaturity of the industry). Industry expressed a desire for more guidance on product requirements, and for common terminology that can help to simplify purchasing, avoid potential pitfalls, and enhance competition.

Interestingly, most of the identified barriers are associated with deploying the enabling IT and data management infrastructure. Once this enabling digital infrastructure is in place, deploying energy saving software analytics solutions becomes relatively straight forward. Supporting the deployment of enabling IT and data-management infrastructure, is consequently seen as a key pathway for policy makers to help accelerate the adoption of digital energy performance solutions.

In this context, industry identified the critical need for buildings to be ‘digital ready’. A ‘digital ready’ building was seen as one that achieves certain minimum standard levels of connectivity and data management capability, sufficient to enable modern energy services (particularly demand flexibility). Clear digital-ready guidelines or standards should be enshrined in relevant policy mechanisms to greatly simplify and derisk investment in digitalisation.

The New York State Energy Research and Development Authority (NYSERDA) Real Time Energy Management (RTEM) program is an exemplary government initiative for stimulating initial growth in the digitalisation of buildings industry. By pre-qualifying digitalisation products and services, it has helped to simplify and build trust in the technology.

Various existing digitalisation roadmaps were reviewed. In addition to supporting digital infrastructure (described above), commonly cited areas for possible policy development include (i) improving access to energy markets for distributed energy resources, (ii) supporting innovators, (iii) incentivising pilot projects with early adopters and (iv) providing industry capability and capacity building.

Consolidating this literature and feedback from industry, a set of key policy actions were developed to accelerate growth of the industry. These policy actions are categorised under eight themes.

Theme 1: Provide Information – to reduce complexity and information asymmetry for buyers.

Theme 2: Establish ‘digital ready’ certification – to standardise solutions and recognise achievement.

Theme 3: Lead by example – to provide a cohort of early adopters that catalyse the market.

Theme 4: Support researchers and innovators – to catalyse a wider range of product offerings, increase industry maturity, and provide independent validation of the benefits of digitalisation.

Theme 5: Incentivise EMIS technology – to improve the return on investment from the technology.

Theme 6: Reduce data sharing risk – to improve certainty and manage possible compliance issues.

Theme 7: Build workforce skills and capacity – to be able to deliver the services at scale.

Theme 8: Integrate buildings into the electricity system – to prioritise the clean energy transition.

These Themes and the corresponding recommended policy actions are described in Section 5 of this report, along with examples of where relevant policies are being deployed. The recommendations are summarised in the following ‘Roadmap on a page’.

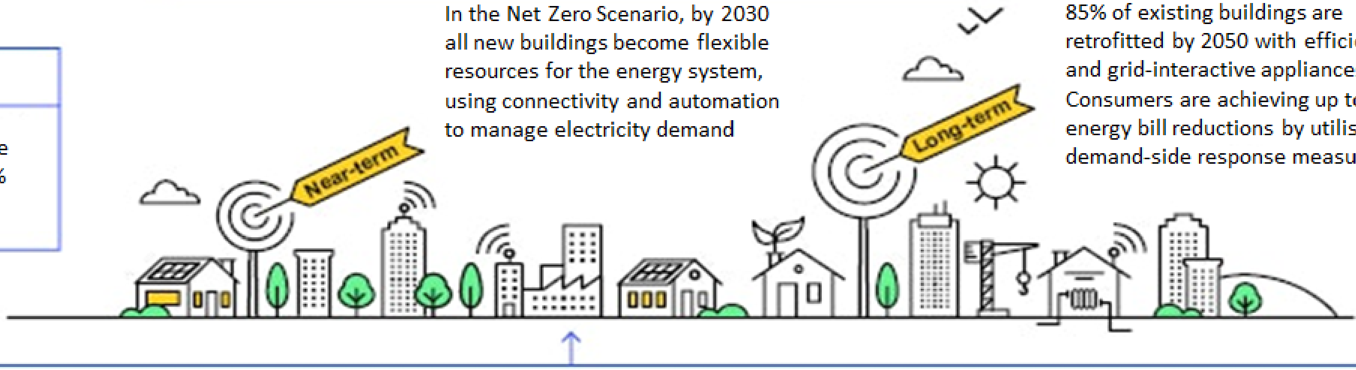
Policy Package – Energy Optimisation in Buildings through Digitalisation

Immediate opportunities

Digitalisation can help reduce energy wastage by up to 40% in commercial buildings

In the Net Zero Scenario, by 2030 all new buildings become flexible resources for the energy system, using connectivity and automation to manage electricity demand

85% of existing buildings are retrofitted by 2050 with efficient and grid-interactive appliances. Consumers are achieving up to 20% energy bill reductions by utilising demand-side response measures



REGULATION

Theme 2: Establish 'digital ready' certification

2.1 Use construction codes to require new buildings to achieve minimum 'digital ready' levels

Theme 6: Reduce data-sharing risks

6.1 Clarify consumer data rights regarding energy data
6.2 Regulate energy data to be collected, use of standard data collection formats and how data can be shared (including provision of price signals)

Theme 8: Integrate buildings into the electricity system

8.1 Reform electricity market rules to encourage participation of DER from Grid Interactive Buildings.
8.2 Require demand-response readiness in MEPS for major appliances
8.3 Place obligations on retailers to support customers to deliver demand flexibility services

INFORMATION

Theme 1: Provide information

1.1 Collate and disseminate knowledge from pilot buildings.
1.2 Prepare guides and terminology for digital infrastructure and data management practices

Theme 2: Establish 'digital ready' certification

2.2 Use 'digital ready' standards and criteria to establish a certification system for recognizing achievement of 'digital ready' status

Theme 3: Government leading by example

3.1 Maintain a centralised expert team to support agencies

Theme 4: Support researchers and innovators

4.1 Engage the research sector in testing, analysis, knowledge sharing and developing tools and standards

Theme 7: Build workforce skills and capacity

7.1 Support digital training across the property sector
7.2 Create incentive strategies for attracting IT talent into the property sector

INCENTIVES

Theme 2: Establish 'digital ready' certification

2.3 Reward achievement of 'digital ready' in a relevant rating scheme and/or as eligibility criteria for an incentive mechanism

Theme 3: Government leading by example

3.2 Invest in digitalisation technology in government buildings
3.3 Adopt 'digital ready' green lease clauses

Theme 4: Support researchers and innovators

4.2 Provide funding and test buildings to help innovators develop and commercialisation new smart products

Theme 5: Incentivise EMIS technology

5.1 Provide co-investment grants or tax incentives
5.2 Recognise EMIS technology in performance-based energy savings schemes
5.3 Authorise M&V methodologies and automated tools

Theme 6: Reduce data-sharing risks

6.3 Provide data stewardship/ data-hub services

Theme 8: Integrate buildings into the electricity system

8.4 Catalyse the market by acquiring a target amount of DER from Grid Interactive Buildings
8.5 Establish a market operations platform to support DER from Grid Interactive Buildings

Figure: Policy Package for Energy Optimisation in Buildings through Digitalisationc (format adopted from IEA[23])

Table of contents

Preface **4**

Summary **7**

Abbreviations **12**

1. Introduction **13**

2. The Opportunity **14**

2.1 What is digitalisation? 14

2.1.1 The transformative role of digitalisation 15

2.2 Use cases and demonstrated benefits of digitalisation 15

2.3 Why focus on digitalisation? 17

3. Barriers to Digitalisation in Buildings **18**

4. Review of Strategies for Accelerating Adoption of Digital Energy Productivity Solutions **21**

5. Recommendations for Government Leadership **25**

5.1 Theme 1: Provide information 28

5.2 Theme 2: Establish 'digital ready' certification 30

5.3 Theme 3: Lead by example 32

5.4 Theme 4: Support researchers and innovators 34

5.5 Theme 5: Incentivise EMIS technology 36

5.6 Theme 6: Reduce data sharing risk 38

5.7 Theme 7: Build workforce skills and capacity 40

5.8 Theme 8: Integrate buildings into the electricity system 42

6. Conclusion **44**

Appendix A **45**

Appendix B **46**

Figures

Figure 2.1: Energy productivity applications that can be hosted on an integrated EMIS infrastructure (adapted from Kramer et al, 2020) 15
Figure 3.1: Ranking the importance of barriers to utilising digitalisation for improving energy performance (Source: Trianni et. al., 2022) 19
Figure 3.2: The journey involved in implementing digital energy performance solutions (Adapted from Trianni et. al., 2022) 20
Figure 5.1: A prioritisation survey of the recommended policy themes 26
Figure 5.2: Policy Package for Energy Optimisation in Buildings through Digitalisation (format adopted from IEA) 27

Tables

Table 4.1: Summary of existing roadmap findings 21

Abbreviations

Abbreviations	Meaning
AI	Artificial Intelligence
API	Application Programming Interface
App	Application
BIM	Building Information Modelling
BMS	Building Management System
DER	Distributed Energy Resources
EMIS	Energy Management Information System
GEB	Grid Interactive Efficient Building
HVAC	Heating Ventilating and Air Conditioning
ICT	Information and Communication Technology
IEA	International Energy Agency
IoT	Internet of Things
IT	Information Technology
M&V	Measurement and verification
MEPS	Minimum Energy Performance Standards

1. Introduction

The International Energy Agency (IEA) Annex 81, "Data-Driven Smart Buildings", is an international collaboration project of the Energy in Buildings and Communities (EBC) Technology Collaboration Programme. IEA Annex 81 is a collaboration across 19 countries and over 50 expert organisations. These organisations include both industry and research participants.

Annex 81 aims to achieve greater understanding and growth in the role of digitalisation, as an enabling tool for improving energy performance in non-residential buildings. A particular focus of Annex 81 is on using near real time data, from energy consuming equipment, to drive advanced analytics that optimise equipment operations.

At COP28, jurisdictions committed to double the global average annual rate of energy efficiency improvements. The IEA policy toolkit[1] provides guidance for policy makers to help them achieve this objective. It identifies 'Leveraging digital innovation to enhance system-wide efficiency' as one of its ten strategic principles for maximising impact from energy efficiency policies and programmes.

This reflects evolving IEA understanding[2,3] , that, in addition to improving energy efficiency (reducing overall consumption), policies must include the emerging need for load shifting (managing the time of energy consumption). This is required to improve the security of energy systems, as part of the transition to variable renewable energy resources. In their Net Zero Emissions by 2050 Scenario, the IEA[4] is calling for a tenfold increase in demand response availability from buildings between 2020 and 2030.

Amongst other actions, the IEA policy toolkit identifies the importance of 'smart interactive technologies' and 'smart meters' for providing information to manage loads. It recommends both (i) regulation to ensure that buildings are 'demand response ready' and (ii) incentives to support dynamic response to electricity prices.

The IEA further suggests a framework[5] for countries to develop their own pathways to enable efficient grid-interactive buildings, as a means of supporting their energy transition objectives. It groups the enablers of efficient grid-interactive buildings into four categories: energy efficiency, decarbonisation technologies, smartness and building-to-grid interaction.

This report further explores the "smartness" category and its overlapping impact on the "building to grid interaction" category. This is done by considering the barriers to adoption of digitalisation and the policy solutions that could be used to overcome these barriers. The recommendations in this report are the result of analysis and reflection on lessons learnt across the industry. It includes findings from 16 interviews with senior industry practitioners across three continents.

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[1] International Energy Agency, 2022, "7th Annual Global Conference on Energy Efficiency: Policy Toolkit", https://iea.blob.core.windows.net/assets/ef170f7d-606a-4adc-ac32-565f9b6c0579/7thAnnualGlobalConferenceonEnergyEfficiency-PolicyToolkit.pdf

[2] International Energy Agency, 2023, "The Evolution of Energy Efficiency Policy to Support Clean Energy Transitions", https://www.iea.org/reports/the-evolution-of-energy-efficiency-policy-to-support-clean-energy-transitions

[3] International Energy Agency, 2023, "Using Digitalisation in Emerging Markets and Developing Economies to Enable Demand Response in Buildings", https://www.iea.org/reports/using-digitalisation-in-emerging-markets-and-developing-economies-to-enable-demand-response-in-buildings

[4] International Energy Agency, 2023, "Tracking Demand Response", https://www.iea.org/energy-system/energy-efficiency-and-demand/demand-response

[5] International Energy Agency, 2023, "Efficient Grid-Interactive Buildings: Future of buildings in ASEAN", https://www.iea.org/reports/efficient-grid-interactive-buildings

2. The Opportunity

2.1 What is digitalisation?

Data, analytics and connectivity are the three core attributes of digitalisation. These features can be combined in innovative ways to create new energy productivity solutions. Digitalisation benefits from a suite of emerging IT technologies. Some of the key digital technologies, for smart buildings, include:

- *Big data and the Internet of Things (IoT)*: providing data and 'situational awareness' on energy consuming equipment and occupants in buildings – that can inform decision making.
- *Advanced data analytics* (including artificial intelligence): enabling more comprehensive energy performance assessment, and predictive management of assets.
- *Cloud data platforms*: providing IT infrastructure that underpins innovative business models for connecting users, and automating energy efficiency software services. The data platform is often called an Energy Management Information System (EMIS).

Digitalisation can be an ***engineering tool***: for automating equipment operations to reduce energy consumption, and to match energy demand with the availability of variable renewable energy resources.

Digitalisation can also be an ***administrative enabler***: for operationalising Government policies that either (i) support building owners with incentives (eg rating schemes) or (ii) impose relevant regulatory requirements. Digitalisation is particularly suitable for streamlining measurement and verification (M&V) processes that underpin markets and performance-based assessment (a requirement of many schemes).

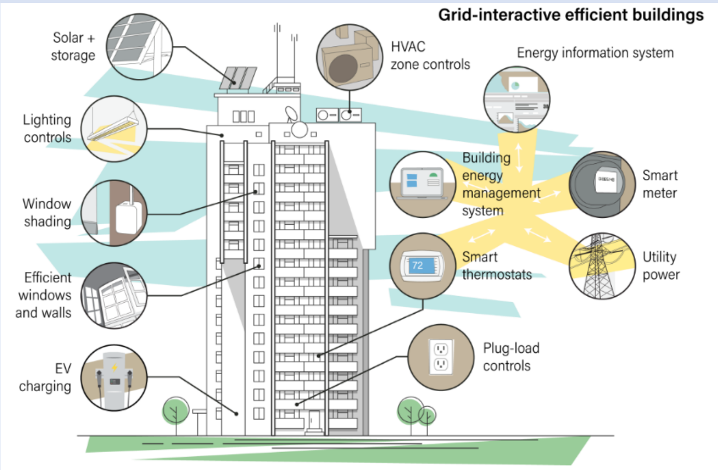
In almost all use-cases, digitalisation plays a key role as an ***information sharing tool***: distributing information to where it is needed. Information/data-sharing can involve either one-way or two-way communication. Information/data-sharing can be machine to human (providing decision support for manual interventions), or machine to machine (automating dynamic processes).

Without digitalisation, occupants will not be able to actively engage in energy-efficient operation of buildings. Without digitalisation, buildings will not be able to actively participate in broader built-environment systems (eg smart-grids or smart-cities). One specific use-case of digitalisation is the concept of Grid Interactive Efficient Buildings.

Digitalisation in Grid-Interactive Efficient Buildings (GEBs)

The US Department of Energy defined a GEB as

"an energy efficient building with smart technologies characterised by the active use of distributed energy resources (DERs) to optimise energy use for grid services, occupant needs and preferences, and cost reductions – in a continuous and integrated way. GEBs contain distributed energy resources such as energy storage, rooftop solar photovoltaics (PVs), and grid-connected water heaters. Smart controls (activated through an EMIS) enable GEBs to play a key role in achieving greater affordability, resilience, environmental performance, and reliability across the U.S. electric power system."[13]



2.1.1 The transformative role of digitalisation

Traditional energy efficiency retrofits have sometimes been seen as labour and skills intensive, and therefore hard to implement. Furthermore, while typically enjoying good return on investment, they have sometimes lacked the financial scale sufficient to attract attention from senior management. These factors are not conducive to driving widespread adoption.

In contrast, energy efficiency through digitalisation has many features that offer the potential to transform the energy efficiency market. These include:

- **Mass-deployment potential (scalability/portability)**: The ability to 'abstract away' the idiosyncrasies of a given implementation, to make software-services universal rather than bespoke. This enables users to deploy software-services for themselves, without needing expensive expert assistance.
- **Business model innovation potential**: In addition to energy productivity benefits, digitalisation is part of a much broader suite of smart-building offerings that range from labour-force productivity use-cases to applications that improve the occupant's experience of a building. This creates opportunities for innovative new business models that provide new 'core-business' consumer touch points, and potential for value stacking.'.

2.2 Use cases and demonstrated benefits of digitalisation

Once an EMIS platform is installed, building owners can access many 'smart' applications for their building. Some specific energy performance applications (use-cases) are illustrated in Figure 2.1.

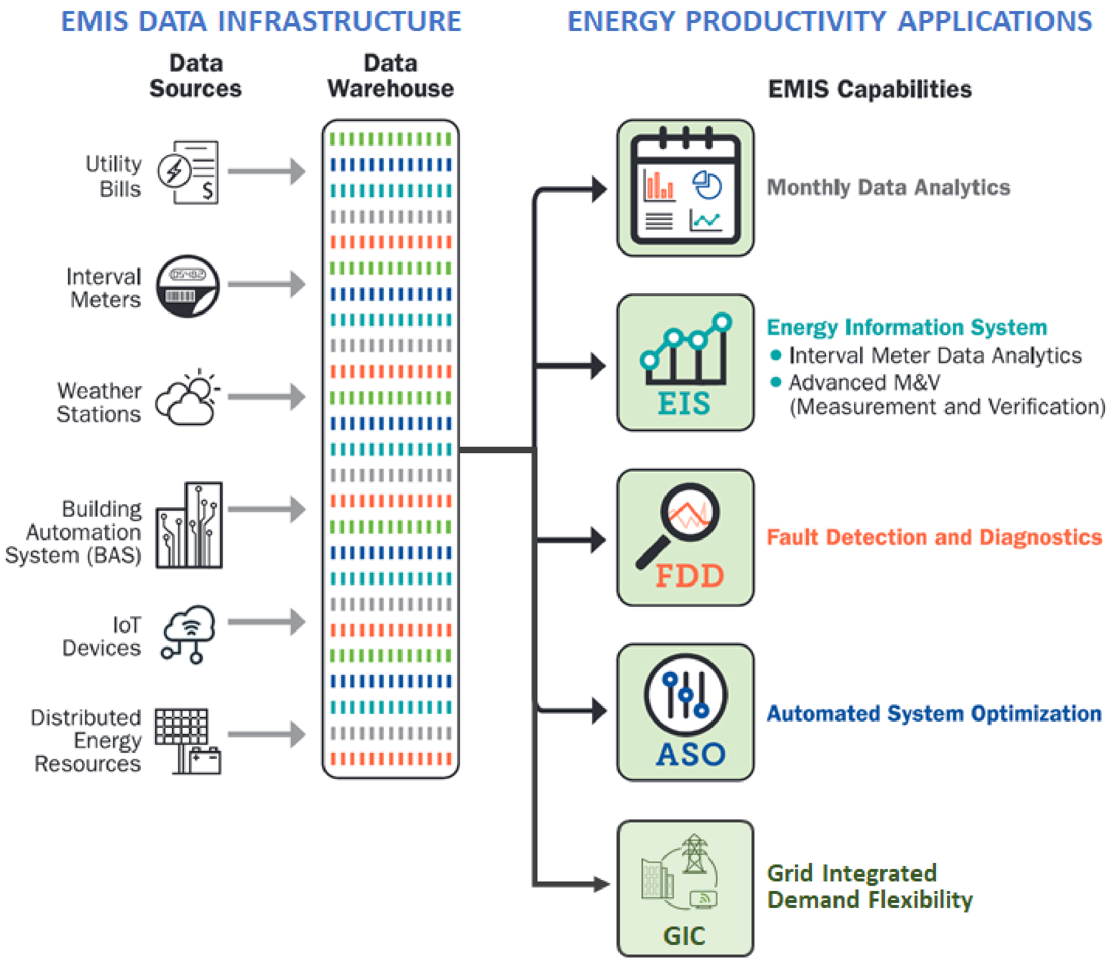


Figure 2.1: Energy productivity applications that can be hosted on an integrated EMIS infrastructure (adapted from Kramer et al, 2020[7])

These digitalisation applications and their benefits include:

- **Monthly Data Analytics**: Energy bill analytics provides information transparency for tracking the aggregate impact of business sustainability initiatives at monthly or annual intervals. For example, normalised energy tracking over a 10-year period, using the NABERS[6] rating system, has helped building owners in Australia reduce their energy use by an average of 30-40%.
- **Energy Information Systems**: Real-time energy (and sub) meter data collection allows more fine-grained analysis of energy trends. These analytics can identify energy consuming equipment and provide energy-consumption baselines to measure the benefits from investing in energy saving activities. Kramer et al. (2020)[7] found that the median annual energy savings across a large cohort of buildings was around 3%.
- **Equipment fault detection and diagnosis (FDD)**: By combining sensor data, heating, ventilation, and air-conditioning (HVAC) equipment data and energy meter data, it is possible to get a more detailed understanding of why energy consumption is higher than necessary. This can be used to get insights into how to reduce energy consumption. Across 1,500 buildings in North America, Kramer et al. (2020)[7] and Crowe et al. (2020)[8] found median annual energy savings of ~9% with a median simple payback time of 1.7 years. FDD derived insights will typically require manual implementation.
- **Automated System Optimisation**: The New South Wales (NSW) Office of Environment and Heritage[9] describes several advanced HVAC control strategies. Each has the potential for significant energy savings. These automated control strategies can override static control set-points with more dynamic seasonal (or even hourly) set-points, or strategies that take advantage of dynamic price and weather forecasts. Despite energy savings of up to 40%[10], the opportunity of this technology has not yet been widely exploited. This is, at least partly, due to fears of automated controls creating unintended or unsupervised consequences.
- **Grid Integrated Demand Flexibility**: Beyond energy efficiency actions in single buildings, the connectivity obtained from an EMIS enables a portfolio of assets to be managed in response to electricity market signals. For example, the Energy Queensland 'Broad Based' flexible demand program connected over 136,000 air conditioners, providing up to 150MW of diversified load under control, during peak demand events, at around 20% of the cost of batteries (Brinsmead et al, 2021)[11].

Smart meters are an important component of digitalisation, enabling more sophisticated energy pricing and user awareness. However, metering alone is rarely enough to understand a building's energy consumption properly and drive performance improvements. Consequently, metering should be viewed as just one part of an integrated Energy Management Information System (EMIS).

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[6] National Australian Built Environment Rating System (NABERS), https://www.nabers.gov.au/about/what-nabers

[7] Kramer H., Lin G., Curtin C., Crowe E, and Granderson J. (2020), "Proving the Business Case for Building Analytics". Lawrence Berkeley National Laboratory, https://eta-publications.lbl.gov/sites/default/files/kramer_provingbuildinganalytics_october2020.pdf

[8] Crowe E., Mills E., Poeling T., Curtin C., Bjørnskov D, Fischer L., Granderson J. (2020), "Building commissioning costs and savings across three decades and 1500 North American buildings", Energy & Buildings 227, https://doi.org/10.1016/j.enbuild.2020.110408

[9] NSW Office of Environment and Heritage (2015), "I am Your Optimisation Guide: Heating, Ventilation and Air conditioning Systems", ISBN 978 1 74359 990 1, https://www.environment.nsw.gov.au/resources/business/150317hvacguide.pdf

[10] Serale G., Fiorentini M., Capozzoli A., Bernardini D. and Bemporad A. (2018), "Model Predictive Control (MPC) for Enhancing Building and HVAC System Energy Efficiency: Problem Formulation, Applications and Opportunities", Energies 2018, 11, 631; doi:10.3390/en11030631

[11] Brinsmead T.S., White S., Bransden C., Stanley C., Hasan K., Nagrath K., Briggs C., Leak J., Harkins-Small L., Murray-Leach R., Jennings K., Sprague M., Northey J., Walgenwitz G. and Alexander D. (2021), "B4 Opportunity Assessment: Flexible Demand and Demand Control Final Report", Report for the RACE for 2030 Cooperative Research Centre, https://www.racefor2030.com.au/opportunity-assessment-reports/

2.3 Why focus on digitalisation?

Digitalisation is an emerging, ready-to-be-tapped opportunity to accelerate energy savings and improve grid resilience. Estimates of the benefits of digitally enabled efficiency and demand flexibility, in different regions, include:

- *Across Europe over a 20-year period*: building automation technology could be ramped up progressively to achieve energy savings of 13%, compared with the reference scenario, with estimated cumulative 3.4 GT of CO2 emissions savings[12].
- *Across the USA over the period 2021 to 2040*: The US Department of Energy[13] estimates that 'Grid-Interactive Efficient Buildings' (GEBs) have the potential to reduce total U.S. electricity supply costs by 2 to 6% (saving the US power system $100-200 billion) and helping to reduce CO2 emissions by around 6% (saving around 80 MT/year of CO2 emissions).
- *Across the Australian National Electricity Market to 2040*: demand flexibility could provide $18b in cost savings[14].

The policy imperative, then, is twofold:

In the short term, digitalisation can provide cost-effective (simple payback time of around 1.7 years[7]) energy savings of up to 40%, using existing technology. This invites an immediate 'no-regrets' policy goal to co-ordinate industry/government action, as a means of addressing barriers and unlocking supply chains.

In the medium term, digitalisation becomes a critical tool for enabling the clean energy transition. Vast amounts of new variable renewable electricity resources will need to be backed up with controllable (dispatchable) resources to maintain electricity system reliability and to avoid discarding unusable renewable energy production. In the very foreseeable future, the critical challenge will no longer be renewable energy resource availability. But instead, the challenge will be to deploy storage and demand response resources that shift electricity demand to match the availability of renewable energy resources.

Hence, the IEA World Energy Outlook[15] identifies that "demand response is set to play an increasingly important part in the provision of short-term flexibility" and identifies the need for "a supportive regulatory environment which is underpinned by adequate price signals, digital tools and smart controls". In addition to maintaining electricity reliability, the IEA finds that digitally enabled demand-response measures can reduce average household electricity bills by up to 20% by 2050.

Consistent with the IEA World Energy Outlook, the IEA Net Zero by 2050 Roadmap[16] sets targets for

- 85% of buildings to comply with zero-carbon-ready building energy codes by 2050.
- mandatory zero-carbon-ready building energy codes to be introduced for all new buildings in all regions by 2030.

Hence, to navigate this energy transition, a zero-carbon-ready building must be 'digital ready'

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[12] Waide P., Ure J., Karagianni N., Smith G. and Bordass B., (2013), "The scope for energy and CO2 savings in the EU through the use of building automation technology", https://leonardo-energy.pl/wp-content/uploads/2017/07/The-scope-for-energy-and-CO2-savings-in-the-EU-through-the-use-of-building-automation-technology.pdf

[13] US Department of Energy (2021), "A National Roadmap for Grid-Interactive Efficient Buildings", https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings

[14] Australian Renewable Energy Agency (ARENA) (2022), "Load flexibility study technical summary", https://arena.gov.au/assets/2022/02/load-flexibility-study-technical-summary.pdf

[15] IEA (2023), "World Energy Outlook 2023", https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-edf61467e070/WorldEnergyOutlook2023.pdf

[16] IEA (2021), "Net Zero by 2050: A Roadmap for the Global Energy Sector", https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

3. Barriers to Digitalisation in Buildings

Despite demonstrated cost-effectiveness, various barriers prevent widespread adoption of digital energy performance solutions. These are well documented by the IEA[17] , the Digitalisation Working Group of the Energy Efficiency Hub[18] and the US Department of Energy[13], amongst others.

The Digitalisation Working Group of the Energy Efficiency Hub[17] identified four key barriers where government could potentially intervene, being:

1. **Interoperability Barrier**: Virtually all studies on barriers to digitalisation point out the significance of interoperability issues and the need for data standards to help overcome them. Interoperability barriers arise at the *device communications level* when the communication protocols used by one manufacturer's devices are proprietary and therefore unable to talk with the devices from other manufacturers. Interfacing with older legacy products, that are no longer supported, can be particularly difficult. Interoperability barriers also arise at the *analytics (informational/semantic) level*, when contextual information (i.e. meta-data, that gives meaning to a data source) is removed from the collected data.
2. **Data Access Barrier**: Data can be exchanged locally, between devices on-premises, using various LAN technology options. However, accessibility for potential users is vastly improved by using cloud technology. At best, cloud data platforms enable data to be consolidated in one place, structured to give context, and then efficiently distributed to relevant people via remote PC and mobile devices. Unfortunately, commercial arrangements often inadvertently lead to the loss of data-sovereignty and the inability to provide third parties with access to relevant data. This stifles competition and innovation. Maintaining continuity and ongoing quality of collected data also presents a significant challenge to the reliability and usability of the data.
3. **Privacy Barrier**: Data protection and privacy legislation imposes significant obligations on organisations that collect and/or process personal data (information related to an identified or identifiable living individual). While most energy productivity applications in non-residential buildings do not require personal data, building owners will generally be reluctant to consider activities that might have hidden compliance costs or where it is difficult to quantify risks.
4. **Cybersecurity Barrier**: With the benefits of internet connection comes the risk of cyber-attack; potentially impacting the smooth operation of equipment or leading to data theft. While building services should always be operated on a separate network from enterprise systems (where more sensitive data is stored), building owners will still be reluctant to consider activities involving risk.

In addition to these primarily technical barriers, there are various other key commercial and organisational barriers. Trianni et. al. (2022)[19] conducted focus group research to further understand the barriers experienced by industry practitioners. Barriers were ranked in importance for each of four categories. The rankings are illustrated in Figure 3.1. The rankings demonstrate a tendency for industry to reframe the barriers in terms of the attractiveness of the investment or 'the business-case'

[17] International Energy Agency (2021), "Energy Efficiency 2021", https://www.iea.org/reports/energy-efficiency-2021

[18] Otte K., Stelmach T., Chandan V., and Delgado A., (2022), "Digitalisation in the Buildings Sector: A Literature Review", Energy Efficiency Hub https://energyefficiencyhub.org/wp-content/uploads/2022/09/DWGReport-1.pdf

[19] Trianni A., Bennett N., Hasan A.S.M., Katic M., Lindsay D., Cantley-Smith R., Wheatland F.T., White S., Dunstall S., Leak J., Pears A., Cheng C.-T., and Zeichner F., (2022), "Industry 4.0 for energy productivity: B2 Opportunity Assessment", RACE for 2030 Opportunity Assessment, https://www.racefor2030.com.au/opportunity-assessment-reports/

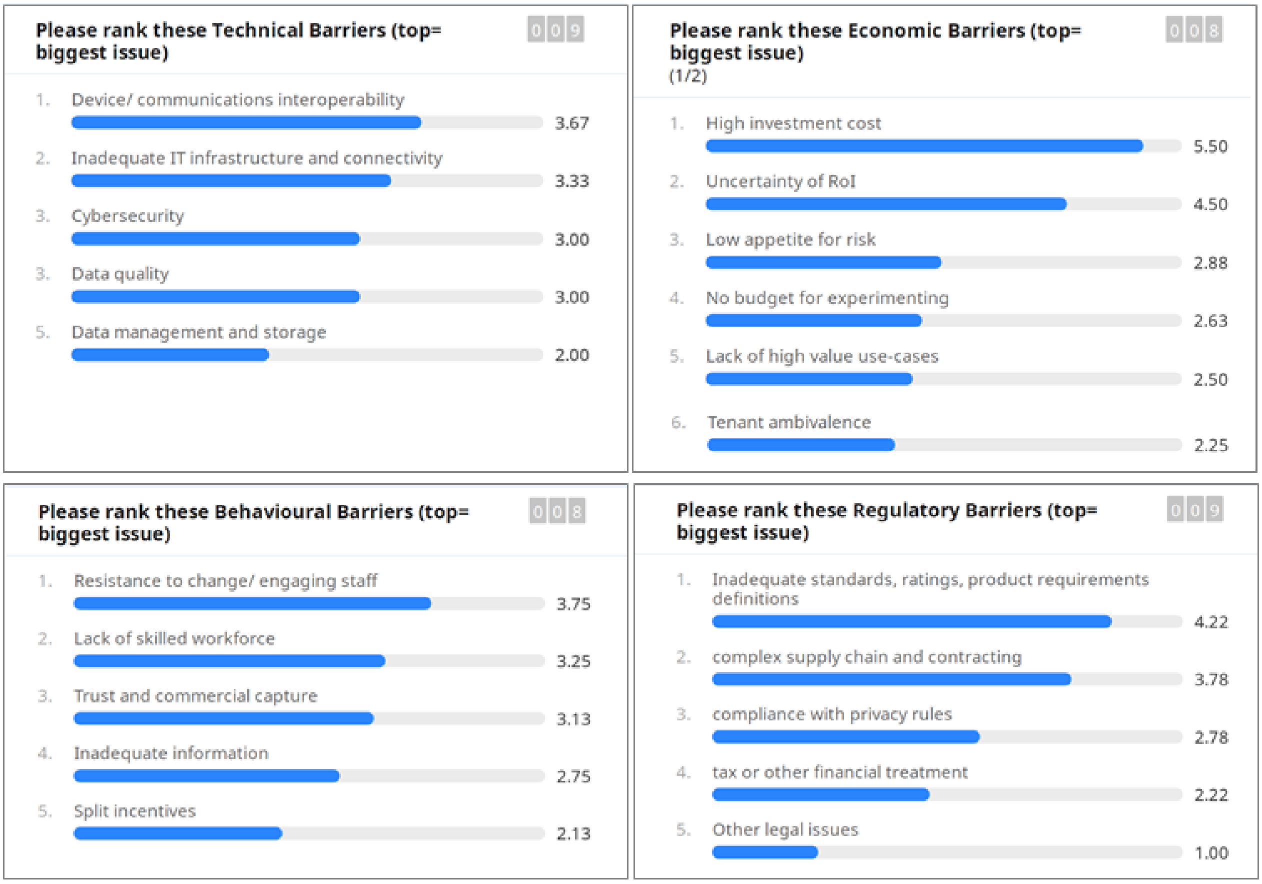


Figure 3.1: Ranking the importance of barriers to utilising digitalisation for improving energy performance (Source: Trianni et. al., 2022[18])

They found that most of the challenges with the business case could be grouped under two core (but connected) themes:

- **Uncertain Return on Investment**: Despite the proven short payback-time, industry perceives the cost of IT infrastructure and digital connectivity to be high, and the returns uncertain. This reflects the highly variable cost of implementing the technology, which can depend on existing controls hardware capability (eg legacy systems, interoperability issues, etc) and the commercial context of the investment (eg supplier work-scope and liability allocation, bundling with other upgrades, etc), amongst other things. The benefits can also vary significantly, depending on how well the building is currently performing (i.e. a poorly performing building has more scope for improvement). Upfront investment is needed to quantify both the costs and the benefits, without any a-priori guarantee that the business case will 'stack-up'. This uncertainty leads to a reluctance to even start the process of exploring the viability of digital energy productivity opportunities.
- **Complexity and Trust**: Industry perceives digitalisation as a complex product to purchase and implement. Various software and hardware 'layers' make up the 'product stack'. Furthermore, implementing the technology can often require changes in work-force practices (to take advantage of the insights obtained from the technology). Industry expressed a desire for more guidance on product requirements, and for common terminology that can help to simplify purchasing, avoid potential pitfalls, and enhance competition.

A "*key theme is the need for control solutions that work better with people and the way they use and operate buildings. These solutions are not simply hardware-based: in many cases, especially for the more complex non-residential buildings, the whole manner in which controls are procured, designed and specified, installed, commissioned and managed within building services is in need of improvement, with the right incentives to deliver appropriate technical and organisational capacities, resulting in better facilities management for energy efficiency. The effective deployment of controls will thus be as much an organisational challenge as a technical challenge*"[12].

In summarising the situation, Trianni et. al. (2022)[19] identified that the task of implementing digital energy performance solutions can be divided into two steps – (1) establishing IT infrastructure and connectivity in the building and (2) deploying relevant data analytics applications. It is apparent that most of the barriers to adoption relate to the first step.

Unfortunately, solution providers with innovative technology for step 2, generally need to combine this with a data acquisition platform (as a bundled service) to address step 1. This is a significant barrier to market entry and can lead to multiple platforms being installed in a building (each for its own application), with the resulting potential for cost duplication and data management conflicts.

Separating out the delivery of IT infrastructure and connectivity (step 1), from the delivery of desired data analytics application services (step 2), as illustrated in Figure 3.2, would be an important step forward for the industry – allowing (i) a more agile approach to application deployment, (ii) more sophisticated data management practices, (iii) greater competition (iv) more innovation and (v) a more diverse range of use cases than is currently encountered in practice.

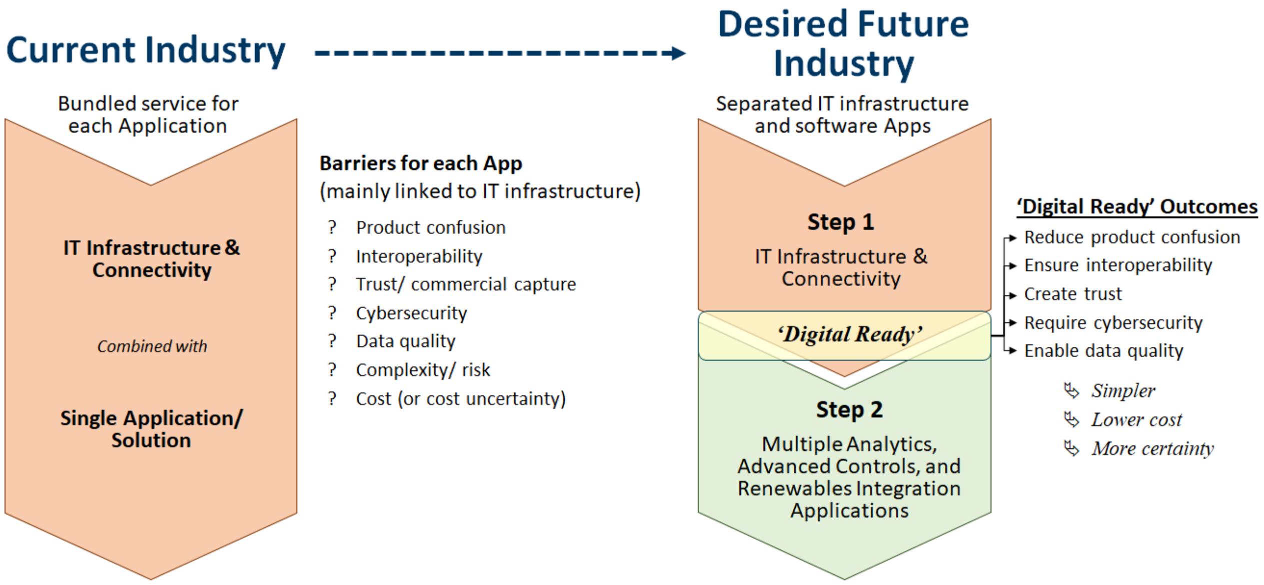


Figure 3.2: The journey involved in implementing digital energy performance solutions (Adapted from Trianni et. al., 2022[18])

A way to achieve this separation could be to enshrine the concept of achieving 'digital ready' as a distinct intermediate objective associated with completing step 1. 'Digital readiness' would involve achieving certain minimum standard levels of connectivity and data management capability, sufficient to enable key energy services (particularly demand flexibility).

Clear digital-ready guidelines, enshrined in relevant scheme requirements, would greatly simplify and derisk investment in digitalisation. However, noting the need to avoid technology obsolescence in a rapidly developing industry, articulation of 'digital ready' compliance should be outcomes-based. It should not be overly prescriptive or lock in a single dominant technology over others.

4. Review of Strategies for Accelerating Adoption of Digital Energy Productivity Solutions

Various roadmaps have proposed solutions for addressing barriers to digitalisation and digital energy productivity solutions. These roadmaps aim both to unlock energy savings and to enable buildings to participate, as flexible distributed energy resources, in the clean energy transition. Relevant recommendations, from a sample of these roadmaps, are summarised in Table 4.1.

Table 4.1: Summary of existing roadmap findings

	IEA "Energy Efficiency 2021"[17]	**EE Hub "Roadmap on Digitalisation for Energy Efficiency in Buildings"**[18]	**IE 4E TCP "Interoperability"**[20]	**US DoE "Grid Interactive Efficient Buildings Roadmap"**[13]	**Green Building Council of Australia "From Net Zero to Zero"**[21]
Roadmap Focus / **Barrier**	Advocate for policies that enable innovative energy efficiency solutions and drive system-level benefits for the clean energy transition	Address barriers to implementing digitalisation policies and programs that drive energy efficiency in buildings	Understand the impact of IoT device level interoperability on efficiency and demand Flexibility.	Ensure a robust portfolio of flexible and cost-effective resources to navigate the clean energy transition.	Develop a set of principles and actions that align economic and environmental outcomes for building owners
Interoperability	✓ Remove interoperability barriers	✓ Develop policies that utilise interoperability standards. Require clear communications protocols between consumers and external markets	✓ Minimum interoperability requirements for flexible appliances (thermostats, pool pumps, heaters etc) Informatory labelling for interoperability capability. Incentivise interoperable devices. Develop/adopt standards.	✓ Accelerate adoption of existing open standards. Require system and device level reporting capabilities. Explore methods to rate or score interoperability of devices and buildings	

	IEA "Energy Efficiency 2021"[17]	EE Hub "Roadmap on Digitalisation for Energy Efficiency in Buildings"[18]	IE 4E TCP "Interoperability"[20]	US DoE "Grid Interactive Efficient Buildings Roadmap"[13]	Green Building Council of Australia "From Net Zero to Zero"[21]
Data Access	✓ Provide (i) supportive institutional arrangements and (ii) access to data platform infrastructure	✓ Equip consumers with actionable energy use information. Provide infrastructure for sharing meter data and energy system data. Incentivise improved data availability, quality, and analysis		✓ Develop standard metrics and methods for data collection, data analysis, and measurement and verification (M&V) of demand flexibility. Enhance existing building performance tools to include demand flexibility and GHG emissions information. Integrate EE data and communications standards requirements with grid-interactive standards	✓ Introduce requirement for grid-interactive functionality in buildings as part of building construction codes. Develop a digital strategy for the integration of buildings as distributed energy resource (DER) nodes in the electricity system through better use of data flows and appropriate software.
Cybersecurity and Privacy	✓ Ensure adequate protection from cyber security and data privacy risks through frameworks and guidelines	✓ Create a cybersecurity certification process. Enact data handling regulations that include data protection, data security, and data sovereignty		✓ Enable users to provide control permissions to trusted third-party applications and services while ensuring cybersecure controls and communications	
Return on Investment	✓ Ensure energy markets value the services provided by digital energy efficiency. Utilise digitalisation to streamline measurement and verification of energy efficiency and flexibility			✓ Provide incentive mechanisms to encourage investment in demand side programs. Consider customer adoption of EE and demand flexibility as part of tariff design objectives. Package demand flexibility with other consumer offerings.	✓ Explore how incentives or rating programs can be used to incentivise grid-interactive solutions in the built environment. Introduce obligations for retailers to engage with and support customers on active efficiency measures.

	IEA "Energy Efficiency 2021"[17]	EE Hub "Roadmap on Digitalisation for Energy Efficiency in Buildings"[18]	IE 4E TCP "Interoperability"[20]	US DoE "Grid Interactive Efficient Buildings Roadmap"[13]	Green Building Council of Australia "From Net Zero to Zero"[21]
				Identify opportunities for improving demand flexibility access to wholesale markets. Increase consideration of non-wires solutions Incentivise demand flexibility through energy performance contracting	Explore how to improve current carbon certificate schemes to add time-of-use (and ideally real time) carbon information.
Complexity and Trust	✓ Increase stakeholder awareness and trust in digital technology and infrastructure			✓ Research and socialize data on demand flexibility programs and operation experiences: including data on the hard and soft costs of advanced sensing and control technologies. Design and market demand flexibility programs with a focus on consumer preferences. Provide technical assistance. Government to participate in DR and EE programs and markets with their own buildings.	✓ Provide clear communication, and education to promote opportunities for testing and delivering grid-interactive efficient buildings at scale.
Digital skills	✓ Provide training programmes that include digital skills.			✓ Establish skills standards and credentials relevant to advanced building technologies and operations. Broaden relevant workforce development programs. Establish building training and assessment centers.	

	IEA “Energy Efficiency 2021”[17]	EE Hub “Roadmap on Digitalisation for Energy Efficiency in Buildings”[18]	IE 4E TCP “Interoperability”[20]	US DoE “Grid Interactive Efficient Buildings Roadmap”[13]	Green Building Council of Australia “From Net Zero to Zero”[21]
Technology and business model innovation	✓ Provide finance for pilots and demonstration projects. Provide funding for start-ups, and remove barriers for new market entrants		✓ Provide an open platform environment to support private sector IoT technology innovation.	✓ Support development and field testing of integrated whole-building control and grid service delivery. Develop and demonstrate integrated low-carbon building retrofit packages. Encourage and publicize innovative demand flexibility programs and pilots.	✓ Pilot digitalisation technologies and establish a program to implement digitalisation technology and demand flexibility in government buildings. Undertake research to understand further opportunities for grid-interactive efficient buildings

These roadmaps converge on the need for government to play a coordinating role, to support adoption of digitalisation in buildings. They particularly identify the need to focus on activating digitally-enabled demand flexibility resources. Commonly cited areas for possible policy development include:

- Provide guidance and certification tools, as a means of simplifying the purchase of digital infrastructure and to help manage risk.
- Set ‘digital-ready’ expectations through mandatory data collection and reporting requirements, and by including digital infrastructure requirements in construction codes for new buildings,
- Enable improved access to energy markets,
- Incentivise both innovators and pilot demonstrations by early adopters, and
- Provide support for industry capability and capacity building.

[20] International Energy Agency (2022), “Interoperability”, https://www.iea-4e.org/wp-content/uploads/2022/10/EDNA-Studies-Interoperability-Final.pdf

[21] Green Building Council of Australia (2023), “From net zero to zero: A discussion paper on grid-interactive efficient buildings”, https://gbca-web.s3.amazonaws.com/media/documents/grid-interactive-efficient-buildings-discussion-paper_Q0FoGV8.pdf

5. Recommendations for Government Leadership

In addition to reviewing literature relating to (i) barriers to adoption of digitalisation and (ii) possible policy solutions for accelerating adoption of digitalisation in buildings, the IEA Annex81 team interviewed leading practitioners to further understand industry pain points and aspirations.

Sixteen interviews were conducted, representing industry perspectives across Europe, North America, and Asia-Pacific. Interviewed stakeholders included Software-as-a-Service (SaaS) platform providers, design consultants, building owners, hardware suppliers and an energy retailer. The questions asked in the interviews are detailed in Appendix A.

Results of these interviews are included in this section, including quotes that incapsulate stakeholder sentiment. Striking, was the fundamental importance attributed to data quality and data management. Improving data quality and data management practices was seen as one of the keys to fostering the spread of smart building applications.

Energy Users Want to Take Advantage of Digitalisation

The IEA Annex 81 industry interviews generally found that there is a strong desire to use digitalisation technology to achieve sustainability goals, particularly where it is cost-effective and simple to implement. These motivations include a desire for improved building ratings, to comply with the corporate ESG policies of stakeholders (including tenants) and compliance responsibilities.

Similar findings were seen in the RACE for 2030 Cooperative Research Centre 'Opportunity Assessment on Flexible Demand' in Australia[22]. They found that successful engagement with energy users will follow when flexible demand is perceived as (i) easy and trustworthy (ii) relevant and (iii) financially visible and viable.

Policy Actions

Consolidating all the relevant information, and responsing to the above sentiment of energy users, the following policy recomendations were developed for accelerating growth in the industry. These policy actions are categorised under eight themes.

Theme 1: Provide Information – to reduce complexity and information asymmetry for buyers.

Theme 2: Establish 'digital ready' certification – to standardise solutions and recognise achievement.

Theme 3: Lead by example – to provide a cohort of early adopters that catalyse the market.

Theme 4: Support researchers and innovators – to catalyse a wider range of product offerings, increase industry maturity, and provide independent validation of the benefits of digitalisation.

Theme 5: Incentivise EMIS technology – to improve the return on investment from the technology.

Theme 6: Reduce data sharing risk – to improve certainty and manage possible compliance issues.

Theme 7: Build workforce skills and capacity – to be able to deliver the services at scale.

Theme 8: Integrate buildings into the electricity system – to prioritise the clean energy transition.

[22] Brinsmead T.S., White S., Bransden C., Stanley C., Hasan K., Alexander D., Sprague M., Northey J., Walgenwitz G., Nagrath K., Briggs C., Leak J., Harkins-Small L., Murray-Leach R., Jennings K., 2021, "Flexible Demand and Demand Control" Opportunity Assessment, https://issuu.com/racefor2030/docs/race_b4_oa_final_report

These Themes and the corresponding recommended policy actions are described in the following subsections, along with examples of where relevant policies are already being deployed. The recommendations are summarised in Figure 5.2 as a 'Roadmap on a page', using the policy package format of the IEA[23].

Together, these recommendations provide a comprehensive roadmap, targeted to create the right conditions for digitalisation to thrive, consistent with international COP28 commitments to double the global average annual rate of energy efficiency improvements.

A ranking poll (Figure 5.1) was conducted during an IEA Annex81 webinar, as a way of validating the priority of these policies.

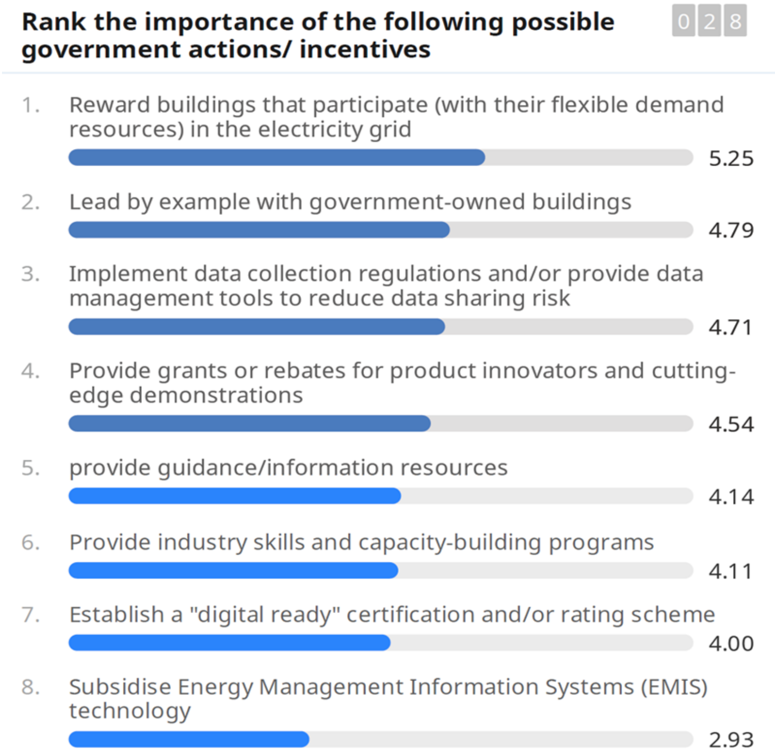


Figure 5.1: A prioritisation survey of the recommended policy themes

While the 'snap poll' may not be fully representative, or deeply thought through, it shows a relatively even allocation of priorities, with the possible exception of 'providing subsidies'. Perhaps the low preference for subsidies supports the understanding that the technology is already cost-effective (under the right conditions).

[23] IEA, 2023 "Energy Efficiency Policy Toolkit 2023", https://iea.blob.core.windows.net/assets/8b8c2e20-6581-4a6e-bdab-230afa17694d/EnergyEfficiencyPolicyToolkit2023FromSonderborgtoVersailles.pdf

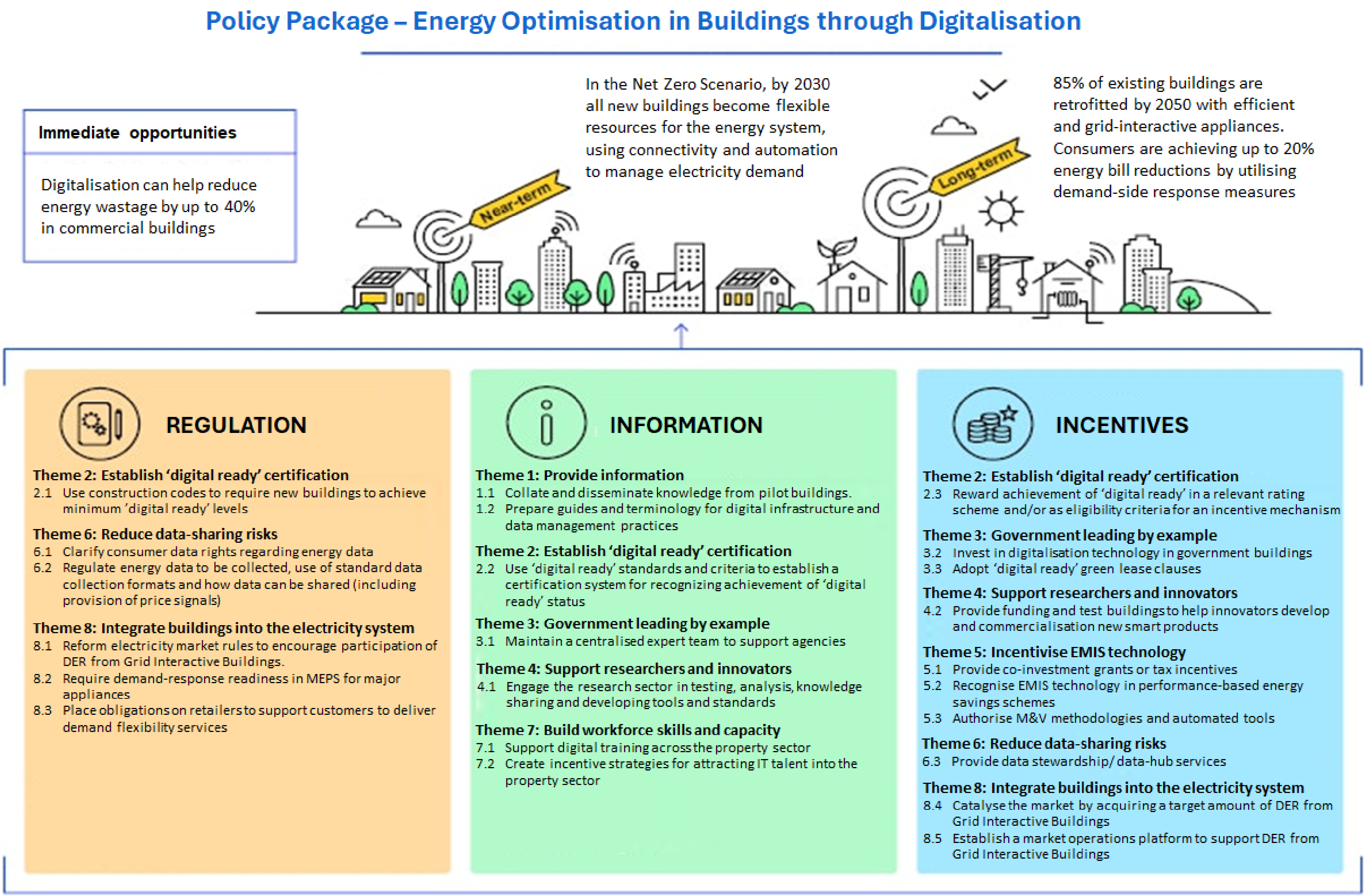


Figure 5.2: Policy Package for Energy Optimisation in Buildings through Digitalisation (format adopted from IEA[23])

5.1 Theme 1: Provide information

ISSUE	SOLUTION	NYSERDA's RTEM Program
Digitalisation is an emerging class of technologies for the property industry. Research shows that industry has relatively low awareness of the opportunities that come from digitalisation and has a poor understanding of how to implement digitalisation projects. As a result, digitalisation is seen as a complex technology, with uncertain costs and benefits. This uncertainty makes it difficult to mount the business case for consumer investment in the technology.	Government should help to create and disseminate representative and authoritative information on digitalisation technology, including advice on how the technology can be effectively implemented. This information should be particularly targeted at building owner staff who are involved in technical and purchasing roles. It should aim to de-risk investment. Actions could include: **1.1 Collate and disseminate knowledge from pilot buildings**: This could be achieved by financially supporting product/service pilots and collating knowledge as implementation case studies for dissemination. Best practices and lessons learned would be shared through easily accessible web portal. **1.2 Prepare guides and terminology for digital infrastructure and data management practices**: This could be achieved by facilitating technical working groups to prepare guidelines, technical advice and reference architectures for digital infrastructure and data management practices, suitable for different audiences. This would include preparing 'digital enablement specification' documents that could be used for tendering smart building solutions.	The New York State Energy Research and Development Authority (NYSERDA) 'Real Time Energy Management' (RTEM) Program was initiated in 2016, with the aim of creating a large portfolio of digitalisation projects, sufficient to provide industry with unbiased information on technology performance and availability. The RTEM Program provides a cost-share subsidy on systems and is delivered through a panel of 'RTEM Qualified Vendors'. The technology has been implemented in over 1,200 buildings covering ~27.5million m^2 of building floor area. The RTEM Program has helped to create a common understanding and trusted vendor list to simplify purchasing requirements for building owners. The RTEM Program has also de-risked the technology so that electricity utilities can consider running demand management programs that utilise the technology. A more detailed account of the RTEM program is provided in Appendix B.

Theme 1: Provide Information

"Now for customers looking for an ESG outcome; they are quite confused as to where all the pieces need to come together. It just feels like every discussion we have, we're educating customers"
SaaS Platform Provider

"industry should be encouraged to share best practices"
Hardware Supplier

"Typically, [information] is more accessible for portfolios, but not all buildings are part of a larger portfolio. So there's a lack of knowledge."
Consultant

"the other key challenge actually, is that there's so much information out there. But, it's kind of there's no clarity. So if I ask a building owner "have the they come across smart building controls?", they go, "Oh yeah, we've got smart building controls""
Consultant

"The obvious issue with implementation is that nobody knows what it'll do to their building ... there's lots of different players in that space with different technologies. So how do you evaluate them?"
Consultant

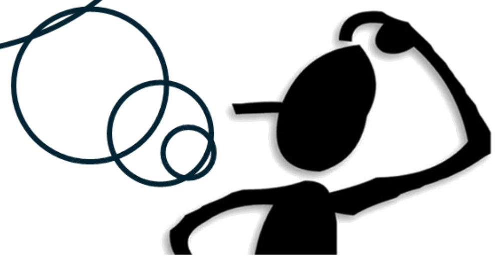
"You can do that on a portfolio level, and you get a lot of efficiencies, and you got a lot more ability for the client to direct their multiple vendors according to a single strategy"
SaaS Platform Provider

"There's definitely an opportunity for the government to write a dummy's guide on smart control systems."
Consultant

"And then there's also a lack of clear case studies. Most of the case studies that are there, it's hard to define what was just fixing up the building in the first place."
Consultant

"So if you go and ask a customer if they've got analytics, they'll say, yeah, I've got analytics, I'm all good. They've got no idea what they've got. They've got very little idea of what it's doing and they've got even less idea of the outcomes that it's providing, because there's no way of benchmarking"
SaaS Platform Provider

"If we have a process or place where people can go and get better standardised, almost guaranteed, neutral information... Educate people, so there's less risk"
Consultant



5.2 Theme 2: Establish ‘digital ready’ certification

ISSUE

The term ‘digitalisation’ covers a variety of applications (use cases). These applications are deployed on top of a digital infrastructure stack that is generally integrated from various software and hardware components - often from different vendors. Different suppliers can use different marketing language to describe the same product/ service.

Hidden costs may also be incurred when devices can’t talk with each other due to proprietary communications protocols. Furthermore, parts of the property industry are relatively unsophisticated with respect to data governance. All these factors make digitalisation a complex product to purchase and implement.

Industry has expressed a desire for greater standardisation and guidance on product requirements to simplify purchasing, avoid potential pitfalls and enhance competition.

SOLUTION

Government should recognize, and give authority to, relevant guidelines and supporting tools that address interoperability barriers, and identify standard levels of connectivity and data management capability, sufficient to enable key energy services (particularly demand flexibility). This could include:

2.1 Use construction codes to require new buildings to achieve minimum ’digital ready’ levels.

2.2 Use ‘digital ready’ standards and criteria to establish a certification system for recognizing achievement of ‘digital ready’ status. This could be incorporated into a renovation ‘digital passport’.

2.3 Reward achievement of ‘digital ready’ in a relevant rating scheme and/or as eligibility criteria for an incentive mechanism.

Recognising buildings that can prove they have achieved requisite digital-ready attributes, through an independent scheme, would help to

- Simplify purchasing with a common language for (i) buyers of services to describe their desired outcome and for (ii) providers to pitch their services.
- Support market separation of data management capability from building services applications, helping to facilitate innovation and competition.

Certification could utilise a stand-alone quantitative rating (e.g. SRI) or be a qualitative component in an existing mechanism (e.g. green lease clauses). Many other certification approaches are also available.

Digital Ready Green-Lease Clauses

The Australian Affordable Heating and Cooling Innovation Hub (***i***-Hub) program distilled the learnings from various digitalisation pilot studies into suggested ‘digital ready’ green-lease clauses. Two clauses (with a schedule of acceptance criteria) provide high level requirements for:

(1) *Digital ready infrastructure*: ensuring the building has the basic digital infrastructure required to enable the building to adopt and utilise smart building technologies that support the intent of a green lease; and

(2) *Basic digital service functionality*: a minimum suite of currently available smart building applications that improve building efficiency and operation in line with the intent of a green lease.

Smart Readiness Indicator (SRI)

Under the Energy Performance of Buildings Directive (EPBD) 2018/844/EU, the European Commission introduced an optional scheme for rating ‘smart readiness’ in buildings. The SRI indicator aims to measure the capability of a building to use information/communication technologies and electronic systems to adapt the operation of buildings to the needs of occupants and the grid, and to improve the energy efficiency and overall performance of buildings. The SRI scores the perceived impact across each of seven impact criteria from ‘services’ provided in nine domains. Weighting factors can be set to each domain and each impact criteria to arrive at a score expressed as a percentage of a perfect building. While the SRI has significant shortcomings, it offers a first attempt at addressing the identified barrier.

Theme 2: Establish ‘digital ready’ certification

“when you talk about analytics, it's all about data management, right? - Data quality, data management.” SaaS Platform Provider

“I mean, it's not a secret that in anything data driven 80% of the effort is in the data part” SaaS Platform Provider

“Standards on data modelling/ acquisition would be very helpful” Controls Contractor

“I think for me it all comes back down to the data structures. How fast it can go will be related to how interoperable and structured in standard are the different assets”. SaaS Platform Provider

“the next challenge is ultimately standardisation” SaaS Platform Provider

“A digital ready audit for the customer. There's no point putting analytics on the table if a customer's not digitally ready.” SaaS Platform Provider

“We have to convince them with lot of certifications. We have to spend so much of our budget qualifying for the cyber security so that our product is qualified” Hardware Supplier

“How do we get consistent data and how consistent does the data need to be. At the moment, everyone's got data and different bits and pieces [of data but] it's not associated with a clear taxonomy or labelling piece” Consultant

“[Facilities Management is] like going into a library and someone's got in there before you and messed it all up, and they've swapped all the books around and you spend a day trying to find something which should be categorized properly” Facilities Manager

“regulatory measures might be like specifically implementing smart metering properly and that gets the infrastructure in place to collect the data appropriately” Consultant

“The ability to get like that, bronze, silver and gold kind of data cost effectively is critical and it might be about how that again is in their specification clauses - examples that you can kind of write out so it's easy to embed them in your future contracts.” Consultant

“What will it do to my building and how do I evaluate that? So it's kind of the quality assurance of AI piece that needs to be understood.” Consultant

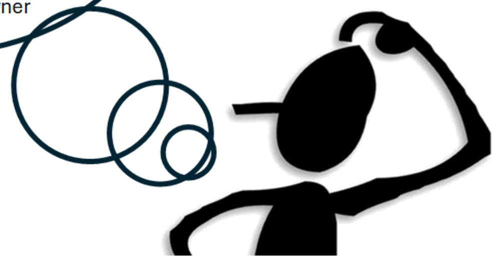
“A clearly defined cloud infrastructure that is NIST compliant helps the owner or operator to overcome their fears” Hardware Supplier

“It's better to focus on what the minimum pieces are for the minimum viable product?” ... “how do we transfer that digital information across at each stage and what should actually be required in that”. Consultant

“If we had a plaque that says «you are digitized», at a standard level, silver level, etc... If something like this exists, then I can come into that building and provide my services very, very, very quickly.” SaaS Platform Provider

“Buildings need to have at least certain level of digital maturity (accessibility for example)” Building Owner

“I'm always against anything that's trying to standardize ... because it usually has the attitude that it's one answer, and that answer fits everything... we know that's not the case”. Consultant



5.3 Theme 3: Lead by example

ISSUE	SOLUTION	Hong Kong Building Semantic Artificial Intelligence Project
The property sector is known to be a conservative industry. Unsurprisingly, it has been relatively slow to unlock the benefits of digitalisation technologies. Government is a major user of commercial office space and the owner of public buildings (hospitals, education facilities etc). This gives government significant purchasing power to drive market transformation. Equally, it would be disingenuous to ask industry to implement energy saving digitalisation technology if it were not doing so itself. Importantly, government property managers face similar barriers (trust, digital capability etc) to those of private industry. Hence, knowledge can be shared across the relevant sub-sectors.	Government should commit to a trajectory of digitalisation upgrades for all government owned and leased properties, over time, with the aim of enabling smart energy efficient controls and grid-integrated demand flexibility. Learning lessons from previous government energy efficiency procurement policies[24], actions for government procurement teams could include: **3.1 Maintain a centralised expert team to support agencies**: Such a team would set clear targets, develop sustainable procurement practices, provide training and outreach, and monitor achievements. The team would ensure lessons learnt are transferred across agency boundaries. **3.2 Invest in digitalisation technology in government buildings:** With appropriate purchasing policies, end of life equipment can be replaced with digitally enabled equipment and systems as standard practice. Agency finance mechanisms need to be clear and accessible. **3.3 Adopt 'digital ready' green lease clauses:** Utilise the purchasing power of government to engage and drive change across a wide range of industry stakeholders.	The Hong Kong Electrical and Mechanical Services Department (EMSD) is responsible for >8,000 government buildings. It plays a crucial role in implementing Hong Kong's smart city blueprint. It introduced a platform to name, classify and represent building systems in a consistent and standardized format. By aligning semantic representations, the solution facilitates data-driven optimisation of building operations and maintenance, using AI. Domain experts can now extract and integrate asset data programmatically and automate data analysis across buildings. It has reduced the time for developing customised AI applications for each building by 70%, saving energy and establishing a solid foundation for digitalisation of urban management in Hong Kong. **Government Leadership on Green Leases** Since 2006, Commonwealth and State governments across Australia have been early adopters of green leases. The newly released APS Net Zero 2030 roadmap has further increased ambition, requiring leases on office spaces >1000m^2 of net lettable area, to maintain a minimum NABERS rating of 5.5 stars (out of 6). This leadership has significantly contributed to a 60% reduction in carbon intensity across the commercial office sector since 2011. **GSA Green Proving Ground** The US General Services Administration's (GSA) Green Proving Ground program leverages GSA's real estate portfolio to evaluate innovative building technologies. The program aims to drive down operating costs in federal buildings and help lead market transformation. The GPG program has 32 ongoing technology evaluations in buildings across the country. 53 results have been published, to date, including a significant number of digital technologies for energy management

[24] Zou P.X.W., Alam M., Phung V.M., Wagle D., Stewart R., Bertone E., Sahin O. and Buntine C., 2017, "Achieving energy efficiency in government buildings through mandatory policy and program enforcement", Frontiers of Engineering Management, 4(1): 92–103, DOI 10.15302/J-FEM-2017101

Theme 3: Lead by example

"Let's start by leading by example. So government probably ought to be implementing these items and publicising the outcomes."

Consultant

"Government buildings can mandate: if you are going to be my controls company, you have to have this set up, because our mandate is now to make data accessible to the public, because these are public buildings, and the energy used is funded by taxpayers' money, so people should know how much the government is spending on energy."

SaaS Platform Provider

"it might be as simple as … government saying what government buildings in five years time will have implemented. Kind of like a target pathway … giving the road map for government buildings"

Consultant

"if you're just doing it on an [individual building] level and not comparing, there's no real way to say, "Oh, this site is doing well or this site's doing poorly". A government database would be so useful because you could then just bring those benchmarks in and come up with a dashboard that goes this is your portfolio versus the government benchmark portfolio".

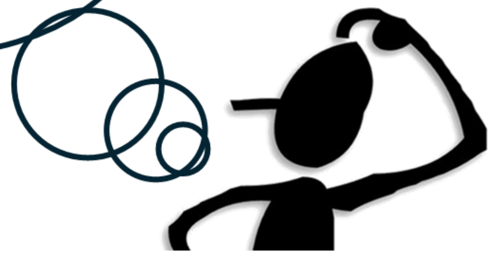
SaaS Platform Provider

"portfolio owners have potential. They say: "Here's one building. Test it out". If they like it, then they say "Here's 40 [more buildings]"

SaaS Platform Provider

"Sharing of government support initiatives in each country"

Energy Retailer



5.4 Theme 4: Support researchers and innovators

ISSUE

Digitalisation is an emerging class of technologies for the property industry. It has unique attributes that have the potential to transform the energy efficiency market through (i) low-cost self-service deployment of software solutions and (ii) innovative business models that can leverage multiple value streams and improve the occupant experience for building-users.

Unfortunately, the property sector is risk averse and innovators have struggled to find pilot sites and finance for scaling prospective technologies and business models.

In some cases, innovators and researchers have lacked access to data and sites due to the monopolistic behaviour of large incumbent product suppliers.

Access to data is critical to enable researchers to provide policy advice, technology transfer assistance, workforce training and, more broadly, to future-proof the industry.

SOLUTION

Governments should leverage their national research institutions and research-funding bodies to deliver an agenda for analysis, innovation and commercialisation in the field of '*Digitalisation in the Built Environment'*.

Actions could include:

4.1 Engage the research sector in testing, analysis, knowledge sharing and developing tools and standards: For example, the sector should be tasked with further developing frameworks, standards and tools for overcoming barriers to data-sharing. Independent analysis will help to boost trust in digitalisation technology.

4.2 Provide funding and test buildings to help innovators develop and commercialisation new smart products: In addition to product development, support is required for early-stage demonstrations and pilots. Support could be in the form of access to government buildings as 'living laboratories'. This would also help support case study knowledge sharing.

Australian Renewable Energy Agency (ARENA)

ARENA supports the clean energy transition by accelerating the pace of pre-commercial innovation. Since 2012, ARENA has supported 663 projects with $2.25 billion in grant funding. In 2022, ARENA's mandate was expanded to support energy efficiency and electrification technologies. ARENA has identified demand flexibility as a priority area, and has committed $180 million to demonstrate enabling technologies and approaches.

ARENA plays a facilitation role, connecting investment, knowledge and people to drive innovation. ARENA convened the Distributed Energy Integration Program (DEIP), a forum for exchanging information on DER issues. It aims to identify knowledge gaps and priorities, and accelerate reforms in the interest of customers.

Portland General Electric Smart Grid Testbed

PGE's Smart Grid Testbed is exploring topics such as customer interest in new program offerings, and ways to leverage automation for customer convenience. Innovative program offerings include peak time rebates, EV smart charging, behind-the-meter battery storage, and smart water heating. A particular focus of the pilot is to determine the methods that are most effective for engaging various sub-segments of the population. The activities of the pilot are intended to provide "valuable insight into customer interactions with the programs and opportunities to demonstrate the benefits of adopting smart grid technologies at an unprecedented scale."

Theme 4: Support researchers and innovators

"Instead of focusing on developing advanced AI algorithms, more attention should be spent on the amount of manual work that is needed to get the algorithms working"
Building Owner

"Vendors are developing the same thing in parallel. If they could develop a library to convert protocols, it could be a contribution"
Building Owner

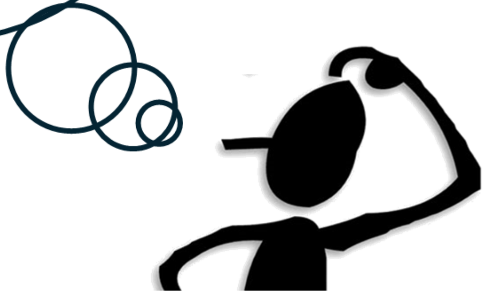
"They should support landmark projects…we don't need a lot of money"
Facilities Manager

"There should be more cooperation between implementors and researchers"
Controls Contractor

"Government-funded research could involve collaboration with students that have to publish something"
SaaS Platform Provider

"government should support them with money, and resources to research and build the test cases prototypes"
Facilities Manager

"academia could be bolder, fundamental, and take risks where the fallout should be the smallest"
SaaS Platform Provider



5.5 Theme 5: Incentivise EMIS technology

ISSUE

Digitalisation (EMIS technology) is generally considered to be cost effective. However, there are considerable differences in both the implementation costs, and the savings achieved - across different sites, depending on circumstances. Unfortunately, there is a lack of unbiased information on (i) technology performance, availability and cost, and (ii) circumstances in which EMIS technology can be deployed with reduced cost and risk.

Furthermore, in this early stage of technology adoption, hidden 'soft costs' are associated with customer education/acquisition and site evaluation. This has limited adoption to larger, more sophisticated building owners who can understand, evaluate and implement the technology.

The national and global benefits of this emerging technology could be much greater if adoption was spread more broadly and fully across the property sector

SOLUTION

Government should accelerate technology adoption by providing incentives to building owners that voluntarily invest in digitalisation, as a means of improving the energy performance of their buildings. Actions could include:

5.1 Provide co-investment grants or tax incentives: In the first instance, it may be appropriate to provide co-investment grants or tax incentives to reduce upfront costs of flexibility markets. But ultimately, incentives should transition to performance-based mechanisms (eg payment per T_{CO2} abated or other desirable energy performance metric).

5.2 Recognise EMIS technology in performance-based energy savings schemes: Some possible performance-based policy instruments include (i) Energy Efficiency Certificate Schemes, (ii) Energy Performance Contracting and (iii) Demand Side Management Programs.

5.3 Authorise M&V methodologies and automated tools: Policy instruments often require comparison between pre (baseline) and post-investment energy consumption, to determine the savings (according to the desired metric being incentivised). Government should implement authorised M&V methodologies that parties can use to track their performance and calculate their incentive.

Separate to direct financial incentives, government should recognise buildings, that have achieved digital ready status, in a new or in an existing voluntary rating scheme (see Theme 2). This could provide a significant reputational incentive, with potential to increase asset value. Government should adopt the rating for its own buildings.

NYSERDA's RTEM Program

The New York State Energy Research and Development Authority (NYSERDA) 'Real Time Energy Management' (RTEM) Program is an example of a targeted grant program utilising a 'vendor qualification' process to help address early-stage barriers to market adoption. It is summarised above and, in more detail, in Appendix B.

Victorian Energy Upgrade Scheme

The Victorian Energy Upgrades (VEU) Program enables 'Accredited Persons' (APs) to generate tradeable certificates associated with investments in eligible energy saving 'Activities'. A market is created by requiring energy retailers to acquire and surrender certificates. The Scheme specifies more than 40 eligible Activities, including an Activity for in-home displays (Advanced Metering Infrastructure in residential premises). The VEU Program is investigating the potential to expand on this Activity with a separate Energy Management Information Service (EMIS) Activity for non-residential applications. It is also investigating ways to use digitalisation technology to automate IPMVP option B and C processes to cost-effectively enable performance-based certificate generation under the proposed EMIS Activity.

Theme 5: Incentivise EMIS technology

"I mean the one big blocker in deployment, is ensuring that there's a budget for deployment, and understanding what the deployment needs to be."

SaaS Platform Provider

"The value proposition needs to be clearer for every stakeholder"

Building Owner

"Subsidies are not helpful because they drive inflation"

Hardware Supplier

"Mandating energy efficiency performance would push adoption of more advanced data driven solution"

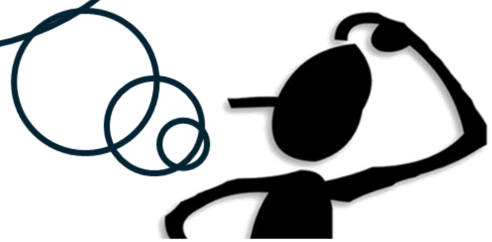
Controls Contractor

"Maybe the stick will be "you have to report your carbon". The carrot would be "we will make it so it is standard and nice", and incentives will be provided to companies that have this protocol implemented."

SaaS Platform Provider

"When we have incentives for the owners and the corporations to implement certain features or certain products on their site, incentives play a major role"

Hardware Supplier



5.6 Theme 6: Reduce data sharing risk

ISSUE

Commercial, technical and legal considerations relating to data access and privacy remain significant barriers for industry.

Ownership of data can be confusing. It's generally assumed that data should belong to the building owner. But this may not be the case, and (irrespective of legal rights) data has a practical tendency to find its way to the service provider – ending up inaccessible to the building owner. Indeed, vendors can use control of data as a strategy for blocking competition.

Privacy legislation imposes significant obligations on organisations that collect and/or process personal data. While generally less likely to be an issue in non-residential buildings, building owners will still be reluctant to consider activities that might have hidden compliance costs or where it is difficult to quantify risks.

Commercial service providers also face risk if using third-party data, of unknown quality, to deliver services. In the absence of any validation, data could be tampered with, mislabelled or in other ways flawed, leading to erroneous results. Conversely, data providers may fear legal action if held responsible for the performance of third-party software applications that use their data.

SOLUTION

Government should consider areas where it can provide tools and provide legal clarification to reduce risks associated with data sharing.

Actions could include:

6.1 Clarify consumer data rights regarding energy data: Providing more explicit clarification on what energy related data is and isn't private (including consideration of consumer data rights/ consumer data standards), would reduce risk for industry.

6.2 Regulate energy data to be collected, use of standard data collection formats and how data can be shared (including provision of price signals): Regulating for data collection would ensure the right data is collected, interoperability issues are managed, and a level playing field is created for energy services innovation.

6.3 Provide data stewardship/ data-hub services: The EU has identified the need for 'Data Spaces', being common data infrastructures and governance frameworks, that facilitate data pooling, access and sharing. Data Spaces overcome barriers to innovation and create new value from access to data. Energy is one of the EU's priority data space domains.

Green Button

Since 2012, >50 utilities have signed on to the Green Button initiative, providing >60 million homes and businesses with secure access to their own energy information in a standard consumer-friendly and computer-friendly format. It can be used by consumers to choose their preferred retailer and to access energy saving advice through third-party companies and Apps.

Green Button is based on the ESPI data standard released by the North American Energy Standards Board. Green Button 'Download My Data' and 'Connect My Data' tools enable customers to (i) download their energy consumption data to their own computer, (ii) upload their data to a 3rd party application, and (iii) automate secure transfer of their data to authorized 3rd parties, based on affirmative (opt-in) customer consent and control.

Center Denmark

Center Denmark is a non-profit independent company, with a vision to accelerate the green transition by providing digital infrastructure, and supporting energy sector stakeholders to develop new data-driven solutions. In partnership with Danish energy utilities, Center Denmark curates a data platform with daily energy data from more than 200,000 Danish households. As a digital centre of excellence, Center Denmark is also used by the Danish Energy Agency for Energy and Emission Accounting.

Theme 6: Reduce data sharing risk

"we don't make money out of cleaning up data. We only do it because we need to do it in order for our analytics to do what it needs to do. It's not what we're here as a business to provide"

SaaS Platform Provider

"We need the industry to be able to have a chain of custody of data when we're creating good virtual datasets". "contracts might be written [with] a best endeavours kind of piece [where] you can't be sued for kind of getting some of your data slightly wrong when you're transferring it from one organisation to another, for example"

Consultant

"data standards is ultimately what is slowing everyone down at the moment. Not like a standard, but you know certification that says, hey, this site follows this standard and then certified third parties that also follow the standard ultimately know, "cool, if I go to use this third-party application, I have this data standard then I can leverage and negotiate quickly". I think that would bring the prices down across the board"

SaaS Platform Provider

"The brownfield problems are just legacy controllers. Old networks, bad data. You just never know what you're going to get."

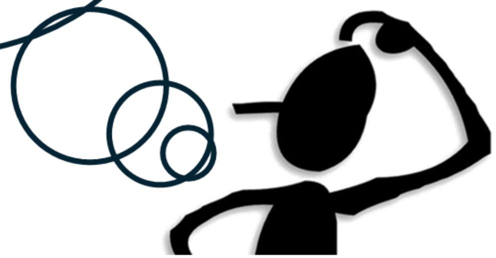
SaaS Platform Provider

"if we want to make it very easy for a facilities manager to kind of take some data, put it in and get some feedback from it, well, we've got to have the right data in the 1st place, right"

Consultant

"We see a need for standardization of energy use disclosure for each building. There should be an obligation to report energy consumption"

Consultant



5.7 Theme 7: Build workforce skills and capacity

ISSUE	SOLUTION	UK BEMS Controls Engineering Apprenticeships
Surveys of the property industry consistently identify workforce shortages and difficulty recruiting in areas associated with digitalisation. There is significant competition for talent with other sectors of the economy. Necessary skills in both consumer IT technologies and industrial OT technologies are less common. The existing property industry workforce is often reluctant to adopt new digital technologies and associated skills. Upskilling in the management of sensitive data, in a manner that allows for innovation, is required across the industry.	Government should develop an education and training agenda for improving digital skills in the property industry. The agenda should have an objective to upskill and grow the workforce in areas that are in need (e.g. BMS control engineers). It should include relevant curriculum for different sectors of the industry, on-the-job training, and incentive strategies to train and attract talent into the sector. Actions could include: **7.1 Support digital training across the property sector**: This should include Apprenticeship programs that seek to upskill existing staff or new recruits. It should also support the provision of continuous professional development modules that professional associations accredit. **7.2 Create incentive strategies for attracting IT talent into the property sector**	The UK Building Energy Management Systems (BEMS) Controls Engineer apprenticeship is a Level 4 program designed to address the industry-wide shortage of BEMS Controls Engineers. Commencing in 2021, it provides a comprehensive program of learning aimed at developing future Building Controls Engineers. It's delivered in partnership between national training providers and the Building Controls Industry Association (BCIA), offering a balance of on-the-job assessments and technical training. The apprenticeship aims to prepare individuals for efficient building management, focusing on reducing energy consumption and emissions for a greener, healthier, and more cost-effective built environment. **The Pacific Gas and Electric Company** The Pacific Gas and Electric Company and Southern California Edison support the California Advanced Lighting Controls Training Program (CALCTP), a statewide initiative that aims to increase the use of lighting controls in commercial buildings. CALCTP features two training components: a technical program with lecture and laboratory instruction on the proper installation, programming, and maintenance of lighting control systems, as well as an acceptance-test technician program. The Californian utilities require their contractors to be CALCTP-certified, and they offer rebates for customers using CALCTP-certified contractors.

Theme 7: Build workforce skills and capacity

"to get a grad out of uni trained up with the necessary skill sets to work in, you know, building's operation, that's a five to six year minimum time frame ... so we really need to figure out how we can shorten that"
SaaS Platform Provider

"its pretty hard for me to get controls engineers on a job in the 1st place. They're that busy. So, I kinda think we can use data to create virtual controls engineers to some degree and that way we can scale up the benefit of that knowledge across the industry."
Consultant

"Many buildings do not have good operators on site and it is hard to train human to have that much knowledge"
Controls Contractor

"We'll get smart building specs ... that could be 2 lines or 150 pages ... so there's still a lot of education needed."
Consultant

"a lot of consultants don't understand the requirements to bring data to the cloud. So there's a lack of accurate specifications out there and there's also a lack of checking during the construction administration phase".
SaaS Platform Provider

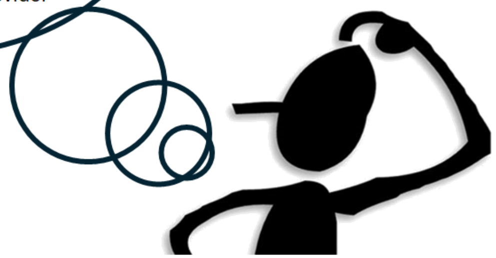
"Then you get to the network layer ... traditionally that was just the BMS person. Now we're seeing that becoming a much different skill set. Who can connect you to the Internet? Who can give you the relevant URLs required to get through firewalls so that you can get data up to the cloud."
SaaS Platform Provider

"What they've discovered is that contractors that have a tool are better at delivering an FDD outcome than [just] analytics providers".
SaaS Platform Provider

"facility management and IT services are two separate worlds. In the future, it is important to merge these"
Hardware Supplier

"if you have 50 buildings and it takes you a month to deploy each building by the time it's the last building I reckon 50 to 75% of that team is gone"
SaaS Platform Provider

"there's a digital skill set that's lacking and that's gonna continue that way until this newer generation grows up. So the first question is going to be can we entice these kids into the property industry?"
SaaS Platform Provider



5.8 Theme 8: Integrate buildings into the electricity system

ISSUE

As a low-cost measure, electricity system planning models[2,25] consistently forecast that demand flexibility, from buildings, will provide a significant fraction of the future need for dispatchability in electricity grids.

Unfortunately, utilities (responsible for operationalizing these system plans) lack the regulatory models and market mechanisms to fully consider grid integrated control of buildings. Utilities also lacks skills to recruit and manage large numbers of small DER assets. They are also concerned about (i) sharing control over assets with customers and (ii) the ability to persistently access DER resources, when customers are given the ability to opt-out of dispatch events.

This perverse lack of investment (in lowest-cost dispatchable resources) by utilities, eliminates a key revenue stream for digitalisation in buildings.

SOLUTION

Government should develop a digital strategy for including buildings as distributed energy resource (DER) nodes in the electricity system. Strategy actions could include:

8.1 Reform electricity market rules to encourage participation of DER from Grid Interactive Buildings: Electricity markets are typically designed with supply-side technologies in mind (hence they are often not fit-for-purpose for demand-side flexibility). Government would ideally catalyse the flexible demand industry using incentive mechanisms *outside* of traditional electricity markets. Integration with traditional electricity markets could be considered once DER scale is achieved.

8.2 Require demand-response readiness in MEPS for major appliances: Factory default IT capability and DR mode switching comes at a fraction of the cost of retrofitting and avoids possible voiding of warranties.

8.3 Place obligations on retailers to support customers to deliver demand flexibility services: For example, energy efficiency obligation (certificate) schemes could be adapted to incentivise flexibility.

8.4 Catalyse the market by acquiring a target amount of DER from Grid Interactive Buildings: A series of auctions could be used to recruit initial DER capacity and to demonstrate a progressive cost reduction learning curve.

8.5 Establish a market operations platform to support DER from Grid Interactive Buildings: A single independent market operation platform[26] would support data collection, sharing of price signals and financial settlement with M&V tools.

Utility Programs State of the Market

Perry et. al. (2019)[27] reviewed various utility energy management incentive programs. A number of these utility programs make use of smart controls. However, they identified a lack of more fully integrated programs to value-stack both energy savings and demand response services. They note that utilities may need to overcome internal silos between energy efficiency and grid management functions. They identified the need for increased emphasis on information technology, including advanced metering infrastructure and two way DER connectivity.

California Title 24 and SB 49

The California Building Standards Code (Title 24) requires buildings to install DR automation technology. Under the new requirements, thermostats, HVAC systems, networked lighting controllers, BASs must have two-way communication and be demand responsive using OpenADR, a common open industry led standard. These requirements are to reduce the cost for automated DR and enable buildings to operate more flexibly in the future. California also requires the CEC to adopt and update standards for appliances in order to facilitate the deployment of demand flexibility technologies.

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[25] Australian Energy Market Operator (AEMO), 2022, “2022 Integrated System Plan or the National Electricity Market”, https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en

[26] Ofgem (2019), “Ofgem’s Future Insights Series: Flexibility Platforms in electricity markets”, https://www.ofgem.gov.uk/sites/default/files/docs/2019/09/ofgem_fi_flexibility_platforms_in_electricity_markets.pdf

[27] Perry C., Bastian H., and York D., 2019, “Grid-Interactive Efficient Building Utility Programs: State of the Market”, https://www.aceee.org/sites/default/files/pdfs/gebs-103019.pdf

Theme 8: Integrate buildings into the electricity system

"I think the government policy definitely needs to work out how to implement a reward system to reward when you do grid interactive control of buildings, and get the right behaviours out of the buildings".

Consultant

"There are predictable [tariff structures], and then there are funky ones. There are cases where … you need to predict "is it going to be that [top 5 of the year] event tomorrow at this time?" But you will only know this at the end of the year, and there may be hundreds of hot and humid days in the summer."

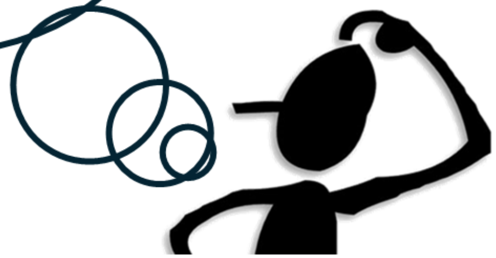
SaaS Platform Provider

"Data-driven control can be much more responsive than [rules based] control". "So that dynamic piece can unlock other things. And specifically, what it can help unlock is interactive control in buildings which respond to the amount of renewable energy that is coming into the grid variably and that is only going to become more problematic in the future, right?"

Consultant

"Strengthen the energy code and increase digital maturity"

Building Owner



6. Conclusion

At COP28, jurisdictions committed to double the global average annual rate of energy efficiency improvements. Digitalisation technology offers an attractive (but underutilized) tool for unlocking immediate cost-effective energy efficiency improvements. Critically, digitalisation will become essential for providing flexibility (dispatchable) resources, as part of the global transition to a future energy system powered by variable renewable energy.

This report provides government with guidance on policy mechanisms that can address barriers to digitalisation and thereby unlock flexibility resources, from buildings, to support the clean energy transition. These policy mechanisms aim to enable the IEA's Net Zero Emissions by 2050 Scenario, which calls for (i) all new buildings to become flexible resources by 2030 and (ii) 85% of existing buildings to be retrofitted by 2050 with efficient and grid interactive appliances.

Consolidating literature and feedback from industry interviews, a number of key policy actions were developed and categorised under the following eight themes.

Theme 1: Provide Information – to reduce complexity and information asymmetry for buyers.

Theme 2: Establish 'digital ready' certification – to standardise solutions and recognise achievement.

Theme 3: Lead by example – to provide a cohort of early adopters that catalyse the market.

Theme 4: Support researchers and innovators – to catalyse a wider range of product offerings, increase industry maturity, and provide independent validation of the benefits of digitalisation.

Theme 5: Incentivise EMIS technology – to improve the return on investment from the technology.

Theme 6: Reduce data sharing risk – to improve certainty and manage possible compliance issues.

Theme 7: Build workforce skills and capacity – to be able to deliver the services at scale.

Theme 8: Integrate buildings into the electricity system – to prioritise the clean energy transition.

These Themes and the corresponding detailed policy actions are described in Section 5 of this report, along with examples of where relevant policies are already being deployed.

A number of the policy recommendations are targeted at addressing market friction associated with data and data management infrastructure. Defining, certifying and rewarding achievement of minimum levels of 'digital readiness' in buildings, was seen as a key enabler for widespread market adoption. Such definitions/standards/certification could be incorporated into a range of important industry drivers such as construction codes and rating schemes. This would greatly simplify and derisk investment in digitalisation for building owners.

The New York State Energy Research and Development Authority (NYSERDA) Real Time Energy Management (RTEM) program is an exemplary government initiative for stimulating initial growth in the digitalisation of buildings industry. By pre-qualifying digitalisation products and services, it has helped to simplify and build trust in the technology.

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Appendix A

Industry Survey Questions

About your company

1. *What does your company or organization do?*
   - *what building typologies do you mainly deal with?*

2. *What is your role in the company?*

3. *What data-driven services does your company provide and/or use?*

About the industry

4. *What are some of the best use-cases of data-driven services?*
   - *where do you see the value proposition of these services?*

5. *What do you see as the future of data-driven services?*
   - *what will be the role of cloud solutions vs on-premises solutions?*
   - *how could digitalisation impact on building controls?*

Implementing the technology

6. *What steps are involved in implementing data-driven services?*
   - *who are the actors and what do they do?*
7. *What issues/challenges typically arise in this implementation process?*
   - *do you see these as significant barriers to industry growth?*
8. *What if any of these implementation challenges could benefit from government or collective industry action?*

What can we do to accelerate adoption?

9. *What government policy/regulatory measures would you suggest we investigate?*

10. *What technologies, software tools or other knowledge outputs should researchers be focusing on, in order to help the industry to progress further and faster?*

11. ***Do you have additional comments on potentially helpful recommendations that could be included in an industry roadmap?***

Appendix B

RTEM Program Case Study

Introduction to the RTEM Program

The New York State Energy Research and Development Authority (NYSERDA) 'Real Time Energy Management' (RTEM) Program was initiated in 2016.

The RTEM Program aims to stimulate adoption of RTEM technology and services. It does this by gathering, analysing and sharing independent technical information (relating to RTEM technology) and sharing information on successful implementations. This work is targeted at increasing investor confidence and catalysing private investment in the technology.

NYSERDA describes RTEM technology as a combination of building data collection systems (sensors, meters, equipment feeds), data analytics and building data information services – with the purpose of (i) showing building management staff the actual state of building performance at any point in time, and (ii) providing insights about operations and systems. RTEM technology is used to fine-tune building performance and identify capital projects. NYSERDA's definition for RTEM functionality includes use of the cloud for providing servers, storage, data, and software applications. Data is typically sampled at frequencies of 15 minutes or less. Use of the cloud provides greater access to analytics and expertise.

The RTEM Program recognises 'RTEM *System* Providers' (who provide and maintain the monitoring hardware and software used to extract, process, and store energy usage data), and 'RTEM *Service* Providers' (who provide consulting services that analyse data from the RTEM system and provide/enable and/or implement energy savings measures based on the data).

The RTEM Program provides a cost-share subsidy (typically around 30%) for both system capex and for the ongoing consulting services required to drive energy saving actions.

The RTEM Program is delivered through a panel of '*RTEM Qualified Vendors*'. Typically, these approved vendors apply for funding (on behalf of the building owner) from the RTEM Program on a project-by-project basis. The RTEM Program pays the successful applicant directly (ie not through the building owner).

Motivation for the RTEM Program

While RTEM technology is generally considered to be cost effective, there are considerable differences in the savings achieved (across different sites). Uncertainty in the business case is further exacerbated by the perceived complexity of the technology. More specifically, the NYSERDA RTEM Program aims to address the following barriers:

- **Information barriers**: Lack of unbiased information on technology performance and availability.
- **Skills and capability barriers**: Uncertainty of vendor qualifications and the best approach for procuring RTEM technology. Customers have difficulty assessing site-specific design requirements, associated cost, and return on investment.
- **Technology barriers**: There are challenges associated with integrating multiple systems, including interoperability issues.

By demonstrating RTEM technology across a large number of different sites, and with a wide variety of different providers, the RTEM Program is expected to obtain statistically representative and authoritative information to address these barriers. In particular, the program is expected to

- **Reduce soft costs (e.g., customer acquisition, project development)** by developing a common language (descriptions of relevant hardware, software and services) that can help address information barriers for purchasing departments procuring RTEM technologies.
- **Develop capabilities and business models in the RTEM service vendor community** to meet the range of energy management needs across the commercial buildings sector. In particular, the vendor pre-qualification approach is expected to support standardisation of services and more scalable business models.
- **Improve the predictability of returns and inform the business case for RTEM investment** by collecting and distributing aggregated data from the deployment sites.

RTEM Program Results

Over seven years, since inception, the RTEM Program has invested US$77.4million in RTEM projects at over 1,200 sites, covering almost 300 million ft^2 (27.5million m^2) of building floor area. RTEM Program investment has leveraged a further US$246 million in private investment (3.2:1 private to public investment ratio).

Initial uptake, over the first two years, was relatively slow as the program established relevant processes and recruited Qualified Vendors. It accelerated rapidly from around year 3.

The RTEM Program demonstrated that RTEM technology can be installed at a cost of around $\$1/ft^2$ floor area. This is significantly higher than the reported cost[7] of SaaS technology alone (around $\$0.06/ft^2$), partly reflecting the inclusion of some Building Management System (BMS) upgrade costs in overall project investment. It is noted that some level of business-as-usual BMS capital expenditure may have been inadvertently supported. Future program design should carefully consider additionality in regard to BMS capital costs.

Investment in RTEM technology led to an average 7.2% (0.81kWh/ft^2) annual energy savings from the first year of monitoring and analysis. Energy savings continued to increase in subsequent years with implementation of additional energy saving measures identified by the analytics. At an electricity price of 12¢/kWh, the technology offers building owners a simple payback time of around 10 years (or much less if there is existing requirement for BMS capital expenditure).

The RTEM Program also produced learnings for the industry. For example, it identified the most common causes of energy wastage in buildings (Figure B.1).

It also identified that user-engagement with the data (produced by the RTEM system) is a key indicator of successful outcomes. Conversely, the efficacy of the technology was reduced when systems were installed without an ongoing monitoring and analysis framework.

It was evident that RTEM solutions are not a once-off technology installation. Instead, they should be seen as a monitoring and continuous improvement process.

1. **Equipment control in bypassed/override/manual mode**
2. Faulty devices (e.g., leaky valves, sensors, controllers)
3. Extensive operations during unoccupied periods
4. Set points too high/low or inconsistent
5. Inefficient equipment/plant sequencing
6. Coincidental equipment operation generating high demand
7. Convert constant set points to conditionals
8. Free cooling/heating opportunities not used
9. Unintended heating, cooling and simultaneous conditioning
10. Manual operations that should be automated

Figure B.1: Top 10 reasons for energy wastage

Relevant Learnings for Implementing Future Programs for Advancing RTEM Technology

Around 500 RTEM product vendors were reviewed of which only 150 vendors were successful to become '*RTEM Qualified Vendors*'. Of the official RTEM Qualified Vendors, around half offered a Software as a Service (SaaS) platform. Other vendors specialised in energy management consulting services, supporting the realisation of energy savings. And some provided a 'full stack' of hardware, software and consulting services. The variety of product claims discovered in the market, and the high vendor rejection rate by the RTEM Program, confirmed the existence of information barriers and product confusion.

To address these barriers, future-program design should categorise the different technology types distinctively and use clear language to describe the alternative technology options. In this way, the program can help to support standardisation of solutions and simplify the technology for buyers. Clear product/service categories also help (from a program management perspective) to ensure funding is directed to the target activities, and not diverted to other business-as-usual activity.

The ‘Qualified Vendor’ approach was effective at creating a distribution channel for finding new sites/ projects for the RTEM Program. Projects were generally delivered effectively, with only a hand-full of the 1,200 projects failing (to the extent that money needed to be recouped). Data collected from the vendors was of varying quality. This had some impact on the ability to perform fully rigorous program evaluation. Future-programs should pay attention to standardised reporting requirements and program data collection methods.

Future-program design should also have a tailing funding component for ongoing project measurement, monitoring and reporting. This would help to incentivise both (i) ongoing user engagement with the data produced by the RTEM system, and (ii) maintaining the quality of collected data.

The RTEM program was technology agnostic (to the extent that it was not prescriptive of the specific category of RTEM product/service that a qualified vendor offered). Over the life of the program, the majority of implemented RTEM products fell into the general category of Automated System Optimisation (ASO) and Fault Detection and Diagnosis (FDD). Relatively few RTEM implementations deployed both ASO and FDD, as an integrated system, or provided demand response control solutions. In future, the program could be adapted to encourage adoption of grid interactive building controls, in support of the broader renewable energy transition.

The cost to administer the RTEM Program represented less than 10% of distributed project funds. Administration costs included salaries for up to 4 project managers to oversee projects. Additional staff provided support for knowledge sharing and for leveraging program results (total NYSERDA program staff varied between 3 and 12 over the life of the program).

With NYSERDA’s initial RTEM commercial base-building offering concluding in Q1 2021, results are being leveraged to help implement new programs in two local energy utilities. The NYSERDA RTEM program has de-risked the technology for those electricity utilities who are interested in running energy efficiency/ demand-management programs.

ANNEX 81

EBC

Energy in Building and Communities Programme

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Technology Collaboration Programme

by iea