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INTEGRATE TO ZERO

Integrate to zero

Policies for on-site, on-road, on-grid distributed energy resource integration

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Introduction

The power sector is leading the energy transition, but the pace of change must quicken to achieve decarbonisation goals. A doubling of the annual rate of investment in the transition is required to ensure that clean power is the most affordable and reliable option for all countries to meet their power needs efficiently by 2030. Investment will need to flow to low-carbon generation and to grid infrastructure upgrades, to meet growing demand and enable flexible deployment of both demand and supply.[1]

An estimated 7.4-8.0 TW of additional renewable power capacity is needed globally by 2030, quadrupling the current deployment rate.[2] Centralised renewable generation will not deliver this level of change on its own. Nor should it. Distributed energy resources (DERs) such as heat pumps, water heaters, small-scale solar generation and battery storage can help to overcome the challenges to centralised supply stemming from the poor state of many electricity grids, long permitting times and the disruption caused by climate impacts. Behind-the-meter DERs can be found **on-site** at a consumer's facility or home, or **on-road** in the form of electric vehicles (EVs). The market is now vibrant and the benefits to consumers and the energy system are growing. To fulfil their potential as electricity system resources, DERs must be effectively integrated **on-grid**.[3]

Effectively integrated DERs can shift when they draw power from or feed power into the grid according to the value their flexibility provides to the system. This reduces carbon emissions from fossil generation used to meet peaks in electricity demand, increases system resilience, and benefits all consumers through the lower prices resulting from avoided generation and network capacity costs.

This brief sets out the policy approaches that will help promote the effective integration of behind-the-meter DERs. We highlight best practices from around the world to allow the full potential of DERs to be tapped.

Four policy insights arise from the discussion in this brief:

1 **A strong set of enabling policies can remove barriers to DER integration.** Enabling policies include smart codes and standards; innovative subsidy programmes; regulatory reform to allow market access; and capacity building among consumers, supply chains, network operators and regulators. Together, these policies augment the flexibility potential of DERs and enable their participation in power system optimisation.

2 **Price signals should reflect power system optimisation needs.** To promote the flexible use of DERs, price signals aligned with energy and network costs should flow through the electricity system. Payments for energy services should vary in proportion to how much, when and where they are used or delivered. In some jurisdictions, time-of-use tariffs and compensation regimes are mandated or set as the default option.

3 **Cost-reflective price signals should be combined with fair market access for DERs.** Not all consumers want to be exposed to price volatility. With nondiscriminatory access to energy service markets and with pricing that reflects the full value of DERs, third-party service providers can shield consumers from price volatility in return for flexible management of DERs within agreed boundaries.

4 **International collaboration among policymakers and regulators can spread best practice.** No one jurisdiction has a monopoly on best practice, but some have made more progress on DER integration than others. Cross-border knowledge transfer among regulators is a growing phenomenon and can help each place to find its own way, guided by local circumstances, politics and experience.

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1 International Energy Agency, International Renewable Energy Agency & U.N. Climate Change High-Level Champions. (2022). *Breakthrough Agenda report 2022: Accelerating sector transitions through stronger international collaboration.* https://iea.blob.core.windows.net/assets/49ae4839-90a9-4d88-92bc-371e2b24546a/THEBREAKTHROUGHAGENDAREPORT2022.pdf

2 International Energy Agency et al., 2022.

3 Moss, A., Briggs, J., Killengray, E., Downey, J., & Lewis, E. (2023). *Integrate to zero: Carbon and cost reduction opportunities from integrated energy in GB.* Cornwall Insights. https://www.cornwall-insight.com/wp-content/uploads/2023/03/CI-Integrate-to-Zero-Insight-Paper-March-2023.pdf

DERs: Tools for the new energy age

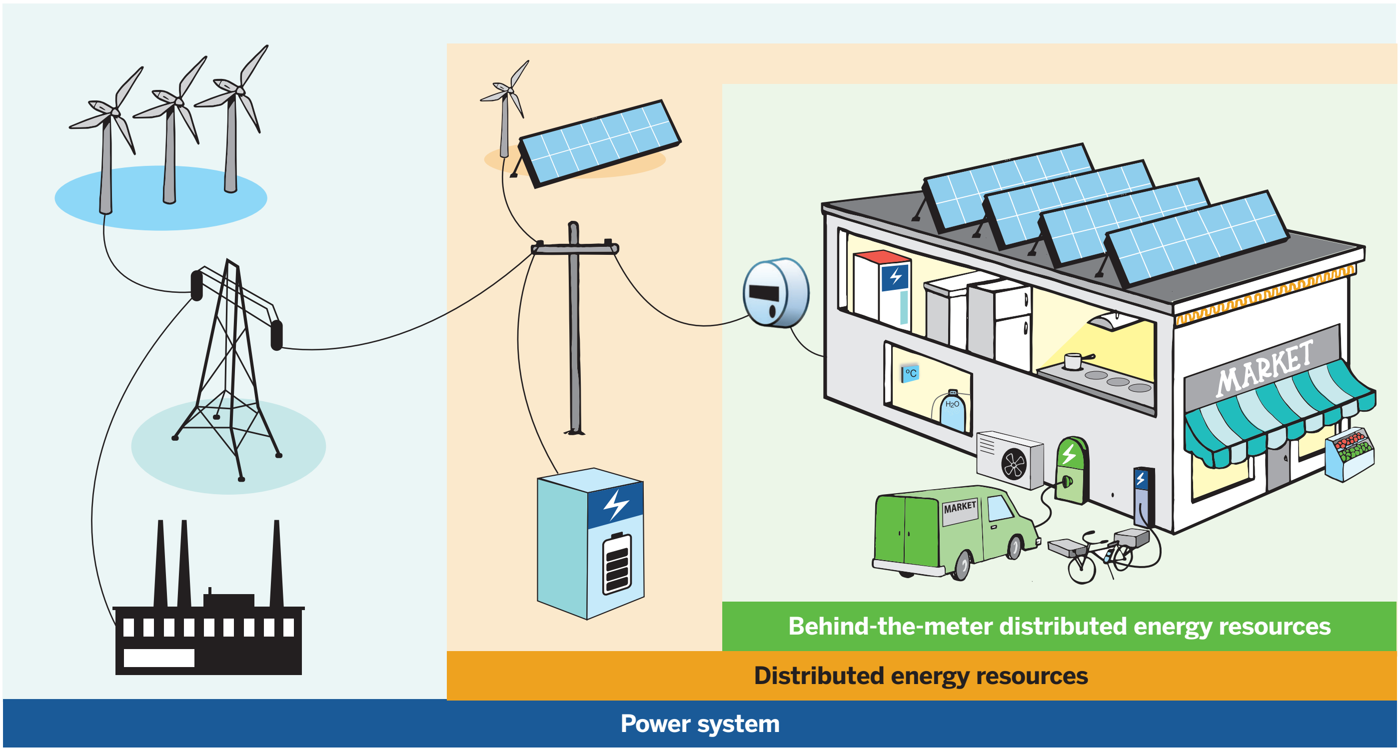
The rapid decarbonisation of the power system and the electrification of end uses are fundamentally changing the way in which electricity systems are best operated. We have moved away from a world in which only large dispatchable supply assets are called upon to meet demand. The future will be dominated by decentralised, intermittent generation. In this context, the integration of flexible DERs, across both demand and supply, lies at the heart of effective systems operation.

Distributed generation is proliferating. Renewable energy is growing fast, with solar photovoltaics (PV) leading the way, as costs fall. Businesses and households increasingly generate and store their own electricity in addition to drawing it from the grid. More than 130 countries are providing continuous policy support for renewables,[4] which are projected to dominate future electricity markets.[5] Most new generation will be on the distribution grid as renewable deployment dominates.[6] For G-7 countries to decarbonise their power supply by 2035 and to keep the world on track for net zero by 2050 (with a 45% reduction by 2030), an acceleration in these trends is essential.[7]

> **"Solar is becoming the new king of the world's electricity markets, leading the renewables charge."**
> — Fatih Birol, executive director, International Energy Agency

Electricity demand is growing. Most demand is also on the distribution grid, with electricity set to grow its share of energy use. Fossil-fuel-driven heating and transport systems are losing ground to much more efficient, electrically powered heat pumps and EVs. Rising incomes and global warming are pushing up air conditioning demand and electrical appliance use.[8] Figure 1 shows a small retail business with a set of behind-the-meter DERs, in the context of the power system.

Figure 1. Behind-the-meter distributed energy resources in the power system



4 International Energy Agency. (2021). *Renewables 2021*. https://www.iea.org/reports/renewables-2021

5 International Energy Agency. (2020). *World energy outlook*. https://www.iea.org/reports/world-energy-outlook-2020

6 Monitor Deloitte. (2021). *Connecting the dots: Distribution grid investment to power the energy transition.* https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/energy-resources/deloitte-ch-en-eurelectric-connecting-the-dots-study.pdf

7 International Energy Agency. (2021). *Net zero by 2050.* https://www.iea.org/reports/net-zero-by-2050

8 International Energy Agency. (2018). *The future of cooling.* https://www.iea.org/futureofcooling/

Behind-the-meter DERs can reduce the need for grid-scale resources. The costs of developing new grid-scale wind, solar and storage are falling rapidly. However, the opportunity cost of land use[9] and social resistance[10] can lead to push-back. A concerted effort to optimise DERs will be useful to assure those sceptical of grid-scale clean energy investments that projects are being built only if they're needed.

Effective DER integration is increasingly valuable. With renewable supply dependent on weather conditions and with the demand for heating, cooling and transportation liable to peak when renewables are not generating, storage and demand-side flexibility become increasingly valuable. Poorly integrated DERs can place additional burdens on the grid, if they add demand at peak and are unable to respond adequately to system needs. Effectively integrated, they can shift their demand or supply according to the value it provides to the electricity system.

Flexibility is the key to effective DER integration. Consumers can use the energy they produce, store it, or feed it into the grid. They can also reduce or shift their demand, increasingly through automated technologies. All these options can help the grid to operate efficiently, as well as enable consumers to benefit financially from their flexibility. To be able to perform each action when needed, DERs work best in combination. The combined value of various DERs can be greater than the sum of each in isolation.[11] Solar PV plus storage enables flexible supply and reduces the likelihood of curtailment. Solar PV plus a smart inverter enables improved grid stability. Heat pumps plus building insulation enables flexible demand, as does the combination of EVs and smart chargers. Bidirectional smart chargers enable EVs to offer flexible supply and demand services. Figure 2 shows some examples of combinations that can be called upon to provide flexibility services for the benefit of the electricity system.

Figure 2. Combining distributed energy resources enables flexibility

	Flexibility adders: Storage	Flexibility adders: Grid interface
Solar PV	Battery	Smart inverter
Electric vehicle	Battery (built in)	Bidirectional charger
Heat pump	Building fabric (insulation, etc.)	Smart meter
Water heater	Insulated tank	Grid-interactive controller

Policy needs to reflect the nature of behind-the-meter DERs to unlock their potential. They are largely invisible to system operators and are installed, owned and operated by numerous, varied actors: households, businesses, utilities and aggregators of energy services. Policy needs to adapt to this new reality to ensure that DERs can be effectively integrated, lowering the costs of the electricity system for all consumers.

9 van de Ven, D.-J., Capellan-Peréz, I., Arto, I., Cazcarro, I., de Castro, C., Patel, P., & Gonzalez-Eguino, M. (2021, 3 February). The potential land requirements and related land use change emissions of solar energy. *Scientific Reports, 11*, 2907. https://www.nature.com/articles/s41598-021-82042-5

10 Jarvis, S. (2022). *The economic costs of NIMBYism: Evidence from renewable energy projects.* https://stephenjarvis.github.io/files/jarvis_jmp_nimbyism_renewable_energy.pdf

11 Shenot, J., Linvill, C., Dupuy, M., & Brutkoski, D. (2019). *Capturing more value from combinations of PV and other distributed energy resources.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/capturing-more-value-from-combinations-of-pv-and-other-distributed-energy-resources/

Four insights for effective DER policy

For DERs to be effectively integrated, they need to be able to react flexibly when called upon, and they need to face price signals reflecting the value of demand and supply to the electricity system. Enabling policies support the building of the flexible DER asset base and remove barriers to their participation in energy system optimisation. Once the assets are installed, pricing policies can ensure that price signals provide incentives for their integrated use.

These two sets of policy measures are mutually reinforcing. Price signals that are aligned with grid needs encourage customers to add DERs where they are most valued, growing the DER asset base. At the same time, enabling policies that support the addition of DERs make it all the more important to ensure that price signals support their integration.

The key is to quickly get policies in place that will shape DER deployment in the public interest. Aside from climate outcomes, urgency is needed to more efficiently allocate capital. Government, businesses and households are allocating huge amounts of capital every day as they build and renovate buildings, build and retool factories, and manage vehicle fleets. If policy and markets are out of sync with stated government objectives, capital is likely to be spent on low priority or even contradictory investments, and priority investments overlooked.

This section goes into more depth on each of four broad policy insights and provides global examples of policy in action.

POLICY 1 INSIGHT

A strong set of enabling policies can remove barriers to DER integration.

DERs are inherently flexible, particularly in combination, and exploiting that flexibility lies at the heart of effective integration. The mass charging of EVs during peak heating or cooling hours creates unnecessary energy and network costs, increases emissions and reduces reliability, all of which could be remedied by a combination of delayed charging and preheating or cooling of energy-efficient buildings using heat pumps. Similarly, the large-scale export of PV generation during off-peak periods creates operational and economic challenges to system operators that could be managed efficiently by storing that generation and supplying it during peak hours, when it is more valuable.

The following pages provide examples of policy measures designed to build flexibility capital — the ability to be flexible in energy use[12] — and enable the integration of DERs.

Codes and standards

Building codes and product standards have a long history of driving successful market transformation in North America, Europe, Asia and Oceania. What has been successful in improving the energy performance of buildings and equipment can be replicated in making them 'flexibility-ready.'

Leading jurisdictions are introducing smart building codes to ensure that they include DER provisions.

- The EU Solar Energy Strategy of 2022 is part of the plan to quickly reduce dependence on Russian gas imports. The strategy includes a phased-in legal obligation to install solar panels on all new public and commercial buildings by 2026-27. EU Member States must ensure that all new buildings are solar-ready, including energy storage and heat pumps.[13]
- California has required rooftop PV on all new buildings since 2020. The 2022 building code made the coupling of PV with battery storage mandatory for new commercial, public use and multifamily buildings. The PV must be sized to provide at least 60% of the building's expected load, and the storage must be sufficient to reduce export to the grid to 10% of total on-site solar generation. New residential homes must be storage-ready.[14]

12 For a discussion on this topic, see: Powells, G., & Fell, M. J. (2019, August). Flexibility capital and flexibility justice in smart energy systems. *Energy Research & Social Science, 54*, 56-59. https://www.sciencedirect.com/science/article/abs/pii/S2214629619301185

13 European Commission. (2022). *EU solar energy strategy* (COM[2022] 221 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A221%3AFIN&qid=1653034500503

14 California Energy Commission. (2022). *2022 building energy efficiency standards for residential and nonresidential buildings*. https://www.energy.ca.gov/publications/2022/2022-building-energy-efficiency-standards-residential-and-nonresidential; see also: Weaver, J. F. (2021, 16 December). California first state to require solar power and batteries in commercial structures. *pv magazine*. https://pv-magazine-usa.com/2021/12/16/california-first-state-to-require-solar-power-and-batteries-in-commercial-structures/

Product standards can enable DERs to communicate with the grid to reduce disturbances and provide grid services.

- The U.S. states of Washington[15] and Oregon[16] require all new water heaters to be grid-integrated and controllable with rapid flexibility capability through a modular demand response communications port.
- In 2017, California was the first U.S. state to require the use of smart inverters in solar and other distributed generation projects.[17] Several other U.S. states are developing similar rules that will enable advanced grid management and pave the way for more DER integration.[18]

Smart charging standards are key to EV integration, allowing charging to be scheduled when electricity is most abundant.

- The UK's Smart Charge Points Regulations require all EV chargers sold to have smart functionality and meet standards for data connectivity, delayed charging, energy security, interoperability and data privacy.[19]
- The EU's proposed revision of the Energy Performance of Buildings Directive would require all new nonresidential buildings and those with more than five parking spaces undergoing major renovation to include charging points and provide cabling for all parking spaces to enable smart charging.[20]
- The proposed revision to the EU Renewable Energy Directive would require all private charging infrastructure installations to support smart charging.[21]
- Complementing this, the proposal for the Alternative Fuels Infrastructure Regulation would mandate smart charging and digital connections for all new publicly accessible charging points, while also recommending that all normal charging points at which vehicles are typically parked for a longer period should support smart charging.[22]

Programmes that promote flexibility

Government programmes can help to overcome barriers to the adoption of the range of solutions needed to boost integration capabilities. For example, existing subsidy programmes can be tweaked to favour integration readiness, and pilot programmes can provide the on-the-ground experience often needed before mass implementation. The best pilots examine the potential for scaling up.

DER subsidies can be linked to flexibility criteria, as well as incorporating other elements of good programme design.

- The Irish One Stop Shop, launched in 2022, links subsidies for heat pumps with minimum standards for the building's fabric efficiency. This ensures that heating systems can be operated at low flow temperatures, reducing electricity demand, and buildings can be preheated to shift electricity consumption from peak periods. The programme has other best-practice features. It reduces the hassle costs for building owners, providing a single point of contact for managing the renovation, heating system installation, energy audit and grant application. It also gives certainty to the supply

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15 State of Washington, 66th Legislature, 2019 Regular Session. Second substitute House Bill 1444, Chapter 286, Laws of 2019: Appliance Efficiency Standards. https://lawfilesext.leg.wa.gov/biennium/2019-20/Pdf/Bills/Session%20Laws/House/1444-S2.SL.pdf?q=20200611070408

16 Oregon Department of Energy. (n.d.). *Energy efficiency standards rulemaking*. https://www.oregon.gov/energy/Get-Involved/Pages/EE-Standards-Rulemaking.aspx

17 Aurora Solar. (2022, January). *California's new smart inverter requirements: What "Rule 21" means for solar design.* https://aurorasolar.com/blog/californias-new-smart-inverter-requirements-what-rule-21-means-for-solar-design/

18 Driscoll, W. (2021, 2 July). States would be smart to require smart inverters for new distributed resources. *Solar Today Magazine*. https://ases.org/states-would-be-smart-to-require-smart-inverters-for-new-distributed-resources/

19 His Majesty's Government. (2021). *The electric vehicles (smart charge points) regulations 2021*. https://www.legislation.gov.uk/uksi/2021/1467/contents/made

20 European Commission. (2021, 15 December). *Proposal for a directive of the European Parliament and of the Council on the energy performance of buildings (recast)* (COM[2021] 802 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889

21 European Parliament and Council of the European Union. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG

22 European Commission. (2021, 14 July). *Proposal for a regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0559

chain, with a clearly set out budget that runs until 2030, providing the policy predictability needed for the private sector to build capacity.[23]

Support programmes can build flexibility capital.

- In the United States, under the Inflation Reduction Act, households can claim federal tax credits for EVs, building fabric improvements, rooftop solar panels, geothermal heat pumps and batteries, and a rebate of up to $4,000 for upgrading building wiring systems and breaker boxes. Qualifying upgrade costs include both equipment and installation costs. The upgrading of a building's electricity infrastructure is often necessary but is not recognised in the programme design.[24] Private companies are using the subsidies available through the Inflation Reduction Act to bundle DER offerings.[25]

Pilot projects can provide real-world trials of innovative use cases.

- The Swiss Federal Office of Energy is supporting the V2X Suisse grid stabilisation demonstration project using vehicle-to-grid (V2G) technologies. This real-world trial involves motor manufacturers, car-sharing companies, software developers, solar-powered charging station developers, aggregators and scientific advisers. It aims to gain rapid insights into how V2G could become a reality in Switzerland.[26]
- In San Diego, California, a pilot programme is feeding power back to the grid during peak hours using a fleet of school buses.[27]
- In Hawaii, a company called Shifted Energy is controlling roughly 3,000 electric water heaters, primarily in multifamily and low-income housing. Customers get a financial reward for participating and providing the utility with grid services such as load building during times of excess solar generation and fast frequency response.[28]
- UK Research and Innovation invested over $120 million, matched by industry, to help businesses, researchers and local communities develop, test and prove smart local energy system solutions that incorporate EVs, renewable generation, batteries and digital data technology.[29]

Market access for distributed energy resources

A reliable and least-cost renewables-based electricity system requires the use of all available forms of flexibility. Demand-side flexibility and storage need to be able to align with variable supply. Consumers' energy consumption and production can be flexed via tariffs (see the section on price signals below) or channelled by aggregators or third-party service providers to various electricity markets (wholesale and balancing) or to the network operator at both the distribution and transmission levels.

The ability to sell energy to the grid is a fundamental building block of DER integration. In many emerging and developing countries, restrictions limit the extent to which this is possible. Market reforms that remove these restrictions can advance DER integration, although in many cases access is still limited.

- In Morocco, a new bill 82.21 aims to reduce restrictions on sending electricity from distributed generation to the grid, with up to 20% of annual production being proposed as the limit and a threshold of 5 MW before the need to enter the licensing system.[30]
- In Zimbabwe, the capacity threshold to apply for compensation for energy sent to the grid from renewable distributed generation was capped at 100 kW, meaning that many opportunities for oversizing rooftop and

23 Sustainable Energy Authority of Ireland. (n.d.) *One stop shop service.* https://www.seai.ie/grants/home-energy-grants/one-stop-shop/

24 U.S. Department of Energy. (n.d.). *Inflation Reduction Act of 2022.* https://www.energy.gov/lpo/inflation-reduction-act-2022

25 See, for example: Electrum. (n.d.). *Home electrification solutions.* https://www.electrum.co

26 Mobility. (2022, 6 September). *Swiss pilot project for grid stability is launched: 50 electrically powered Mobility cars become power banks* [Press release]. https://www.mobility.ch/fileadmin/files/about/media/media_releases/20220906-Media-release-Mobility-V2X.pdf; V2G Hub. (n.d.). *V2X Suisse.* https://www.v2g-hub.com/projects/v2x-suisse/

27 Descant, S. (2022, 2 August). *San Diego electric school buses to gird grid during peak times.* Government Technology. https://www.govtech.com/fs/san-diego-electric-school-buses-to-gird-grid-during-peak-times

28 Shifted Energy. (n.d.). *Support clean energy, get paid, feel good.* https://www.shiftedenergy.com/hawaii/

29 UK Research and Innovation. (2022). *Smart local energy systems: The energy revolution takes shape.* https://www.ukri.org/wp-content/uploads/2022/01/UKRI-250122-SmartLocalEnergySystemsEnergyRevolutionTakesShape.pdf

30 Kingdom of Morocco. (2022). *Adoption Du Projet De Loi N° 82.21 Relatif À L'autoproduction D'énergie Électrique Par La Chambre Des Représentants.* https://www.mem.gov.ma/Pages/actualite.aspx?act=358

mounted solar installations were missed. The cap has now been raised to 5 MW per site.[31]

Market-access rules that provide equal access for demand and supply are crucial for energy service providers to get fair compensation that can be shared with their DER consumers.[32]

- In Europe, France (starting as early as 2014) and Ireland provide the widest access to electricity markets. Aggregators can operate in all balancing, day-ahead, intraday and capacity markets.
- The inclusion of demand-side flexibility in capacity markets has a much longer history in the United States[33] and is still the dominant market for demand-side resources in terms of revenue.[34] Nevertheless, it is important to note that capacity markets dampen wholesale energy price signals, reducing the rewards available for demand reduction and shifting at peak. This makes it especially important that capacity markets are designed to be genuinely inclusive of behind-the-meter DERs.[35] The EU electricity regulation requires Member States to explore energy market design options before considering capacity markets, having considered the potential of DERs to resolve resource adequacy concerns.[36]

Demand-side flexibility can unblock network congestion, often more cost-effectively than investing in the grid. As such it can be key to managing the growth of a renewables-based power system on the distribution network. Local flexibility markets, built on the ability of consumers and third parties to access granular data on grid constraints previously held by network operators, are evolving in Europe to help integrate DERs but are still a niche practice.[37]

- GOPACS, introduced in 2018 in the Netherlands, is one of the first local flexibility markets where the transmission and all distribution system operators cooperate in solving network congestion. Although it is still relatively new, its importance is likely to grow with the increasingly congested Dutch grids.[38]

Capacity building

The acceleration of the energy transition requires skilled labour, able to install and maintain integrated DERs; informed customers, willing to invest in DERs and use them to the mutual benefits of themselves and the grid; and innovative regulators that push forward enabling reforms.

To advance the transition, regulators need to ensure that network operators invest in smart grids. Regulators should reexamine various long-standing practices to steer the decarbonisation process. In particular, they should incentivise network operators to invest in grid technology that senses and communicates local grid needs so that it can effectively integrate DERs. Building capacity among regulators to make the necessary reforms to system operator regulation is essential in this context. Information sharing between regulatory offices can enhance the efficacy of regulatory reforms, as successes in leading jurisdictions help the adoption of innovative solutions elsewhere.

- Associations of national regulatory authorities, such as the Council of European Energy Regulators and the Energy Regulators Regional Association, have long-standing training curricula for their members involving

31 Kuhudzai, R. J. (2022, 15 December). *Update on Zimbabwe's net metering program.* CleanTechnica. https://cleantechnica.com/2022/12/15/update-on-zimbabwes-net-metering-program/

32 For a European overview see: Murley, L., & Alberti Mazzaferro, C. (2022). *European market monitor for demand-side flexibility 2021.* Delta-EE and smartEn. https://www.delta-ee.com/report/2021-european-market-monitor-on-demand-side-flexibility/?nocache=1672806722

33 Partly because centralised capacity markets have a relatively long history in the United States and partly because behind-the-meter DERs have not had direct access to wholesale markets.

34 Walton, R. (2017, 6 September). *PJM considers tweaks to boost demand response in wholesale power markets.* Utility Dive. https://www.utilitydive.com/news/pjm-considers-tweaks-to-boost-demand-response-in-wholesale-power-markets/504346/

35 Yule-Bennett, S., & Sunderland, L. (2022). *The joy of flex: Embracing household demand-side flexibility as a power system resource for Europe.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/joy-flex-embracing-household-demand-side-flexibility-power-system-resource-europe/

36 European Parliament and Council of the European Union. Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast), Article 20. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN

37 Chondrogiannis, S., Vasiljevska, J., Marinopoulos, A., Papaioannou, I. & Flego, G. (2022). *Local electricity flexibility markets in Europe* (EUR 31194 EN). Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC130070

38 Bellini, M. (2021, 14 December). Netherlands updates grid congestion map. *pv magazine.* https://www.pv-magazine.com/2021/12/14/netherlands-updates-grid-congestion-map/

academic and technical expert institutions, offering standard and on-demand courses on various regulatory issues.

- The newly established African School of Regulation will focus on Africa, building on European and U.S. regulatory experiences.[39]

A social licence is needed for consumers to fully integrate their DERs. As DERs become more mainstream, moving beyond enthusiastic early adopters, coordinating authorities need to create and maintain the conditions within which consumers are prepared to use their assets in ways that benefit the energy system. Pilot programme research on flexible load management across many countries found that successful projects develop and communicate clear shared goals, include informed consent protocols, and compensate consumers in ways deemed to be commensurate.[40]

- The Local Energy Oxfordshire (UK) project investigated the value propositions for participants in smart local energy systems, so it could improve its engagement with potential participants. It found that, while financial considerations are important, environmental and 'energy citizenship' benefits were sometimes perceived as more valuable, at least to early adopters. At the same time, among those for whom financial considerations were most important, the value proposition was least apparent.[41]
- Data handling and protection can be a major concern, particularly in some European countries — for example, when rolling out on-site integration infrastructure, such as smart meters. The EU Digitalisation Action Plan asks for "consumer-focused digital tools designed to meet the needs, skills, conditions, habits and expectations of different categories of market participants."[42]

Training and certification can build up a skilled labour force. Many countries have stepped up training programmes aimed at delivering a qualified workforce for a low-carbon economy.[43]

- The EU Skills Agenda highlights the intersection between the green and digital transitions, which underpins the effective integration of DERs.[44]
- The Skill Council for Green Jobs in India aims to facilitate training for 1 million people in green technologies and clean energy by 2030, including in key integration areas such as storage and EV charging.[45, 46]
- Germany and Jordan have worked together to set up an Energy Academy in Jordan, bringing together partners from industry and utilities with academia to deliver training on key integration enablers, including smart grids.[47]
- Panama has worked with the Inter-American Development Bank to set up a technical training programme focused on electromobility and distributed generation, aimed at reskilling transport and energy sector workers.[48]

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39 Florence School of Regulation. (2022, 31 January). *The African School of Regulation (ASR) initiative has been launched by a partnership of leading institutions in energy and climate change.* https://fsr.eui.eu/the-african-school-of-regulation-asr-initiative-has-been-launched-by-a-partnership-of-leading-institutions-in-energy-and-climate-change/

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41 Banks, N. (2022). *Value propositions in a smart local energy system.* Local Energy Oxfordshire. https://project-leo.co.uk/wp-content/uploads/2022/08/Value-Propositions-in-a-Smart-Local-Energy-System.pdf

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POLICY INSIGHT 2

Price signals should reflect power system optimisation needs.

To fully integrate DERs, price signals should better align with the value that their use can bring to the energy system. This makes tariff design crucial.

High fixed charges reduce the incentive and ability for customers to save money through actions that are efficient for the system, including investing in on-site generation. While there is not enough space in this policy brief to do justice to all the arguments around the balance between fixed and variable charges, it is true that high fixed charges do not motivate consumers to choose climate-friendly options.[49] Ultimately, this leads to a bigger and more expensive electricity system.

Time- and location-specific tariffs for electricity use and export drive consumers to make optimal choices for an increasingly variable energy system. As the energy transition progresses, the need grows for more granular price signals to flow through the system. Default time-of-use (TOU) tariffs for EV charging, for example, help to ensure that a significant proportion of this load can be operated flexibly, while still ensuring agency for consumers. Other loads, such as heat pumps, can also be used flexibly, but their ability to flex depends on other factors such as building energy performance, internet access and users' digital skills.

Effective DER integration should lead to lower electricity prices for all. However, to protect vulnerable consumers without access to highly flexible assets, it is important to provide protection from high prices — for example, through social tariffs — while ensuring that targeted deployment programmes support technology take-up.

- Hawaii is introducing a system-aligned tariff regime for all. In 2022, Hawaii became the first U.S. state to approve a rate design for all consumers that provides strong incentives to reduce peak time consumption.[50] This is an imperative for Hawaii, being an island state that has shut down fossil-based power plants, substituting them with solar and batteries. Customer bills are made up of three components. A small, fixed charge in each bill covers utility billing and payment-collection expenses. A 'grid-access charge' is proportional to the capacity a customer pulls from the grid in each month. Most of the bill, however, depends on how much and when the customer consumes energy. The three-period TOU rate design with a 1:2:3 price ratio among time periods makes off-peak water heating and EV charging very attractive. The rate does not differentiate between PV owners and other consumers. This pioneering rate reform may well set a precedent for states where the pressing need for demand-side flexibility is yet to come.[51]
- China now has TOU pricing. In 2021, China's National Development and Reform Commission (NDRC) issued a policy requiring provincial governments to design and implement TOU electricity pricing. TOU pricing will now be in place for nearly all retail customers — industrial, commercial and residential. Most provinces have now implemented TOU policies to comply with the NDRC's requirement.[52]
- Kenya is introducing TOU pricing for EVs. Following a proposal by Kenya Power, the Kenyan energy regulator is introducing off-peak pricing at half the rate of on-peak prices. Off-peak charging will help the Kenyan power system to operate more efficiently, while the cheaper rates should encourage more uptake of electric mobility, cutting fossil fuel imports.[53]
- California provides an interesting example of the evolution of compensation for export. It was one of the first jurisdictions to offer support to small-scale solar generation through feed-in tariffs, in response to federal

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53 Kuhudzai, R. J. (2023, 28 March). *Kenya's energy regulator approves new e-mobility specific electricity tariffs & new time of use tariffs.* CleanTechnica. https://cleantechnica.com/2023/03/28/kenyas-energy-regulator-approves-new-e-mobility-specific-electricity-tariffs-new-time-of-use-tariffs/

legislation in 2005.[54] The use of net energy metering (NEM), in which customers' exports were netted off their consumption monthly, proved very successful in bringing online more than 1.3 million rooftop systems with a capacity of 10 GW.[55] However, with consumption peaking after the sun goes down and generation peaking earlier in the day, this simple approach did not provide the incentives needed to shift exports to peak and consumption away from peak. It also gave rise to equity concerns. People generating electricity, who were disproportionately wealthy, were being paid more than their exported generation was worth, with the costs being borne by all consumers. As a result, NEM 2.0 was introduced in 2016, including time-differentiated tariffs and limiting the netting period to one hour for households and 15 minutes for commercial customers.[56] NEM 3.0, adopted after a year of fierce discussions between stakeholders and the regulator, changed the compensation for power exported to the grid from the retail rate to an hourly 'avoided cost' basis for each climate zone in California.[57]

- Denmark recently introduced TOU pricing for distribution networks. In most examples of TOU pricing around the world, electricity generation costs are allocated into TOU periods, but distribution network costs (such as the cost of capital, operation and maintenance) are allocated equally across time periods. In 2021, Denmark built on its long experience with time-varying electricity pricing and created a new framework that recognises the fact that distribution network costs also vary according to time of use. This will be important as electrification proceeds, given that times of peak use on distribution networks tend to drive the need for investment in costly distribution assets. By sending additional signals to shift demand away from peak periods, the Danish policy promises to avoid some costly distribution network upgrades while still allowing for electrification.

POLICY 3 INSIGHT

Cost-reflective price signals should be combined with fair market access for DERs.

Not all consumers wish to be exposed to volatile price signals. Ensuring fair market access for DER services, such as energy supply and demand response, enables third-party service providers to offer accessible and desirable retail products to consumers in return for flexible management of DERs within agreed boundaries. However, the true value of DER actions can be captured for the benefit of consumers only if electricity market design reflects that value and allows DER services to compete on a level playing field. The combination of cost-reflective price signals and nondiscriminatory market access enables service providers to offer a range of attractive retail products. This fosters consumer choice and agency, making further investment in cost-effective DERs more attractive.

POLICY 4 INSIGHT

International collaboration among policymakers and regulators can spread best practice.

No jurisdiction has a monopoly on best practice. Indeed, the priorities for DER integration policy will vary in line with geographical differences, economic development, institutional capacity, and how far places have travelled in their energy transitions. Some policymakers and regulators have progressed further than others in developing the full suite of measures identified in this policy brief, and many places are facing similar policy questions as they look to accelerate decarbonisation while expanding access to energy services. In this context, the sharing of knowledge, including through international technical assistance, can help push the boundaries of best practice and the spread of effective policies.

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Recommendations

When developing strategies to achieve energy and climate goals, governments should review the suite of policies that will enable and promote DER integration.

The table below provides an overview of the policy measures that, if adopted in a coordinated manner, can help drive the integration of DERs on-site, on-road and on-grid.

Barrier	Policy	Impact	Example
Value of flexibility not reflected in new-build market	Smart building codes	Flexible energy supply	Requirement for solar PV plus storage (California)
Value of flexibility not reflected in product markets	Smart product standards	Ability to provide rapid demand response	Requirement for grid-integrated water heaters (Oregon)
Value of flexibility not reflected in charger market	Smart charging standards	Ability to charge EVs when electricity is most abundant	Requirement for smart charging functionality (UK)
Upfront costs of building flexibility capital	Support programmes for integration	More adoption and greater ability to flex	Tax credits for wiring upgrades (U.S.)
Novelty	Pilot programmes	Proof of concept in the real world	Vehicle-to-grid trial (Switzerland)
Legacy energy market regulation	Market reform for DER access	Enhanced value stacking for DER aggregators	Wholesale market rules (France)
Legacy network regulation	Market reform for DER access	Enhanced value stacking for DER aggregators	Local flexibility markets (Netherlands)
Lack of policy and regulatory capacity	International collaboration	Knowledge-sharing and expert support	African School of Regulation (international)
Lack of supply chain capacity	Targeted support and incentives	Sufficient skilled labour	Skill Council for Green Jobs (India)
Value of DERs not reflected in price signals	Value-based tariffs for use and supply	Least-cost integration	System-aligned tariff regime (Hawaii)

Conclusion

As the energy transition ramps up, the energy system will be dominated increasingly by electricity generated from variable renewable sources. Behind-the-meter DERs will have a crucial role in meeting consumer needs. To ensure that DERs can contribute to their fullest extent, policymakers can draw inspiration from the various best-practice policies instituted around the world. Good policy enables the adoption of integration-ready DERs and ensures that the incentives for their use are aligned with system optimisation, benefiting all consumers, whether they have DERs or not.

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