

CleanerGrid 2027

Background Reading & Topic Ideas

November 2026

This guide is designed to help students participating in CleanerGrid to understand the context of this year's topic and to help them narrow the focus of their projects. Use the table of contents to explore areas that match your interests or course. You don't need to solve everything, focus on one or two aspects that align with your skills or interests.

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Table 1 - Definition of Document Acronyms

Acronym	Definition
AI	Artificial Intelligence
CEC	Citizen Energy Community
CRU	Commission for Regulation of Utilities
DER	Distributed Energy Resource
DSO	Distribution System Operator
DUoS	Distribution Use of System
ESB	Electricity Supply Board
EU	European Union
EV	Electric Vehicle
GDPR	General Data Protection Regulation
IEA	International Energy Agency
kV	Kilovolts
LDES	Long Duration Energy Storage
ML	Machine Learning
PR6	Price Review 6
PV	Photovoltaic
REC	Renewable Energy Community
SEAI	Sustainable Energy Authority of Ireland
SONI	System Operator Northern Ireland
TSO	Transmission System Operator
TUoS	Transmission Use of System

1 CleanerGrid 2027

'Powering Up the Energy Citizen'

1.1 Details

This year's CleanerGrid competition asks third-level students to respond to the prompt: *'Powering Up the Energy Citizen'*. The challenge is framed from the perspective of a Transmission System Operator (TSO): how can a TSO support citizens, communities and new consumer technologies to deliver a secure, reliable, affordable and decarbonised electricity system?

As smart meters, electric vehicles, heat pumps, rooftop solar, battery storage and flexible tariffs become more common, citizens will play a more active role in how and when electricity is used. This creates opportunities for flexibility, renewable integration and public engagement, while also presenting challenges around forecasting, visibility, accessibility and system security.

Your challenge is to propose innovative, practical solutions that address both the opportunities and the obstacles ahead.

Whether working individually, in discipline-specific, or interdisciplinary teams, participants should familiarise themselves with:

- Relevant Domestic and EU policies and regulations.
- EirGrid's ongoing and planned projects.

Submissions should build on existing research but focus on fresh innovations and actionable proposals rather than produce literature reviews.

Sponsorship of the project by a member of academic staff is a requirement and their participation must be indicated when submitting the application.

Participants may wish to explore areas such as:

- Flexibility and demand response: helping citizens shift or reduce demand to support the grid.
- Data, forecasting and visibility: using smart meter data, digital tools or analytics to better understand changing demand patterns.
- New consumer technologies: enabling EVs, heat pumps, storage, microgeneration and community energy to support wider system needs.
- Trust, fairness and inclusion: making participation in the energy transition clear, accessible and beneficial for different citizens and communities.
- Market, policy and regulatory design: encouraging citizen actions that support a cleaner, more secure and more efficient electricity system.

Submissions may focus on engineering, data analytics, behavioural insights, digital tools, communications, market design, policy, regulation or community engagement. Students should consider the practical role a TSO could play, including where collaboration may be needed with suppliers, distribution networks, regulators, communities, technology providers or policymakers.

Not sure where to start?

Use the guide below to explore topic areas that align with your course or interests. You can focus on one area or combine ideas across disciplines. Each topic includes background information and optional prompts to help you develop a project that reflects your skills and academic focus.

1.2 Prizes



Figure 1 - CleanerGrid Prize Awards 2027

1.3 Frequently Asked Questions

What does EirGrid do?

As Ireland's Transmission System Operator, EirGrid plans, develops and operates Ireland's high-voltage transmission grid safely and securely, while also planning for Ireland's long-term electricity needs.

EirGrid is responsible for the connection of generation, demand and interconnection customers, connecting directly to the transmission system, and the development of the backbone transmission grid.

(Read more here)

Why was this theme chosen?

Ireland's electricity system is changing as more renewable generation connects to the grid and citizens adopt technologies such as smart meters, electric vehicles, heat pumps, rooftop solar and battery storage. This theme was chosen to explore how citizens and communities can play a more active role in supporting a secure, reliable and decarbonised electricity system, and how a Transmission System Operator can enable that participation in a fair, practical and system-focused way.

Who can apply?

Any student enrolled in a 3rd level institute in the Republic of Ireland below PhD level.

What is in it for students?

Real World Challenge: Tackle a prompt related to Ireland's clean energy transition.

Long Project Timeline: With several months to develop your ideas, you can balance academic commitments while diving deep into energy innovation.

National Recognition: Finalists present their projects at a live event judged by experts from academia, media, and industry.

Build Your Network: Engage with professionals, academics, and peers.

Boost Your CV: Showcase your innovation and presentation skills.

When is the application deadline?

The deadline for application forms to be sent to research@eirgrid.com is 23:59 on Friday the 6th of November 2026.

When is the submission deadline?

The report and video link are to be sent to research@eirgrid.com on or before 23:59 Friday the 12th of February 2027.

What needs to be submitted?

A complete CleanerGrid Competition Entry consists of three components: a Written Report, a Video Submission and a completed Competition Submission Form.

The Written Report should be between 4,000 and 5,000 words, with a ±10% tolerance as set out in the CleanerGrid Grading Rubric. The Video Submission has a target duration of no more than 15 minutes.

Please refer to the CleanerGrid Grading Rubric for the full submission requirements.

What format does my submission need to be in?

Please submit the Written Report in PDF format and upload the Video Submission to YouTube as an unlisted video. Include the video link and completed Competition Submission Form with your email submission to research@eirgrid.com.

Any other key dates?

Finale & Awards Ceremony: Indicatively 25 March 2027, with the exact date and time to be confirmed to shortlisted participants.

What makes a strong CleanerGrid entry?

- Strong entries go beyond summarising existing research. They clearly define a problem or opportunity connected to Powering Up the Energy Citizen, develop an original and practical response, support conclusions with credible evidence, and consider how the proposal could work in practice.
- The CleanerGrid Grading Rubric explains how the Written Report and Video Submission will be assessed. Students are encouraged to read the rubric before starting their project and use it again to review their work before submission

A note on sources and further reading

Sources are provided throughout this guide as links in footnotes to facilitate further reading. These footnotes are intended to help you identify and access useful resources and **do not represent the citation and referencing style expected in your submission**. CleanerGrid submissions should use either Harvard or 'Institute of Electrical and Electronics Engineers' referencing consistently, as set out in the Grading Rubric.



2 Electrification Policy and Regulation

2.1 Background Reading

EirGrid is Ireland's transmission system operator, responsible for planning, operating and developing the high-voltage electricity grid to support a sustainable energy future. Ireland is transitioning from a fossil-fuel-based energy system to one increasingly powered by electricity and renewable energy, while strengthening integration with European energy markets.

This transition is underpinned by the **Climate Action and Low Carbon Development (Amendment) Act 2021**[1], which provides a statutory framework for Ireland's transition to a climate-neutral economy by the end of 2050. This includes allowing for the introduction of legally binding carbon budgets and sectoral emissions ceilings. Key commitments under the Act and associated Government climate policy include:

- A 51% reduction in greenhouse gas emissions by 2030 (relative to 2018 levels).
- Retrofitting 500,000 homes to improve energy efficiency.
- A significant increase in the adoption of electric vehicles.

These policies are accelerating the uptake of technologies such as electric vehicles, heat pumps, rooftop solar and battery storage. As electrification increases, electricity demand is expected to grow substantially, creating new challenges and opportunities for the operation of Ireland's power system.

Traditionally, electricity consumers have played a largely passive role, consuming power supplied by large, centralised generators. However, EU energy legislation is transforming this relationship by enabling consumers to become **Active Consumers**[2], capable of generating, storing, managing and exporting electricity as well as participating in demand-side flexibility programmes.

The EU Electrification Action Plan (COM/2026/595)[3] sets out a roadmap for accelerating electrification while also promoting competitiveness, decarbonisation and security of energy supply. A target for electricity to account for 46% of final energy consumption by 2040 is proposed in the Plan and key actions to tackle barriers to electrification of key sectors are put forward. Amongst these actions include provision of economic incentives, reforms to network charges and energy taxation to promote uptake of electric options, and increased attention towards developing the skills in the workforce needed to enable the electrification transition.

EU energy legislation, including Directive (EU) 2019/944[4] on common rules for the internal market for electricity and Directive (EU) 2018/2001[5] on the promotion of renewable energy, provides frameworks for new forms of consumer and community participation. These frameworks can be seen below:

- **Citizen Energy Communities (CECs)** enable citizens, businesses, local authorities and other organisations to collectively participate in electricity generation, consumption, storage, energy

[1] https://www.irishstatutebook.ie/eli/2021/act/32/enacted/en/html
[2] https://www.cru.ie/regulations-policy/energy/active-consumers-and-energy-communities/
[3] https://energy.ec.europa.eu/topics/eus-energy-system/electrification_en
[4] Directive - 2019/944 - EN - EUR-Lex
[5] Directive - 2018/2001 - EN - RED II - EUR-Lex



sharing and flexibility activities. Their primary objective is to deliver environmental, economic or social benefits to members and local communities rather than maximising profit.

- **Renewable Energy Communities (RECs)** focus specifically on renewable energy projects, allowing communities to jointly generate, consume, store and share renewable electricity from technologies such as solar and wind power.

It should be noted here that Directive (EU) 2018/2001 was subsequently amended by Directive (EU) 2023/2413[6].

As Ireland's electricity system becomes increasingly decentralised, Active Consumers, CECs and RECs have the potential to support renewable integration, demand flexibility and greater public participation in the energy transition.

Furthermore, demand flexibility will play an increasingly important role in a renewables-led electricity system. Aligning electricity use with periods of high renewable generation can help maintain system security and reduce reliance on fossil-fuelled generation. As noted in the National Energy Demand Strategy[7]:

> "Demand flexibility where energy consumption aligns with renewable availability is a positive way of driving secure, sustainable, and affordable energy in Ireland. Energy efficiency and responsive demand are now core components of EU policy development and regulation." (Department of the Environment, Climate and Communications, 2022, p. 24).

Technologies such as smart meters, electric vehicles, heat pumps, home batteries and smart appliances, have the potential to provide flexibility services to the electricity system. The growth of distributed energy resources (DERs), combined with smart metering and enhanced consumer rights under EU legislation, is contributing to the emergence of the **Energy Citizen** - individuals and communities that actively participate in energy generation, consumption, storage and flexibility services rather than simply purchasing electricity. Programmes being developed by EirGrid, SONI and ESB Networks are exploring how these technologies can enable broader participation in demand-side flexibility across residential, commercial and community sectors. Together, these policy, regulatory and technological developments are reshaping the role of consumers and communities within Ireland's clean energy transition.

[6] Directive - EU - 2023/2413 - EN - RED III - EUR-Lex
[7] https://www.cru.ie/about-us/news/cru-national-energy-demand-strategy/



2.2 Prompts for Policy and Regulation

Table 2 - Optional Prompts relating to the Policy and Regulation considerations for Powering Up the Energy Citizen

Optional Policy and Regulatory Framework Considerations for CleanerGrid
• ‘How can Ireland encourage more citizens to become Active Consumers of electricity?’
• ‘What will it take to create Ireland's Energy Citizen?’
• ‘How can policy and regulation unlock the flexibility potential of Irish homes?’
• ‘How can Citizen Energy Communities and Renewable Energy Communities accelerate Ireland's clean energy transition?’
• ‘What policies and regulations are needed to support a highly electrified Ireland?’
• ‘How can Ireland maximise the benefits of smart metering for consumers and the electricity system?’
• ‘Demand flexibility is often described as a key enabler of electrification. How can Ireland make it a mainstream part of everyday life?’
• **Or any other idea you have…**

Multidisciplinary potential!

‘What are the policy or regulatory gaps that need to be addressed to power up the energy citizen and energy communities of 2050?



3 Financing Electrification

3.1 Background Reading

The powering up of Ireland's energy citizens will require significant investment across homes, communities, networks and markets. While electrification presents a major opportunity to reduce emissions and empower consumers, it also raises important questions around affordability, investment, cost recovery and the creation of sustainable revenue streams. As Ireland transforms to a cleaner electricity system, innovative financing models and market mechanisms will be required to ensure that the benefits of electrification are shared fairly and that participation is accessible to all.

Electricity market design will play a critical role in financing the energy transition. The Single Electricity Market provides the investment signals needed to attract private capital into renewable generation, storage, demand-side flexibility, and system support services. As Ireland and Northern Ireland progress towards 80% renewable electricity by 2030, operating a system with up to 95% instantaneous System Non-Synchronous Penetration will require substantial investment in both infrastructure and flexibility services. Through market reviews under the 'Delivering a Secure, Sustainable Electricity System'[8] and 'Shaping Our Electricity Future'[9] programmes, EirGrid and SONI previously estimated that €40-50 billion of third-party investment would be required to achieve 70% renewable electricity, with even greater investment now needed to meet more ambitious decarbonisation targets. Robust energy, capacity, and system services markets, aligned with regulatory and policy frameworks, will be essential to provide investor confidence, maintain security of supply, and ensure consumers benefit from a reliable and affordable transition to a more electrified energy system.

One significant opportunity of electrification lies in reducing renewable energy dispatch down. As increasing volumes of renewable generation connect to the electricity system, renewable output can sometimes be reduced due to operational or network limitations. EirGrid's Renewable Constraint and Curtailment reports[10] show that dispatch down remains a persistent challenge for Irish and international power systems with overall renewable dispatch down reaching 12% in 2025. In the first three quarters of 2026, EirGrid brought 88.5% of renewable electricity generated onto the system (11.5% dispatched down year-to-date 2026)[11].

Reducing these levels represents a substantial economic opportunity, as renewable electricity that is not utilised ultimately increases costs across the system. The deployment of flexible energy technologies such as home batteries, electric vehicles, smart charging systems, heat pumps and community-scale storage such as thermal storage projects, could help absorb excess renewable generation when it is available, reducing dispatch down while creating value for participating consumers and communities.

However, several barriers remain to widespread adoption. The upfront cost of technologies such as rooftop solar, battery storage, heat pumps and EVs can be prohibitive for many households. Although government support schemes, grants and low-interest financing mechanisms are available, achieving mass participation may require new approaches that reduce financial risk and improve accessibility. Existing supports from the Sustainable Energy Authority of Ireland (SEAI), including grants for heat pumps[12], solar PV and home energy upgrades[13], demonstrate how public funding can accelerate adoption, but future solutions may need to go beyond grant-based models.

An equally important challenge is the uncertainty surrounding future flexibility markets and reward structures. Consumers must have confidence that flexible assets will generate sufficient returns over their lifetime. Flexible technologies may create value through reduced electricity bills, participation in flexibility

[8] https://www.eirgrid.ie/ds3-programme-delivering-secure-sustainable-electricity-system
[9] https://cms.eirgrid.ie/sites/default/files/publications/Shaping-Our-Electricity-Future-Roadmap_Version-1.1_07.23.pdf
[10] https://cms.eirgrid.ie/sites/default/files/publications/Annual-Renewable-Constraint-and-Curtailment-Report-2025-V1.0.pdf
[11] https://www.eirgrid.ie/grid/system-and-renewable-data-reports
[12] https://www.seai.ie/grants/home-energy-grants/individual-grants/heat-pump-systems
[13] https://www.seai.ie/grants/home-energy-grants



markets, system services revenues, demand response programmes and future local flexibility schemes. Developing clear and transparent market access arrangements will therefore be critical to creating business cases for electrification technologies as recognised in the distribution system operator (DSO)/TSO 2025-2029 Multi-Year Plan[14].

The emergence of flexibility as an income stream presents a significant opportunity for innovation. Individual assets may have limited value in isolation, but when aggregated they can provide valuable services to the electricity system. Aggregators may coordinate thousands of domestic batteries, EV chargers, heat pumps or other flexible devices, enabling households and businesses to participate in electricity markets that would otherwise be inaccessible. Future aggregation models could create new revenue streams while supporting system balancing, congestion management and renewable integration.

Electrification also creates opportunities for greater community participation in the energy transition. Energy communities, community ownership models and neighbourhood-level initiatives could allow citizens to collectively invest in and benefit from local energy infrastructure. Shared battery systems, locally owned renewable energy projects and community flexibility schemes could generate revenues which are reinvested within communities while increasing local resilience and reducing energy costs. Emerging concepts such as peer-to-peer energy trading may offer additional opportunities for citizens to exchange value from locally generated renewable electricity, further increasing engagement and participation in the energy system.

Consumer protection must remain central to these developments. As new market models emerge, participants should be able to clearly understand potential rewards, risks and contractual arrangements. Financing mechanisms, market incentives and flexibility programmes should be designed to ensure accessibility, inclusivity and fairness, while protecting vulnerable consumers and those at risk of energy poverty. The benefits of electrification should be available to all citizens regardless of income level, location or housing tenure.

The financing of electrification extends beyond customer technologies and community assets. Significant investment in transmission and distribution infrastructure, as recognised in 'Tomorrow's Energy Scenarios[15]', will be required to support increased electricity demand and facilitate the connection of new renewable generation, energy storage, EV charging infrastructure and electrified heating systems. The network operators recover these costs through network tariffs[16], including Distribution Use of System (DUoS) and Transmission Use of System (TUoS) charges[17]. As electrification accelerates, reforms to network charging methodologies, including future DUoS reform, may be required to ensure costs are recovered fairly while incentivising behaviours that support efficient system operation.

EirGrid and ESB Networks are currently undertaking the largest programme of electricity network investment in the history of the State. Through Price Review 6 (PR6)[18], approximately €18.9 billion has been allocated to EirGrid and ESB Networks to facilitate the continued development of Ireland's electricity infrastructure between 2026 and 2030. These investments will reinforce the grid, enable greater renewable integration and provide the backbone required for widespread electrification across Irish society.

Ultimately, financing electrification is not solely about funding new technologies. It is about designing markets, incentives, revenue streams and regulatory frameworks that provide confidence for citizens, communities and investors. The success of Ireland's energy transition may depend on creating innovative financial models that reward flexibility, reduce system costs, encourage participation and ensure that the benefits of a clean energy future are shared by all.

[14] https://cms.eirgrid.ie/sites/default/files/publications/DSO-TSO-2025-2029-Multi-Year-Plan-September-2024.pdf
[15] https://cms.eirgrid.ie/sites/default/files/publications/TES-2023-Final-Full-Report.pdf
[16] https://www.cru.ie/regulations-policy/energy/revenues-and-tariffs/
[17] https://www.cru.ie/about-us/news/cru-approves-annual-electricity-network-charges/
[18] https://consult.cru.ie/en/consultation/price-review-six-0



3.2 Prompts for Financing Electrification

Table 3 - Optional Prompts relating to the Financing considerations for Powering Up the Energy Citizen

Optional Financing Considerations for CleanerGrid
• ‘Propose a solution to address financial losses of dispatch down considering the widespread electrification of Ireland’s citizens.’
• ‘Propose a financing solution that could increase the uptake of electrification technologies and support their widespread adoption.’
• ‘Enhance how citizens are rewarded for offering their flexibility to the grid.’
• ‘How could market or financial mechanisms enable a TSO to leverage consumer flexibility to support the grid and reduce peak demand?’
• ‘What new business models could make electrification affordable for everyone?’
• ‘Can flexibility become a valuable resource traded in energy markets?’
• ‘Propose a new market operating model that attracts investors while ensuring electrification.’
• ‘How could financial incentives and market mechanisms encourage CECs and RECs to provide flexibility to the electricity system?’
• **Or any other idea you have…**

Multidisciplinary potential!

‘How can neighbourhoods become mini energy markets?'

Multidisciplinary potential!

'How can Ireland finance a Just Transition for the electricity grid in which the costs and benefits of electrification are shared fairly'





4 Engineering

4.1 Background Reading

Electrification is a key pillar of Ireland's transition to a low-carbon energy system. The increase in electricity demand discussed in section 2.1 presents engineering opportunities and challenges to the electricity grid. Unlike previous changes to the energy system, electrification affects both the scale and pattern of electricity consumption, creating new engineering challenges across the transmission network.

The following sections outline some of the key technical considerations associated with supporting widespread electrification.

4.1.1 Distributed Energy Resources and Network Integration

As citizens increasingly adopt technologies such as microgeneration, rooftop solar PV, home battery systems, electric vehicle chargers and heat pumps, electricity networks are experiencing a fundamental shift in how energy is generated and consumed. EirGrid anticipates this change and it is recognised in the 'Shaping our Electricity Future' roadmap[19] and 'Tomorrow's Energy Scenarios' report[20].

Traditionally, electricity flowed in a single direction from large-scale generators through the transmission and distribution systems to end users. The growth of DERs is creating more dynamic operating conditions, where electricity may flow in multiple directions depending on local generation and demand patterns.

This introduces several engineering challenges, including:

- Local network congestion.
- Reverse power flows from distribution networks onto the transmission system.
- Reduced visibility of distributed generation output.
- Increased complexity in forecasting demand and generation.
- The need for enhanced coordination between transmission and distribution system operators.

These visibility, forecasting and coordination requirements are explored further in Section 4.1.4.

4.1.2 Network Capacity and Reinforcement

Accommodating the increased demand on Ireland's electricity infrastructure requires substantial investment in both transmission and distribution networks.

As set out in the Transmission Infrastructure Delivery Updates[21], in PR6 EirGrid and ESB have jointly set out to deliver approximately 405 projects that aim to increase network capacity, facilitate renewable energy integration and support future electrification demands across the island. These projects include new substations, transmission line upgrades, asset replacement programmes and innovative technologies designed to maximise the utilisation of existing infrastructure.

Key engineering challenges include:

- Identifying future demand growth centres.
- Delivering infrastructure upgrades while maintaining security of supply.
- Coordinating transmission and distribution reinforcement programmes.
- Ensuring sufficient capacity to support transport and heating electrification.

[19] See page 78 onwards: https://cms.eirgrid.ie/sites/default/files/publications/Shaping-Our-Electricity-Future-Roadmap_Version-1.1_07.23.pdf
[20] https://www.eirgrid.ie/industry/tomorrows-energy-scenarios-tes
[21] https://www.eirgrid.ie/grid/grid-reports-and-planning/transmission-infrastructure-delivery-tid-update



In parallel with traditional reinforcement approaches, innovative solutions that optimise existing assets may help defer or reduce the need for large-scale infrastructure investments.

4.1.3 Future Demand - Electrified Transport and Heating

The widespread adoption of electric vehicles and heat pumps is expected to represent a significant proportion of future electricity demand growth as highlighted in 'Tomorrow's Energy Scenarios'[22].

The timing and location of these new electrical loads can create localised network constraints, particularly where high concentrations of EV chargers or electric heating systems are connected within a relatively small geographic area.

Engineering considerations include:

- Peak demand growth driven by increased roll out of these technologies and consumer behaviour.
- Concentrated EV charging demand at off-peak hours driven by Time of Use Tariffs.
- Cold-weather driven heating dependent loads.
- Network thermal limits.
- Substation and transformer capacity requirements.

Understanding how electrification technologies interact with one another will be essential for developing cost-effective network solutions capable of supporting future demand.

4.1.4 Grid Visibility and Distribution-Transmission Coordination



Figure 2 - EirGrid illustration of key drivers of electricity demand growth to 2030

Historically, transmission system operators maintained direct visibility of most large generation sources connected to the network. The increasing deployment of distributed technologies challenges this traditional model and therefore requires stronger coordination as set out in ESB Networks' DSO/TSO Multi-Year Plan[23].

Millions of smaller devices, including solar installations, batteries, EV chargers and heat pumps, can collectively have a significant impact on power system operation. However, their behaviour may not always be directly visible at transmission level.

This creates a growing need for:

- Enhanced network observability.
- Improved system monitoring.
- Advanced forecasting capabilities.
- Increased data-sharing between network operators.
- Stronger coordination between transmission and distribution networks.

Enhanced visibility will help operators better understand power flows, anticipate network constraints and manage system security under increasingly dynamic operating conditions.

[22] https://cms.eirgrid.ie/sites/default/files/publications/TES-2023-Final-Full-Report.pdf
[23] https://cms.eirgrid.ie/sites/default/files/publications/DSO-TSO-2025-2029-Multi-Year-Plan-September-2024.pdf

4.1.5 Grid Stability and Low-Carbon System Services

The transition towards electrification and renewable energy is changing the physical characteristics of the power system.

Traditional power stations provide inherent system inertia and other stability services through large rotating generators. As these generators are replaced by inverter-based technologies such as wind, solar and battery systems, alternative technologies and system services are required to provide the capability traditionally delivered by synchronous generation.

Key engineering challenges include:

- Managing sufficient inertia.
- Managing frequency stability.
- Maintaining voltage stability.
- Ensuring adequate system strength.
- Preventing oscillatory behaviour.
- Maintaining resilience following disturbances.

To address these challenges, EirGrid continues to procure Low Carbon Inertia Services[24] [25] **and other system support solutions**, enabling technologies such as grid-forming inverters, synchronous condensers and advanced power electronics to provide services traditionally delivered by conventional generation. These technologies are expected to play an increasingly important role in the future power system.



[24] https://www.eirgrid.ie/news/eirgrid-awards-four-contracts-new-renewable-integration-technologies
[25] https://cms.eirgrid.ie/sites/default/files/publications/SOEF-Operations-LCIS-Phase-2-Recommendations-Paper-Requirements-and-Procurement-Approach.pdf

4.1.6 Long Duration Energy Storage (LDES)

As electrification increases demand and renewable generation forms a larger proportion of the energy mix, the ability to store energy over extended periods becomes increasingly important.

Long Duration Energy Storage (LDES) technologies have the potential to:

- Store excess renewable energy during periods of high generation.
- Support system adequacy during prolonged low renewable output events.
- Reduce curtailment of renewable generation.
- Improve overall system resilience and flexibility.
- Support seasonal balancing between electricity supply and demand.

A variety of technologies are being explored globally, including pumped hydro storage, compressed air energy storage, thermal energy storage and emerging chemical storage solutions.

Understanding the technical requirements, operational characteristics and network impacts of LDES remains an important engineering challenge as Ireland develops a more electrified and renewable-based power system. EirGrid recognises this challenge and has developed their Long Duration Energy Storage (LDES) Procurement Mechanism[26] which is now closed for consultation. This was in response to The Electricity Storage Policy Framework's[27] call for immediate procurement of long duration storage.

4.1.7 System Resilience Engineering

As society becomes increasingly dependent on electricity for transport, heating and other essential services, maintaining a resilient power system becomes more critical than ever. The government recognises this criticality, and this is shown in their 'Energy Security in Ireland to 2030' strategy[28]. EirGrid also recognises this and 'Keeping Ireland Powered' is one of our strategic pillars in our strategy[29].

Future electricity networks must be capable of operating reliably under a wide range of scenarios, including:

- Extreme weather events.
- Equipment failures.
- Cyber-physical disruptions.
- Rapid changes in electricity demand.
- High renewable generation variability.

System resilience engineering encompasses:

- Network redundancy and contingency planning.
- Climate adaptation strategies.
- Emergency response and restoration processes.
- Operational preparedness for future network conditions.

The challenge is not only to support electrification, but to ensure that the resulting electricity system remains secure, reliable and resilient for all energy citizens.

[26] https://consult.eirgrid.ie/en/consultation/long-duration-energy-storage-ldes-procurement-mechanism-consultation
[27] https://www.gov.ie/en/department-of-climate-energy-and-the-environment/publications/electricity-storage-policy-framework/
[28] https://assets.gov.ie/static/documents/energy-security-in-ireland-to-2030-265afb44-cdff-4acc-b507-afe44a2462c8.pdf
[29] https://cms.eirgrid.ie/sites/default/files/publications/EirGrid-Strategy-2026.pdf

Table 4 - Mini Engineering Glossary

Capacity	The maximum electrical power that a generator can produce or that equipment or networks can safely carry.
Curtailment	The reduction of renewable electricity generation due to system-wide operational security requirements.
Demand	The amount of electricity being used by consumers at a given point in time.
Distribution Network	The part of the electricity network that delivers power from the transmission system to homes, businesses and communities, operating at lower voltages than the transmission network.
Dynamic Operating Conditions	Continuously changing system conditions influenced by factors such as weather, demand, and generation output.
Flexibility	The ability of the electricity system to respond to changing conditions by adjusting when electricity is generated, used or stored.
Forecasting	The prediction of future electricity demand, generation, weather conditions, or network behaviour.
Frequency Stability	The ability of the power system to maintain a consistent operating frequency, within acceptable limits, despite changes in generation or demand.
Micro-generation	Small-scale electricity generation by households, businesses or communities, typically using renewables such as solar PV.
Network Congestion	A condition where the power flows required through part of the network exceeds its safe transfer capability.
Network Constraints	These are localised network limitations that restrict how electricity can flow through the network.
Network Thermal Limits	The maximum amount of power that network equipment can carry without overheating.
Oscillations	Repeated fluctuations in power system frequency, voltage, or power flows that can occur during normal or disturbed operation.
Resilience	The ability of the power system to withstand, adapt to, and recover from disruptions or unexpected events.
Security of Supply	The ability of the power system to reliably meet electricity demand when and where it is needed.
Surplus Renewable Generation	This is a component of dispatch down which occurs at times when there is more generation than the market needs to meet consumer demand, including exports, sometimes called oversupply.
Transmission Network	The high-voltage electricity network that transports large amounts of electrical power across the country, operating at 110 kV, 220 kV and 400 kV in Ireland.
Voltage Stability	The ability of the network to maintain acceptable voltage levels under normal and disturbed operating conditions.



4.2 Prompts for Engineering

4.2.1 Mechanical Engineering

Table 5 - Optional Prompts relating to the mechanical engineering considerations for Powering Up the Energy Citizen

Optional Mechanical Engineering Considerations for CleanerGrid
• ‘Design a more efficient heat pump system for Irish homes.’
• ‘Design a system that integrates solar PV, battery storage and home heating technologies.’
• ‘Explore new approaches to long-duration energy storage using mechanical engineering principles.’
• ‘Develop an innovative heating solution for low-carbon communities.’
• ‘Design a community energy storage solution using mechanical or thermal technologies.’
• ‘Create a low-carbon solution for electrifying industrial processes.’
• ‘Create an innovative method for reducing energy losses in buildings and infrastructure.’
• ‘How can thermal energy storage help reduce peak electricity demand?’
• **Or any other idea you have…**

4.2.2 Electrical/Energy Engineering

Table 6 - Optional Prompts relating to the electrical and energy engineering considerations for Powering Up the Energy Citizen

Optional Electrical and Energy Engineering Considerations for CleanerGrid
• ‘Design a system that uses flexible electricity demand to support grid stability.’
• ‘Design a smarter way to manage EV charging without overloading the electricity network.’
• ‘Develop a solution that improves visibility of rooftop solar generation across the network.’
• ‘How could homes and businesses work together as a virtual power plant?’
• ‘Design a local energy management system that balances generation, storage and demand.’
• ‘How could microgrids improve resilience during power outages or extreme weather?’
• ‘Create a solution that allows DERs to provide system services.’
• ‘How can electricity networks make better use of existing infrastructure before building new assets?’
• ‘Develop a tool that helps network operators anticipate future capacity constraints.’
• **Or any other idea you have…**

Multidisciplinary potential!

- ‘What engineering innovations are needed to power the Energy Citizen of the future?’



5 Data and Artificial Intelligence

5.1 Background Reading

Artificial intelligence (AI), machine learning (ML), and data-driven technologies are playing an increasingly important role in the transition to a cleaner, more flexible electricity system. As outlined in EirGrid's *Group Strategy (2026)*[30], one of our Key Enablers involves being Digitally Driven, "embedding digital, data and Artificial Intelligence (AI) capabilities at the heart of how we operate, enabling innovation through smarter decisions, faster responses and more efficient ways of working." Progress in this area is detailed in EirGrid's *Annual Innovation Reports*[31].

Data and AI technologies are central to enabling and coordinating energy citizen participation while maintaining a secure and reliable power system.

In Industry and Society, data-driven techniques support data governance, open data initiatives, forecasting, operational planning, and decision-making. As increasing numbers of DERs connect to the network, large volumes of real-time data are being generated by smart meters, sensors, EV charging infrastructure, renewable generators, batteries, and control systems. AI and ML techniques can transform this data into actionable insights for both system operators and consumers.

Examples of data-driven solutions and areas of innovation that support the energy citizen include:

- **Demand and Generation Forecasting:** AI and ML can improve predictions of electricity demand and distributed generation at national, regional and local levels, incorporating weather conditions, consumer behaviour, EV charging patterns and rooftop solar output. EirGrid's System Margins Outlook reports provide context on forecasting and system needs.
- **Flexibility Services Optimisation:** Data analytics can identify when and where flexibility is needed and support the coordination of smart appliances, batteries and EV chargers. AI-driven optimisation could help balance local generation, storage and demand while maintaining overall system security.
- **Consumer Energy Insights:** Advanced analytics can provide households and businesses with personalised information on energy consumption, generation and opportunities to reduce costs or emissions through changes in behaviour.
- **Digital Participation Platforms:** Digital platforms and data-sharing approaches could enable consumers, aggregators and energy communities to participate more effectively in electricity markets and flexibility services.
- **Distributed Resource Integration:** Research can explore how forecasting, optimisation and data-sharing tools work together to support a more decentralised electricity system.

The increasing deployment of smart meters across Ireland, through the National Smart Metering Programme[32], is creating new opportunities to better understand how electricity is consumed and generated throughout the day. Aggregated and anonymised smart meter data can help network operators identify trends, improve forecasting accuracy, assess the impact of new technologies, and develop more targeted solutions to support customers. At the same time, robust data governance and cybersecurity measures are required to protect consumer privacy and maintain public trust.

Looking further ahead, AI could move beyond forecasting and analytics to support real-time responses from aggregated batteries, electric vehicles, heat pumps and smart appliances to grid signals and market conditions, within limits set by system operators and consumers.

Digital twins are also emerging as a valuable tool for modelling the interaction between consumers and the power system. A digital twin is a dynamic, virtual representation of a physical asset, system, or process that is continuously updated using real-world data. Digital twins can be used to simulate future scenarios

[30] https://www.eirgrid.ie/sites/default/files/publications/EirGrid-Strategy-2026.pdf
[31] https://www.eirgrid.ie/sites/default/files/publications/2025-Annual-Innovation-Report.pdf
[32] https://www.esbnetworks.ie/customer-support/customer-support-queries/meter-reading/smart-meters



involving high levels of distributed generation, electric vehicle adoption, battery deployment, and demand flexibility. Details of Ireland's future energy scenarios can be found in EirGrid's Tomorrow's Energy Scenarios[33]. This enables planners and operators to assess potential network impacts and evaluate solutions before implementing them in the real world.

As energy citizens take on a more active role in the electricity system, the ability to collect, manage, analyse, and act upon data will become increasingly important. Data and AI technologies can help unlock flexibility, improve consumer engagement, optimise network investment, and facilitate the integration of renewable energy. Ensuring that these technologies are deployed in a transparent, secure, and inclusive manner will be essential to empowering citizens and supporting the transition to a sustainable, affordable, and resilient energy future.

The potential benefits of AI are significant. At EirGrid, any use of AI is subject to established governance, risk management and compliance processes. AI solutions are assessed and implemented responsibly, with appropriate safeguards to ensure they are aligned with legal, regulatory and organisational requirements, including data protection obligations under GDPR and emerging requirements under the EU AI Act. As the Transmission System Operator for Ireland, security of electricity supply remains our highest priority. Any application of AI is therefore considered carefully, with a strong focus on safety, reliability, transparency and human oversight.

5.2 Prompts for Data and Artificial Intelligence

Table 7 - Optional Prompts relating to the data and AI considerations for Powering Up the Energy Citizen

Optional Data and AI Considerations for CleanerGrid
• 'Propose a project that utilises data gathered from smart meters to improve forecasting.'
• 'Design a system which uses AI to schedule assets based on demand forecasts.'
• 'Propose a method using AI to mitigate generation dips caused by residential solar drop out.'
• 'How can AI be used with smart charging to mitigate dispatch down and/or reduce pressure on the grid?'
• 'Design a system that automatically balances demand and generation taking into consideration widespread electrification.'
• **Or any other idea you have…**

[33] https://www.eirgrid.ie/industry/tomorrows-energy-scenarios-tes



6 Sustainability and the Environment

6.1 Background Reading

Sustainability and environmental impact are central to the electrification of Ireland's energy system. Moving heat, transport and household energy use away from fossil fuels and towards clean electricity can lower greenhouse gas emissions, reduce exposure to imported fuel price volatility, and support Ireland's climate objectives. However, delivering electrification sustainably requires minimising its environmental impacts while supporting renewable generation, efficient energy use, responsible infrastructure development, and fair access for citizens. Ireland's Climate Action Plan 2025[34] sets out a pathway to halve national emissions by 2030 and achieve net zero by 2050, while the Environmental Protection Agency highlights the need for significant emissions reductions across electricity, heat and transport to meet these targets. At the time this guide was prepared, Climate Action Plan 2025 was the latest published plan. Students should consult and reference the most up-to-date Government policy and targets available when preparing their submissions.

As outlined in Section 2.1, Ireland's climate and energy policies are accelerating electrification and renewable energy deployment. From a sustainability perspective, the challenge is to ensure that this transition delivers emissions reductions while also considering energy efficiency, resource use, biodiversity and the environmental impacts of new infrastructure.

A key opportunity is the improvement of home energy efficiency. Energy-efficient homes require less electricity for heating, reduce peak demand on the power system and make technologies such as heat pumps more effective. SEAI guidance notes that home energy upgrades and heat pumps can significantly reduce energy use and associated emissions[35], while the National Retrofit Plan[36] aims to make energy-efficient homes more affordable, comfortable and accessible. Poorly insulated homes may increase electricity demand at times when the grid is already under pressure, highlighting the importance of retrofitting, smart heating controls and citizen awareness as part of any electrification solution. These challenges are particularly important for households experiencing energy poverty, which may face high energy costs while having limited ability to fund the upgrades needed to reduce their energy use. The concept of the energy citizen is closely linked to sustainability because it encourages individuals and communities to play an active role in reducing environmental impacts by using electricity more efficiently and flexibly and by participating in local or renewable energy initiatives. These actions can help maximise the use of renewable electricity, reduce carbon emissions and support a more resilient energy system.

The environmental impacts of new technologies should also be considered. Electric vehicles, home batteries, heat pumps, solar panels and smart energy devices can support decarbonisation, but they also require materials, manufacturing, installation, maintenance and end-of-life recycling. Strong solutions should consider the full lifecycle of these technologies, including opportunities to reduce waste, improve circularity, reuse valuable materials and minimise environmental impacts while maximising emissions reductions.

The transition to a low-carbon electricity system will also require additional infrastructure, including renewable generation projects, transmission and distribution network upgrades, electricity storage facilities and electric vehicle charging infrastructure. While these developments can deliver significant climate benefits, they may also affect biodiversity, land use, visual amenity, cultural heritage, local communities and other environmental receptors. These impacts must be carefully assessed and, where possible, avoided, reduced or mitigated through responsible planning, design and operation.

As electrification accelerates, opportunities exist not only to minimise environmental impacts but also to deliver positive environmental outcomes. Nature-inclusive design, biodiversity enhancement measures,

[34] https://www.gov.ie/en/department-of-climate-energy-and-the-environment/publications/climate-action-plan-2025/
[35] https://www.seai.ie/plan-your-energy-journey/for-your-home/guide-to-upgrades
[36] https://www.gov.ie/en/department-of-climate-energy-and-the-environment/publications/national-retrofit-plan/



sustainable construction practices and circular economy principles can help ensure that energy infrastructure contributes positively to environmental objectives. EirGrid's Biodiversity Strategic Plan[37] emphasises the importance of identifying, managing and mitigating environmental effects while seeking opportunities to enhance ecosystems and support long-term environmental resilience.

6.2 Prompts for Sustainability and the Environment

Table 8 - Optional Prompts relating to the sustainability and environmental considerations for Powering Up the Energy Citizen

Optional Environment Considerations for CleanerGrid
• ‘How could citizens or communities measure the carbon savings of an electrification project, taking account of its full lifecycle?’
• ‘Design a project that helps reduce carbon emissions through smarter electricity use.’
• ‘Design a project that supports sustainable electrification while protecting biodiversity and local environments.’
• ‘How can citizens play a greater role in reducing Ireland's greenhouse gas emissions?’
• **Or any other idea you have…**

Multidisciplinary potential! 'Design a project that helps make the environmental benefits of electrification accessible to everyone'.

Multidisciplinary potential! ‘Create a solution that balances environmental sustainability with growing electricity demand’

[37] https://cms.eirgrid.ie/sites/default/files/publications/EirGrid-Biodiversity-Strategic-Plan-2025-2035.pdf

7 Behaviour, Marketing and Stakeholders

7.1 Background Reading

Behaviour, marketing, and stakeholder engagement are central to the success of widespread electrification. However, their benefits depend not only on technical performance, but also on whether people understand them, trust them, can afford them and feel confident using them. The benefits of electrification should be available to all citizens regardless of income level, location or housing tenure. Research published through the SEAI Behavioural Insights programme[38] highlights the important role that behavioural, social and economic factors play in shaping energy-related decisions. For this reason, the energy citizen theme is as much a social and behavioural challenge as it is an engineering, data or market challenge.

One important question to consider is why citizens choose to adopt, delay or reject electrification technologies. Cost is often a major barrier, particularly where upfront investment is required for home retrofits, heat pumps, EVs or solar PV. Evidence from SEAI Behavioural Insights publications and the SEAI Behavioural Insights for Electricity Demand Flexibility study[39] suggests that other barriers can include lack of awareness, complexity, disruption, uncertainty about savings, limited access to suitable housing or parking, digital exclusion and concern about data privacy. Strong projects may explore how these barriers differ between households, communities, age groups, income levels, renters, homeowners, urban areas and rural areas and how electrification programmes could be designed to mitigate them. Students may also wish to consider how these issues could influence future electrification pathways outlined in EirGrid's Tomorrow's Energy Scenarios.[40]

Participation drivers are equally important. Citizens may be more likely to engage when solutions are simple, trusted, financially worthwhile and linked to clear personal or community benefits. Findings from SEAI Behavioural Insights for Electricity Demand Flexibility highlight how behavioural insights can support the design of more effective communications, incentives and user experiences. For example, clear prompts, default options, trusted messengers, peer comparisons, feedback on energy use and simple explanations of flexible tariffs may all help citizens understand the value of changing how and when they use electricity.

Trust and fairness should be considered throughout. Citizens will be asked to share data, respond to price signals, allow greater automation of appliances, or participate in flexibility services through suppliers, aggregators or community schemes. These changes may benefit the electricity system, but they must be designed in a way that protects consumers and avoids leaving vulnerable groups behind. The CRU National Energy Demand Strategy[41] highlights the importance of enabling active participation while ensuring consumers remain protected and informed. Similarly, the International Energy Agency's Scaling Up Demand Flexibility report[42] emphasises the need for transparent, inclusive and accessible approaches that build trust and ensure all consumers can benefit from the energy transition. Projects in this area could examine how to make smart energy participation transparent, inclusive and accessible, while ensuring that people remain in control of their own energy choices.

[38] https://www.seai.ie/data-and-insights/behavioural-insights/publications
[39] https://www.seai.ie/behavioural-insights-electricity-demand-flexibility
[40] https://www.eirgrid.ie/industry/tomorrows-energy-scenarios-tes
[41] https://www.cru.ie/publications/28200/
[42] https://www.iea.org/reports/scaling-up-demand-flexibility

Marketing and communications also have a role in connecting individual actions to wider system benefits. Many citizens may not immediately see how charging an EV at a different time, pre-heating a home, using a smart appliance or joining a demand response scheme like ESB's Beat the Peak Initiative[43] can help reduce peak demand, integrate renewable electricity or lower system costs. The future energy pathways presented in EirGrid's Tomorrow's Energy Scenarios and Shaping Our Electricity Future[44] rely on increasing levels of electrification and more active demand-side participation. Students may wish to explore how EirGrid, working with partners such as suppliers, ESB Networks, SEAI, the CRU, local authorities, community groups and technology providers, could explain these links in a clear and practical way, building on existing programmes, campaigns and initiatives and considering current levels of public awareness and support.

Stakeholder engagement is particularly important because no single organisation can deliver the energy citizen transition alone. A TSO can provide system-level insight, planning signals and coordination, but customer relationships, local networks, pricing, consumer protection, grants and technology installation involve many other actors. EirGrid's Stakeholder Engagement Plan[45] highlights the value of informing, consulting, involving and collaborating with stakeholders to support better decisions and outcomes. Similarly, EirGrid's Public Engagement Strategy[46] demonstrates the importance of early and meaningful engagement in building understanding, trust and public support. Successful projects may therefore consider who needs to be involved, what information each stakeholder needs and how citizens can be engaged early enough to shape solutions. Projects may also assess the effectiveness of current approaches to trust-building, public engagement and inclusion, identifying ways to improve accessibility, participation and confidence among different customer groups.

Students may also wish to consider how collaboration between citizens, communities, policymakers, regulators, network operators, suppliers and technology providers can support the objectives outlined in the Government's Energy Security in Ireland to 2030 strategy[47], including reducing demand, improving flexibility, strengthening energy security and supporting the transition to a renewable, electricity-led energy system. The IEA Electricity Market Design report[48] may also help students explore how electricity markets, incentives and consumer participation mechanisms could evolve to support a more secure, affordable and sustainable energy future.

[43] https://www.esbnetworks.ie/services/optimise-my-energy-use/beat-the-peak-programme
[44] https://www.eirgrid.ie/shaping-our-electricity-future
[45] https://cms.eirgrid.ie/sites/default/files/publications/Final-Stakeholder-Engagement-Plan-2026.pdf
[46] https://cms.eirgrid.ie/sites/default/files/publications/EirGrid-Public-Engagement-Strategy.pdf
[47] https://assets.gov.ie/static/documents/energy-security-in-ireland-to-2030-265afb44-cdff-4acc-b507-afe44a2462c8.pdf
[48] https://www.iea.org/reports/electricity-market-design



7.2 Prompts for Behaviour, Marketing and Stakeholders

Table 9 - Optional Prompts relating to the stakeholder and marketing considerations for Powering Up the Energy Citizen

Optional Behaviour, Marketing and Stakeholders Considerations for CleanerGrid
• ‘How can electrification be made simple, trusted and worthwhile for everyone?’
• ‘What barriers prevent citizens from participating in the energy transition?’
• ‘How can behavioural science encourage smarter energy use?’
• ‘How can energy technologies and services be made accessible to all communities?’
• ‘How can Ireland ensure that powering up the energy citizen contributes to a Just Transition?’
• **Or any other idea you have…**

Multidisciplinary potential!
- ‘How can every home become an active participant in the energy system?’

Multidisciplinary potential!
- ‘How can communities help balance Ireland's electricity grid?’

Multidisciplinary potential!
- ‘How can homes, vehicles and businesses work together to create a smarter electricity system?'

