

Smart networks, decentralized energy and market tools

12.2.2026

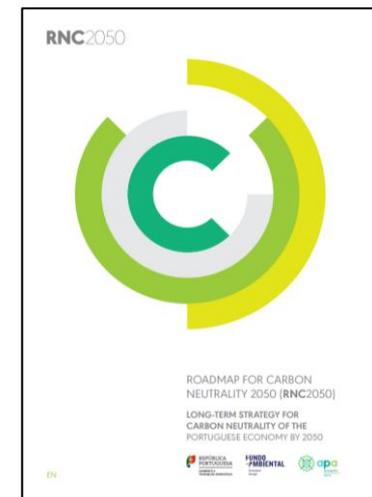
Ambition in the goals of the European Union: **Carbon neutrality by 2050!**



Portuguese Strategies: National Energy and Climate Plan (2030)



Roadmap for Carbon Neutrality (2050)

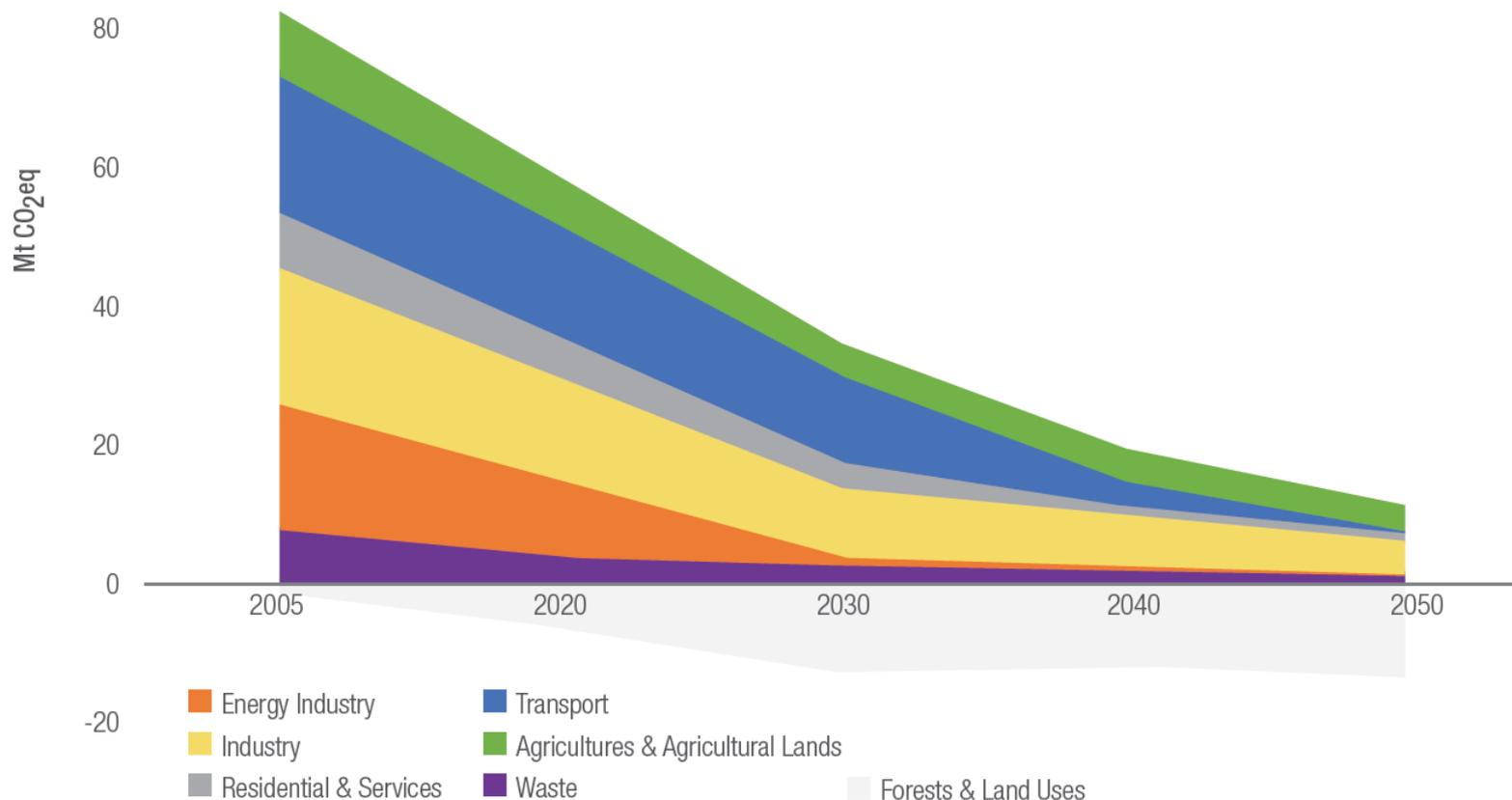


Towards a Neutral Carbon Society



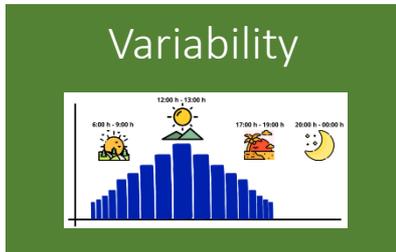
Contribution by sectors to the GHG emissions reduction trajectory by 2050 for Portugal

Data from the 2019 Portuguese *Roadmap for Carbon Neutrality 2050*

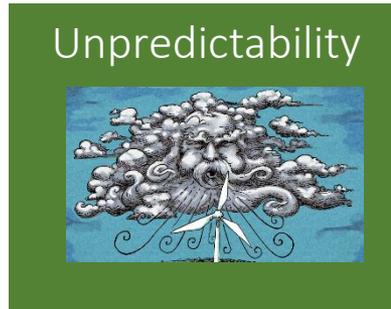


- **Renewable energy production** is predicted to increase from 32% to 85% until 2050
- **Energy dependence** is expected to reduce from 66% to 15% until 2050

Non-dispatchable renewables: main specificities

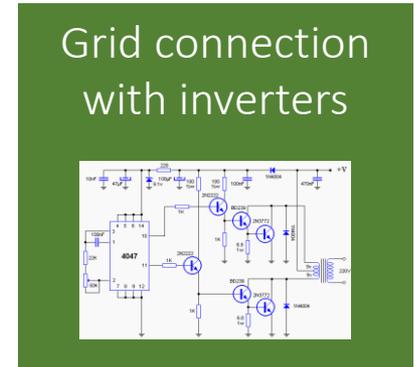


Dependence on the availability of the primary resource



Forecasting remains a challenge

«A transition towards high shares of VRE requires a re-thinking of the design, operation and planning of future power systems from a technical and economic point of view.»
(IRENA, [Renewable Energy Integration in Power Grids](#), 2015)



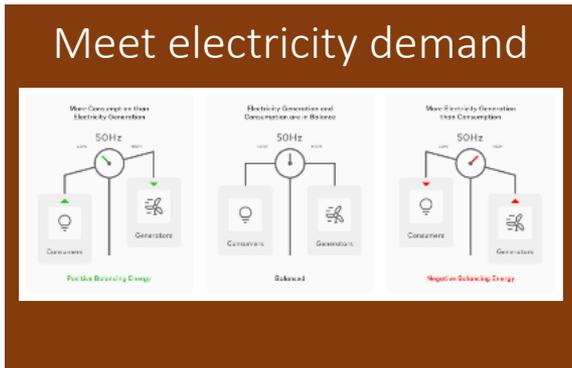
Power electronics
DC/AC



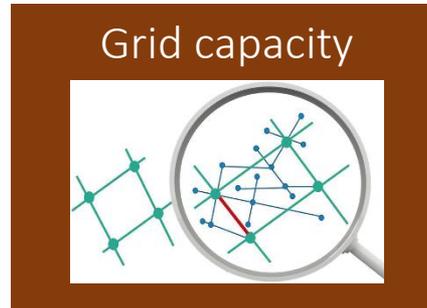
Small and distributed units



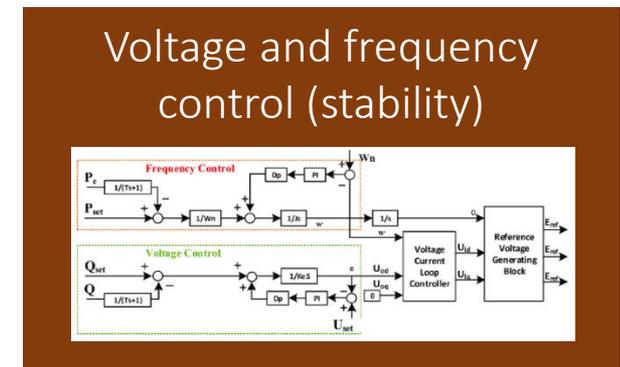
Fixed costs



- Resource scarcity / excess
- Ancillary services
- Flexibility
- Storage

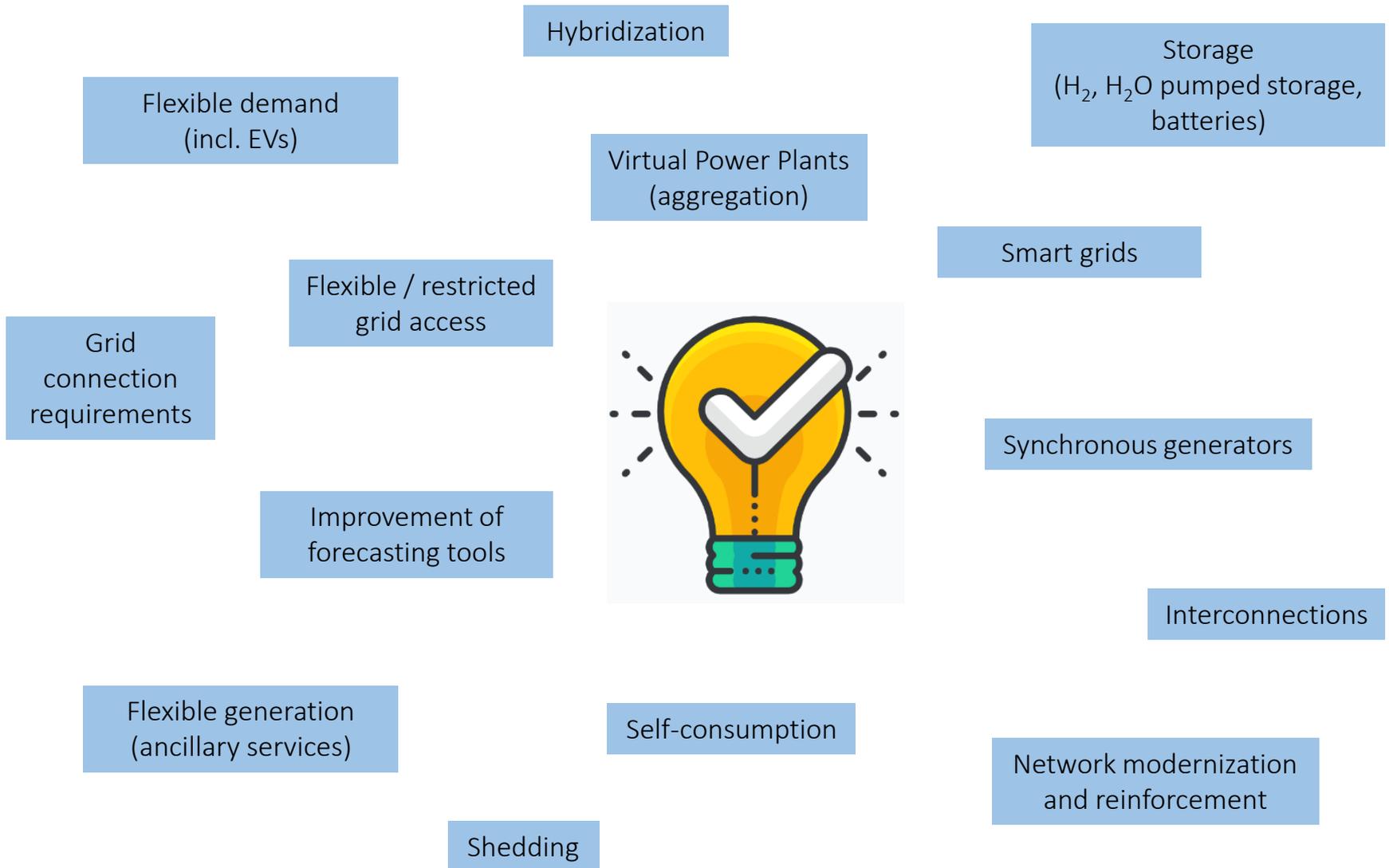


- Congestions
- Flow reversal

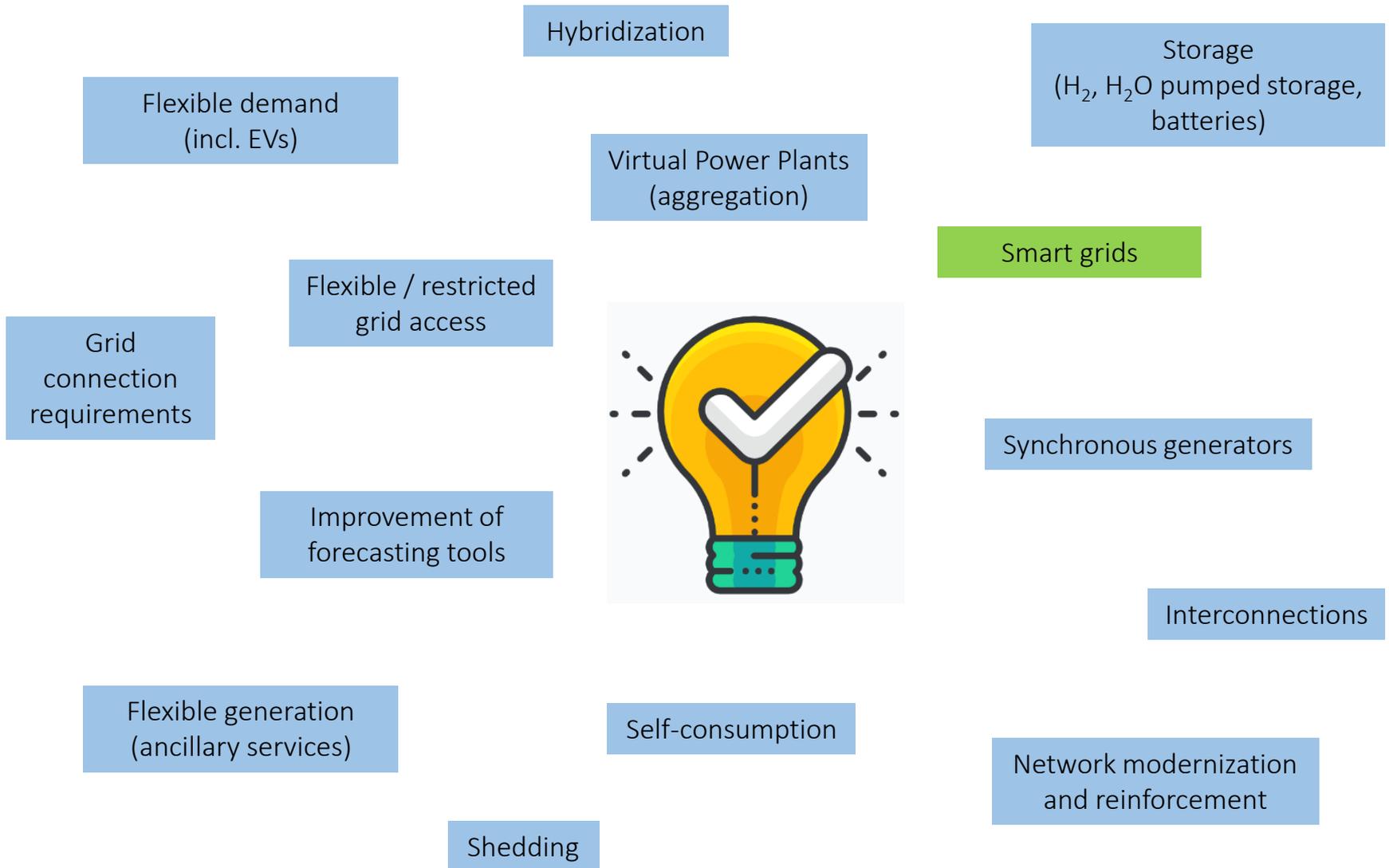


- Observability and controllability of *behind the meter* generation
- Inertia
- Protections

Some possible answers



Some possible answers



What is a smart grid?



⇒ Network capable of ensuring bidirectional flows of energy and data.

⇒ This data allows the monitoring, control and dynamic management of electricity, in real time,

⇒ with a view to optimizing energy flows, the integration of decentralized, variable renewable production, and the active participation of the consumer,

⇒ without compromising the quality and reliability of the electricity supply.



Smart grid as an enabler for renewable integration



“The smart grid introduces a **two-way** dialogue where electricity and information can be exchanged between the utility and its customers.”

“It’s a **developing network of** communications, controls, computers, automation and new technologies and tools working together to make the grid **more efficient, more reliable, more secure and greener.**”

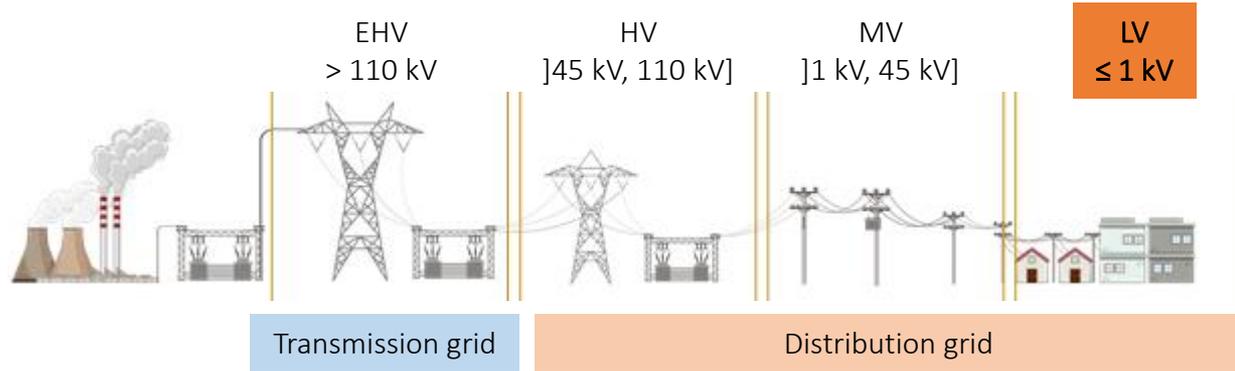
“Smart grids enable new technologies to be integrated such as wind and solar energy production: the smart grid provide the **data and automation needed to enable solar panels and wind farms to put energy onto the grid and optimize its use.**”



“To more **precisely and predictably manage electricity production**”

“Smart meters”

Smart meters: turning LV distribution system smarter



SCADA, EMS, DMS, RTU, State estimation, Network analysis

Passive load

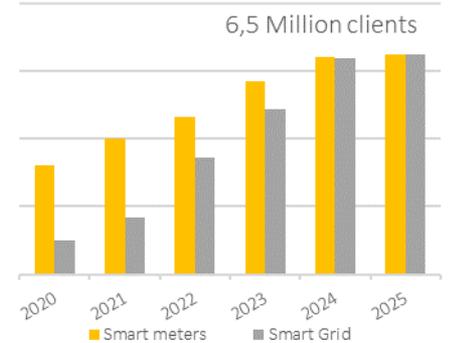
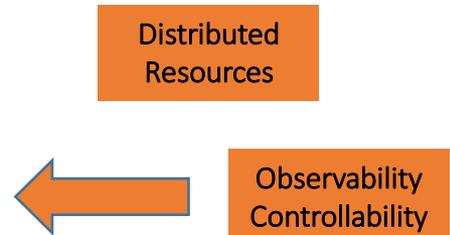
WARNING
YOU MAY BE
IN A
BLIND SPOT

Smart meter – a device that integrates an electronic system prepared to measure electricity consumption or electricity introduced into the network and that can transmit and receive data for the purposes of information, monitoring, control and action, using a form of electronic communication.

Must meet the technical and functional requirements defined by law ([Ordinance no. 231/2013](#))



Smart meters



Source: E-REDES

Storage, generation, active consumers, supporting smart appliances (EV charging) ...



Consumer

- Provides readings directly to the consumer and/or 3rd party
- Update readings frequently enough to use energy saving schemes
- Access to real time information (HAN serial port)
- Data access



Metering operator

- Allow remote reading by the operator
- Provide 2-way communication for maintenance and control
- Allow frequent enough readings for networking planning



Commercial aspects of supply

- Remote ON/OFF control supply and/or flow or power limitation
- Support advanced tariff system (implicit demand response)



Security – data protection

- Provides secure data communications
- Fraud prevention and detection



Distributed generation

- Provides import/export and reactive metering

[Decree-Law no. 15/2022](#), of 14 January, orders the integration in a smart grid of every low voltage (LV) customer in the mainland Portugal, by 2024. Integration in a smart grid allows customers to access a set of new advanced services.

ERSE's Smart Grid Services Code ([RSRI](#)) for electricity distribution, which designed the services to be offered by DSOs to users integrated in a smart grid. Since 2019, a regulatory incentive mechanism for services was made available.

Currently, some of the available services are:

- Daily remote meter reading and availability, in an electronic platform, of the detailed 15 minute demand and generation data
- Bills based on actual consumption, without estimates
- Possibility to access the meter locally, with close to real time data available (+/- 500 requests/yr) [main DSO has a pilot project for near real-time data access - [Smart metering plus](#)]
- Possibility to remotely change the contracted power and access other services, without having to be present at your facilities and with shorter scheduling times (>250 000 operations last year)
- Alerts for consumption level and usage of contracted power

ERSE's supervision activities include the overview of the deployment of smart grids and the development of services by market agents.

New task assigned by Directive (EU) 2019/944 and transposed into national law:

=> Every two years, ERSE will publish a report assessing the performance of SOs in developing a smart grid that promotes energy efficiency and renewables integration, based on a list of indicators (**Smart Grid KPIs**).

ERSE approved the KPIs after a public consultation and published the first report (to be published soon).

Some of the proposed SGKPIs' dimensions:

- Remote monitoring and control of network nodes and user facilities
- Asset management
- Grid planning
- Grid losses
- Continuity of supply
- Provision of information to network users
- Procurement of ancillary services and flexibility services
- Distributed resources
- Smart grid services
- Cybersecurity



CEER published the paper '[Electricity "Smart Grid" Performance Indicators](#)', to provide the National Regulatory Authorities (NRAs) a structured framework and a limited set of output indicators

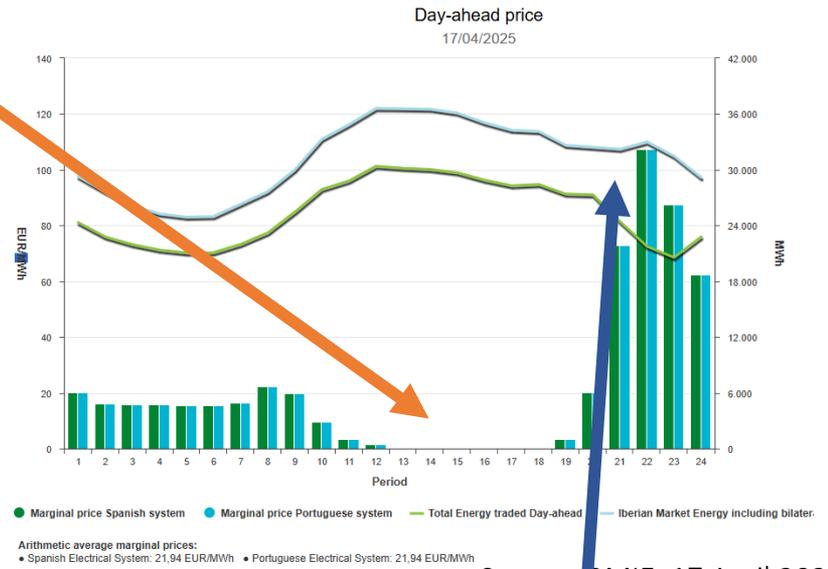
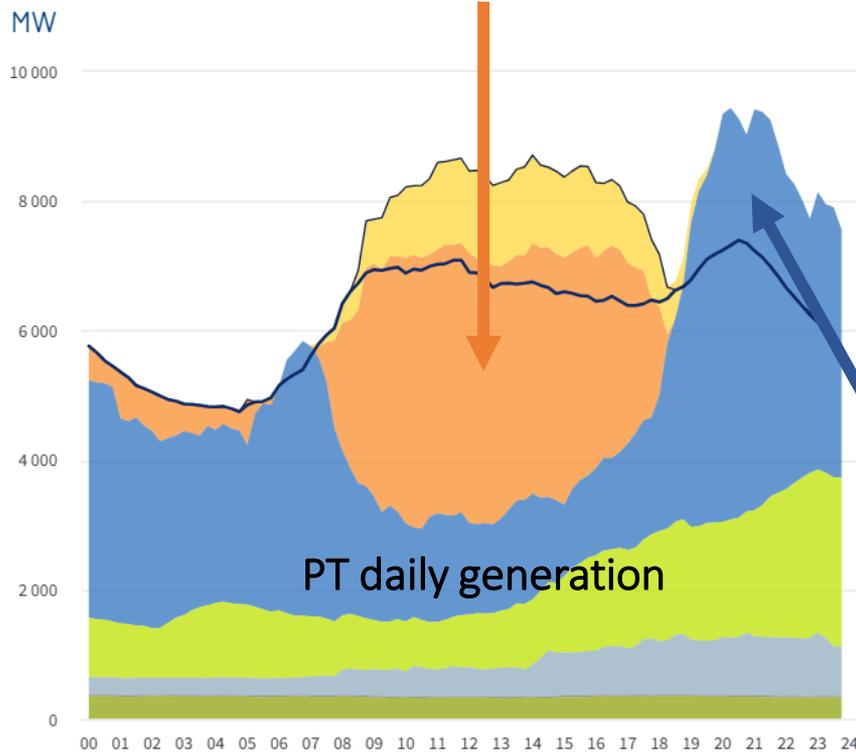
Decentralized energy

Spain and Portugal complimentary power systems



In a typical Spring day, PT imports solar power to pump hydro plants, with low prices, and exports hydro power at high prices in the night peak

Pumping / imports during Solar hours and low prices



Source: DMIE, 17 April 2025

Hydro exports during peak prices

— Consumption + Storage
 — Consumption
 ■ Solar
 ■ Import Balance
 ■ Hydro
 ■ Wind
 ■ Natural Gas
 ■ Other Thermal
■ Biomass
■ Coal
■ Wave
■ Battery Injection
■ Renewable
■ Non-Renewable

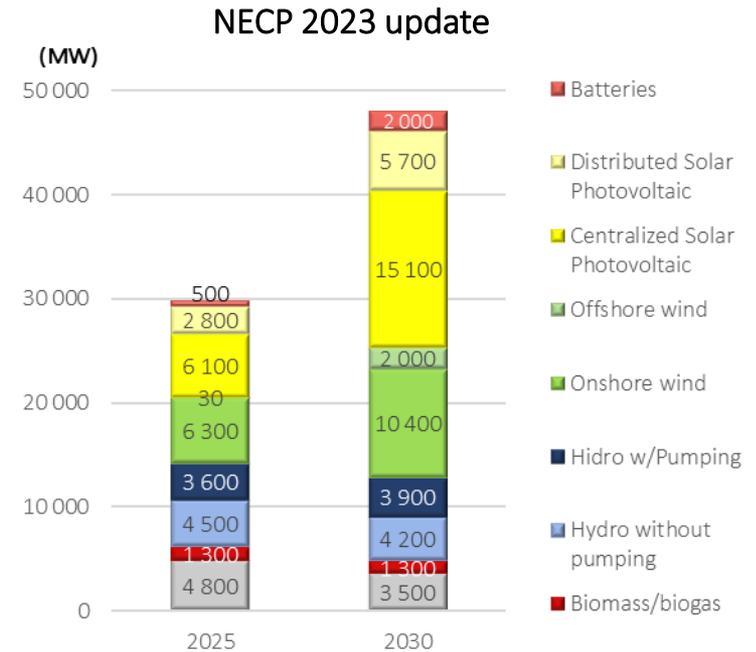
- On the one hand, there is a long way to go to fulfil renewables integration objectives:

Installed capacity

	Dec 25 [MW]
Hydro	8 385
Wind	5 444
Solar	4 855
Wave	0
Biomass	692
Natural Gas	4 396
Coal	
Other Thermal	25
Batteries	19
TOTAL	23 816

Source: [REN Data Hub](#)

There is a gap in the 2025 objective and a bigger one to 2030!



- On the other hand, there is a big issue of network capacity scarcity:

[Transmission Network National Development and Investment Plan](#) (2024)

- The available capacity for new generation is scarce, about 2.6 GVA planned for 2028-2030, related with the most recent network development plan and the previous one

[Distribution Network National Development and Investment Plan](#) (2024)

- There is capacity available in the distribution network for new generation (about 7 GVA) but conditioned upstream by the available capacity in the transmission network (about 6 GVA and additional evaluation)

Flexibility resources description	Distributed generation, self-consumption, storage, microgrids, smart appliances (air/water heaters, electric vehicles)...
Hybrid power plants (hybridization)	Allows better use of the existing network connections Examples: wind/solar, wind/solar/storage, hydro/solar
Consumers with significant flexible capacity (industrial, large commercial)	Facilitation and management by an aggregator that can be an independent service provider or a supplier (residential consumers cannot participate explicitly in the markets)
Flexible connection agreements	Allows connecting of new generation or self-consumption with grid connection, limited to the annual minimum of the network (SO controlled)

Energy efficiency first!

Benefits from Decentralisation and Distributed Energy Resources



Electric technologies are the most efficient and allow direct and decentralized use of renewable energy sources

Distributed Energy Resources ensure the decentralization of the electrical system, local integration and development of a proximity economy for energy

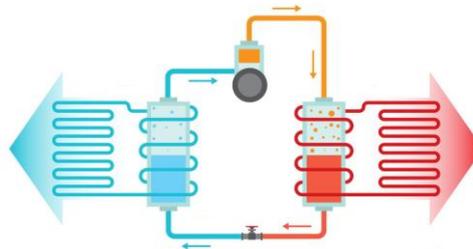
Digitalisation is one more tool contributing to the success of the energy transition

Distributed Energy Resources

Distributed Generation technologies from renewable energy sources



Heat Pumps



Electric Vehicles



Emerging battery and other storage technologies



Digitalisation

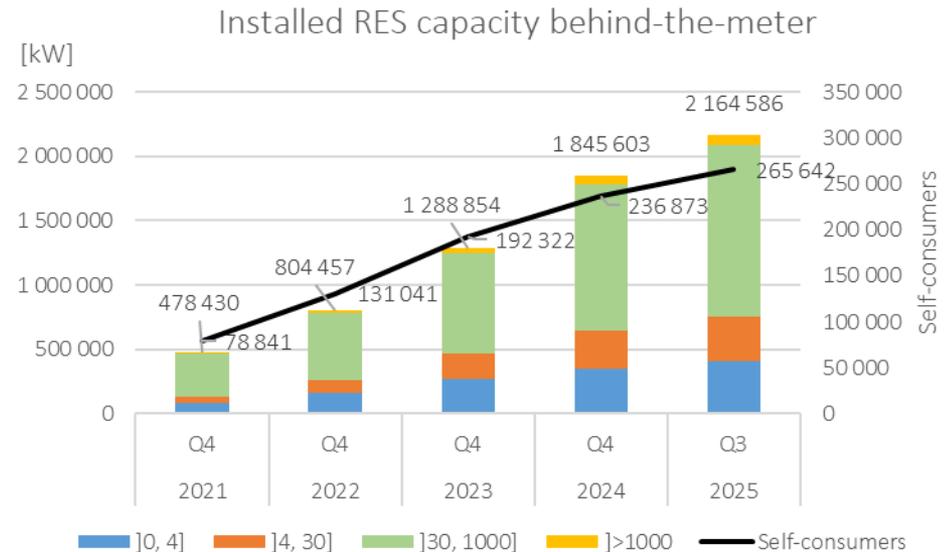


Complete **smart meters roll-out** at the Portuguese continental electric sector in 2024

Self-consumption: an example of renewable integration



- Generation of electricity for own consumption, individual or collective (one or more consumption facilities, respectively)
- Some of the benefits:
 - Savings on electricity bill
 - Less dependence on the grid
 - Net metering (15 minutes)
 - Sale of excess of energy
 - Renewable electricity sharing
 - Support the energy transition
- High incorporation of self-consumption: (3rd quarter 2025)
 - ~26% MV customers are SCs
 - ~4% households are SCs

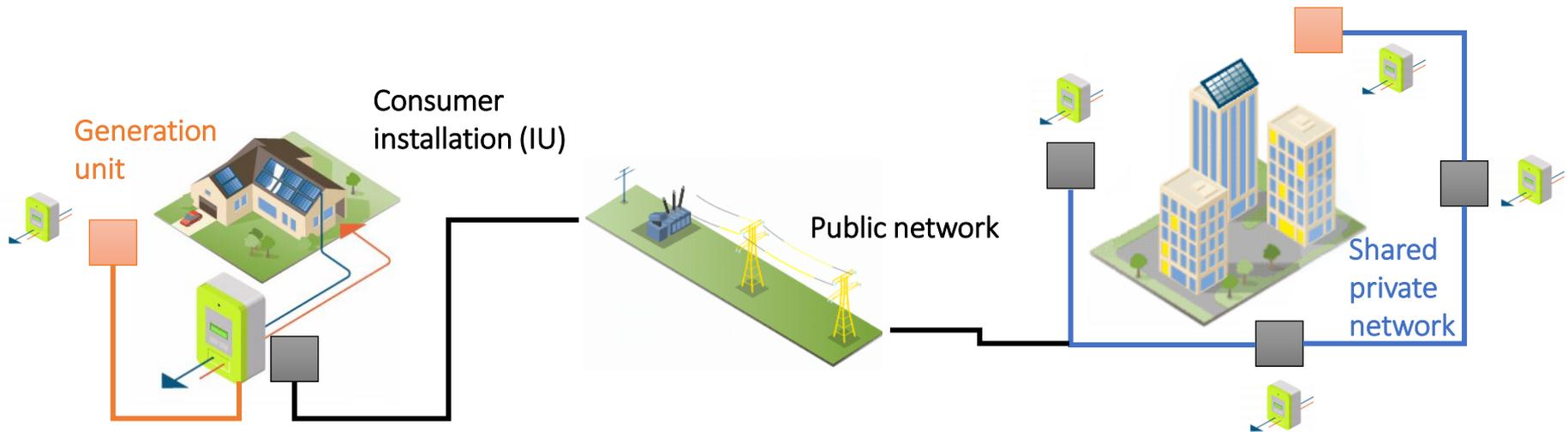


Key aspects:

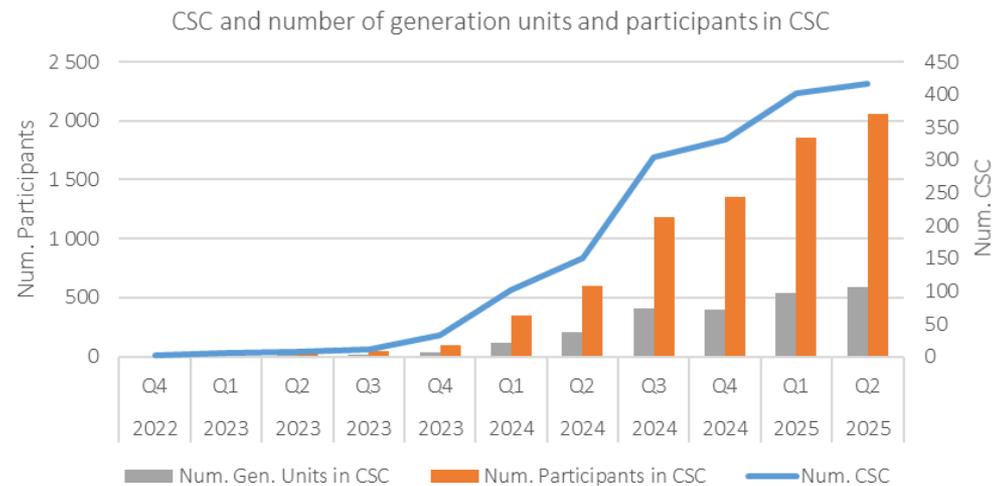
- “Fit and Forget” – Simple to register, low legal and operational requirements
- Simplified licensing
 - Up to 30 kW, electronic registration, no fee
 - Registration and certification up to 1 MW, electronic registration, fee, depends on grid capacity
 - Above 1 MW, licensing required, depends on grid capacity
- DSO installs or adapts smart meter for self-consumption
- Normalized grid connection procedures (required standards)



Self-consumption: collective self-consumption



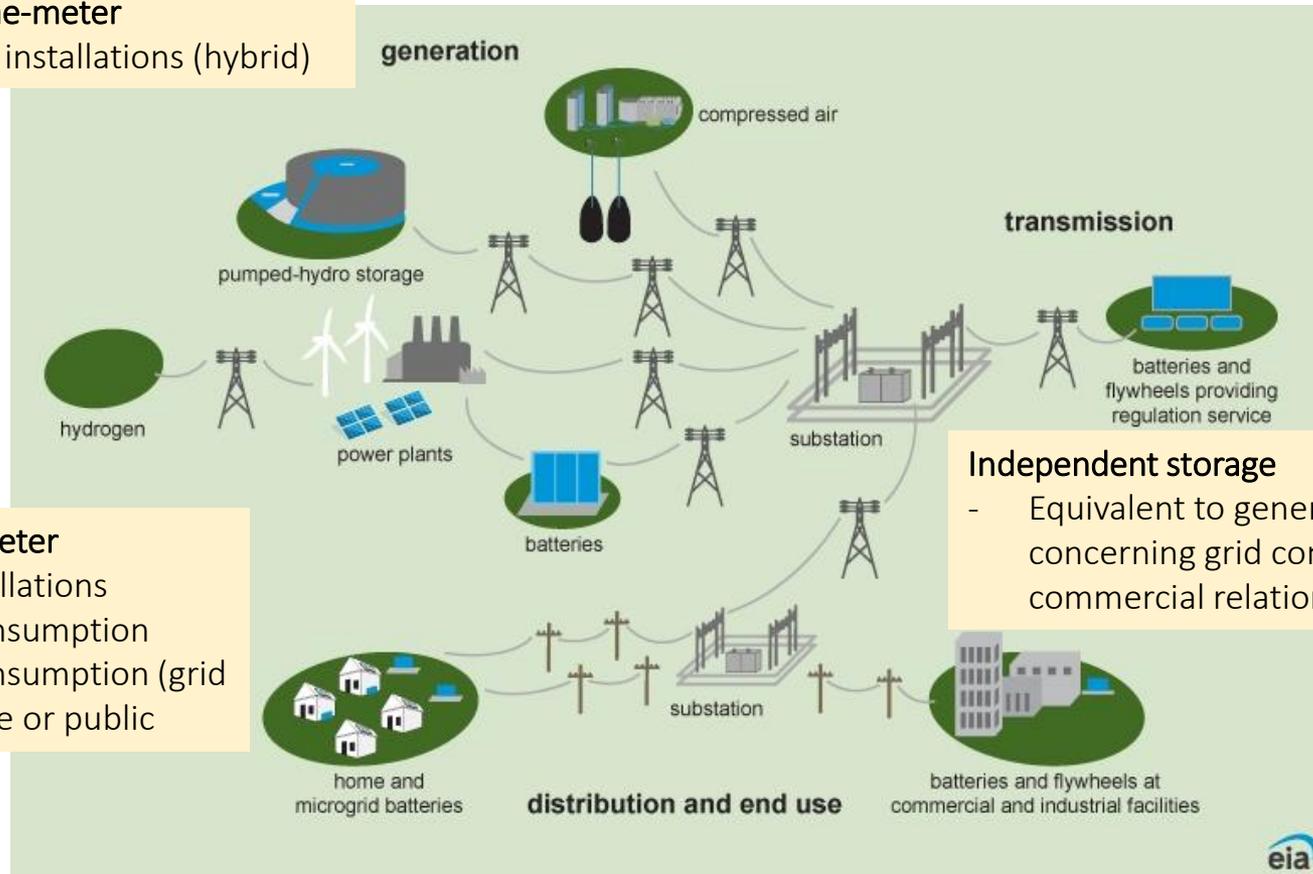
- Proximity of generation
- Smart grid/smart meter need
- Complex DSO systems
- **Responsible party:** consumption and network contracts, information access, sharing rules, ...
- **Sharing rules:** fixed, proportional, hierarchic and dynamic



Only 3 Renewable Energy Communities

Storage behind-the-meter

- In generation installations (hybrid)



Storage behind-the-meter

- In consumer installations
- Individual self-consumption
- Collective self-consumption (grid connected: private or public)

Independent storage

- Equivalent to generation, concerning grid connection, commercial relations

Source: International Energy Agency (IEA)

Hybrid power plants (floating solar example)



Alto Rabagão (2017)

- 1st pilot project in Portugal to study and test the complementarity between hydro and solar power, as well as the possible environmental and economic advantages of this technology;
- 840 solar panels, 2500 m²;
- 220 kWp installed capacity;
- Expected annual generation of 300 MWh.



Alqueva (2022)

- 12000 solar panels, 4 ha (40000 m²);
- 4 MW installed capacity;
- Expected annual generation of 7.5 GWh (equivalent to the consumption of about 1500 families of that region);
- Lithium-ion batteries – 1 MW/2 MWh;
- The project also tests the complementarity between Hydro, solar and storage (pumping hydro and batteries);
- Innovative floater technology, based on a new cork composite, that allows for a 30% reduction in the carbon footprint of this floaters.



Access to the Networks and Interconnections Code:

- **General provisions and access models:**
 - To new network access requests or to requests to increase capacity, **in which network operators conclude that it is not possible to allocate all the capacity requested**, operators must offer access to the network with restrictions;
 - Network access with restrictions **does not apply to normal low voltage consumers** (usually households).
- **Flexible connection agreements for generation and autonomous storage facilities:**
 - Access with restrictions is proposed by network operators and is materialised through the drawing of an **Agreement**;
 - **The conditions for access with non firm capacity** (e.g. maximum capacity) are defined in the **capacity reservation title and/or in the respective production license** (granted by the Directorate-General for Energy and Geology – DGEG);
- **Pilot project for non firm capacity for consumers:**
 - Its ERSE's responsibility to approve the implementation of pilot projects in the scope of access with restrictions for consumer installations;
 - The DSO must propose at least one pilot project that materialises a network access with restrictions for a consumer installation (deadline of 180 days after the code publication date).

- General conditions (proposed by network operators and approved by ERSE after a public consultation) include:
 - Network operator procedures to communicate the occurrence of restrictions;
 - Communication means to be established in order to assure the activation of the restrictions by network operators;
 - Motives and procedures to suspend or cease the Agreement.
- **Specific conditions** must include:
 - Duration of the agreement;
 - Definition of the firm capacity and of the capacity with restrictions allocated;
 - Identification of the restrictions and/or limitations, probability of their occurrence, as well as, duration, time period of occurrence and magnitude;
 - Deadlines for prior notification of the network operator regarding the occurrence of restrictions;
 - Mechanisms for communicating restrictions/limitations.

Market tools

The power system is in a technological, commercial and organizational transition



Negative wholesale prices signal inadequacies in the generation mix and bring risk to new renewable investments

Lack of connection capacity creates a big time lag between investment needs and actual implementation

Small and dispersed generation behaves with lower responsibility levels towards systems needs

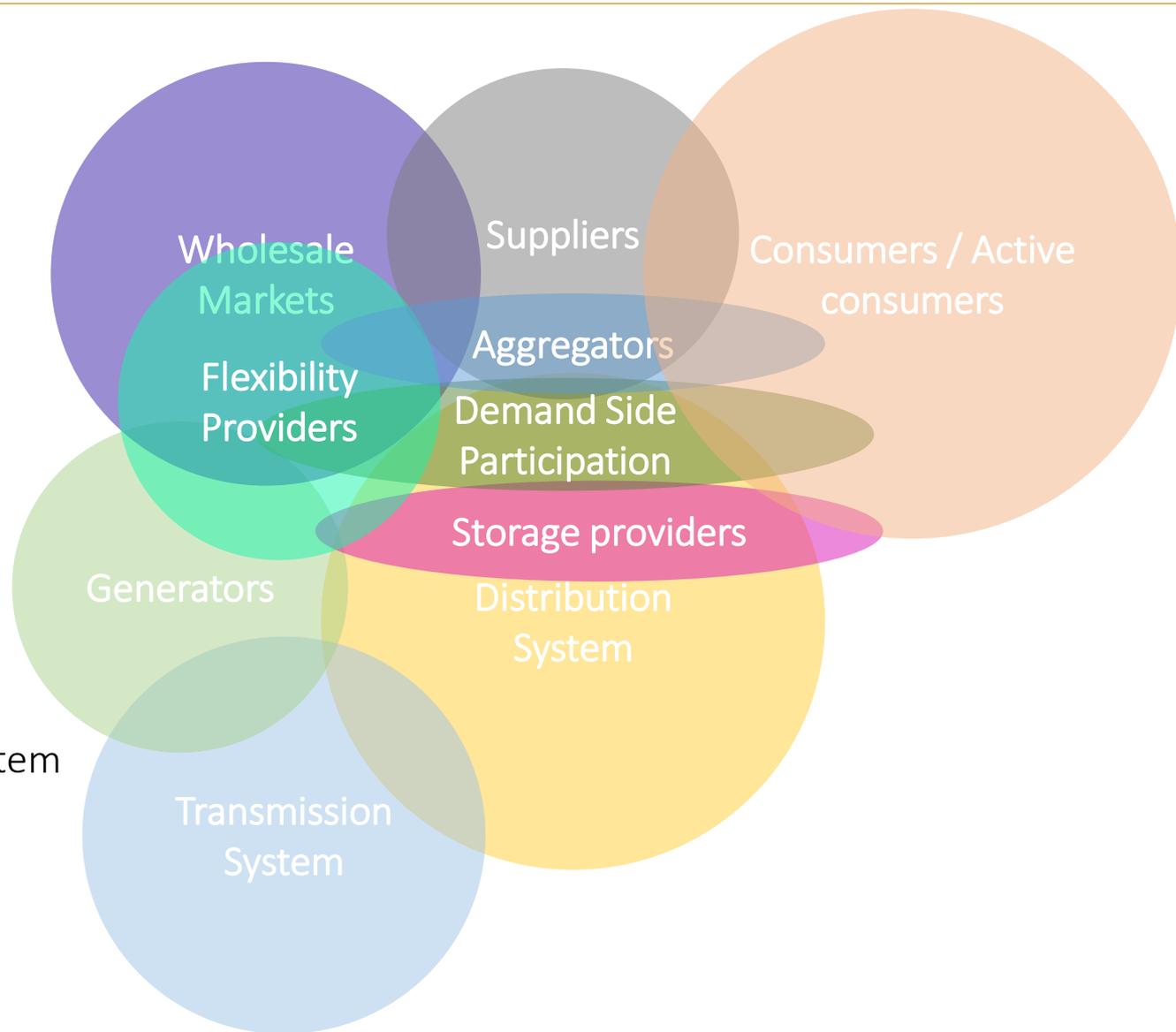
New inverter-based assets are not guaranteed to provide system services, must be required/incentivized to do so

Conventional generation is often called by the TSO to ensure reserves and other ancillary services, displacing market allocated resources

Volatility is high (primary energy resources, market results, incentive misalignment)

Electrification push creates new problems in already established networks

Participation of small distributed resources only possible through aggregation, adding commercial complexity and requiring new market design



The Distribution System will develop a more Central Role in the future

- **Network development plans**

Alternatives to grid investment, based in cost-benefit analysis
(market contract of flexibility, such as storage, demand response and generation)

- **DSO to encourage flexibility providers**

Portuguese DSO developed a pilot-project to procure and contract flexibility providers to solve grid congestion ([FIRMe](#))

- **Update grid codes**

DERs such as distributed PV systems should have advanced inverter functions, such as voltage/frequency ride-through and voltage regulation

- **Prepare for potential challenges**

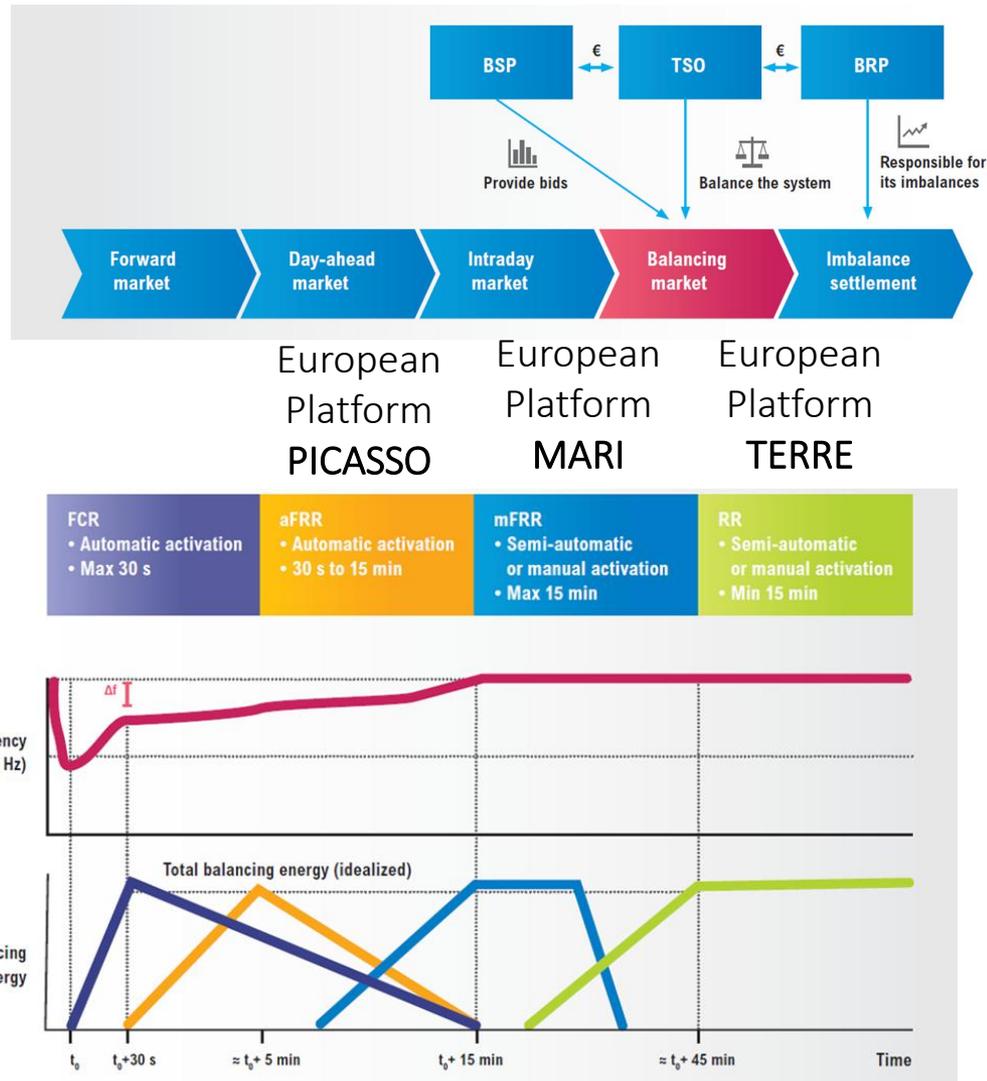
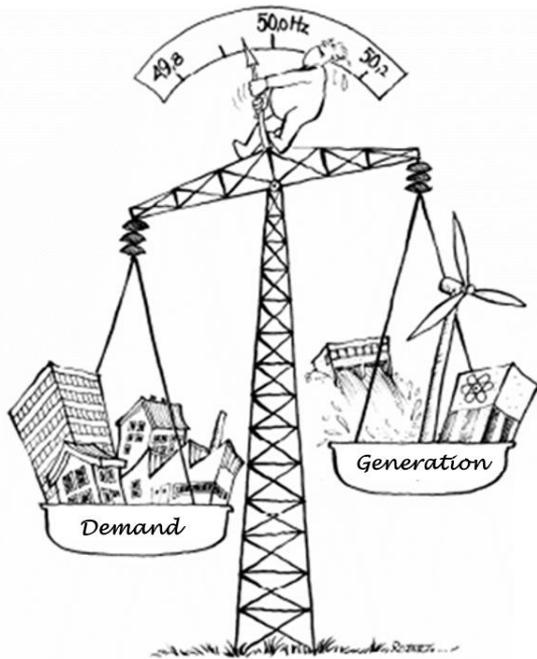
Lower operational demand and system inertia may accompany broader use of DERs

- **Flexible grid connections**

Introduce flexible grid connection arrangements that reflect the impacts of each resource



Perspectives of a bigger importance of the balancing market in the future



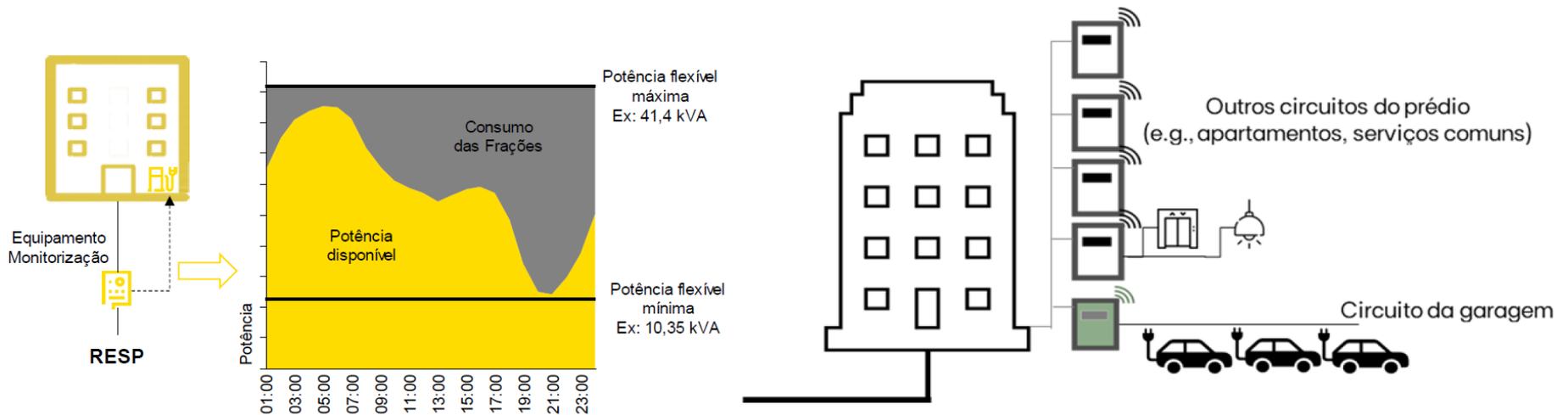
More information at:
<http://www.erse.pt/pt/electricidade/regulamentos/operacaodasredes/Paginas/ProjetoPilotoReservaRegulacaoA7A3o.aspx>

Challenges

- Maximum capacity available in existing buildings is not enough
- Network reinforcement is necessary

Opportunities

- Smart charging, allowing the change of the charging capacity according with the needs of the system (peak or off peak hours, applying tariffs with different time periods)
- Consumption flexible connections ([Project FlexC](#))



System operator services portal - client information

DSO makes available information regarding readings, generation, consumption, capacity

Bem-vindo ao Balcão Digital

Todas as suas operações e informações sempre disponíveis, em qualquer lugar.

Escolha o que pretende fazer

Os meus locais

Leituras, contadores, consumos e potências, produção de energia e dados do local.

Ligações à rede

Novas ligações, alterações de potência, modificações de elementos de rede e simulação de encargos.

Anomalias e Intervenções

Avárias, prejuízos, fraudes, situações de risco e intervenções técnicas.

Consulte aqui

Pedidos

Pedidos submetidos no Balcão Digital

Agendamentos

Vistas técnicas agendadas para sua instalação

Atalhos

Enviar leituras

Estou sem luz

Avaria iluminação pública

Comunicar prejuízos

Simulador ligação à rede

Video chamada

Other services include: submit meter readings, report of malfunctions, public lighting malfunction, meter access requests (serial port HAN)

Daily readings by tariff period:

- Consumption (E), injection (I)
- Daily settlement
- 36 months history

Histórico de leituras

Contador: 000002223172539

Período: 2023-12-22 a 2024-02-20

[Exportar excel](#)

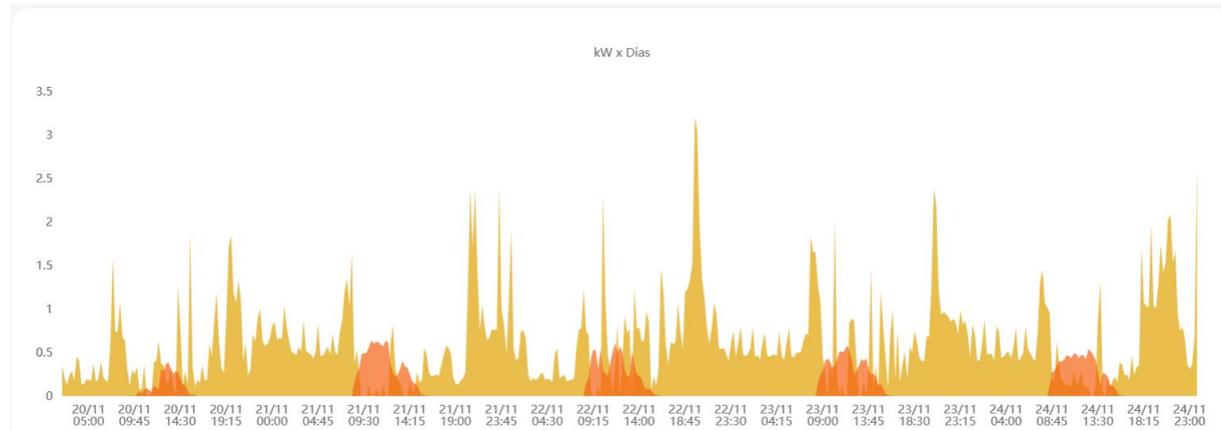
ESTADO	DATA	ORIGEM		VAZIO		PONTA		CHEIAS	
				VALOR	SALDO	VALOR	SALDO	VALOR	SALDO
Valido	20-02-2024 00:00:00	Operador de Rede de Distribuição	E	1260	1260	944	927	1749	1681
			I	0	0	52	34	166	97
Valido	19-02-2024 00:00:00	Operador de Rede de Distribuição	E	1256	1256	939	922	1744	1676
			I	0	0	52	34	164	95
Valido	18-02-2024 00:00:00	Operador de Rede de Distribuição	E	1253	1253	938	921	1741	1673
			I	0	0	51	34	161	93

Source: E-Redes (DSO)

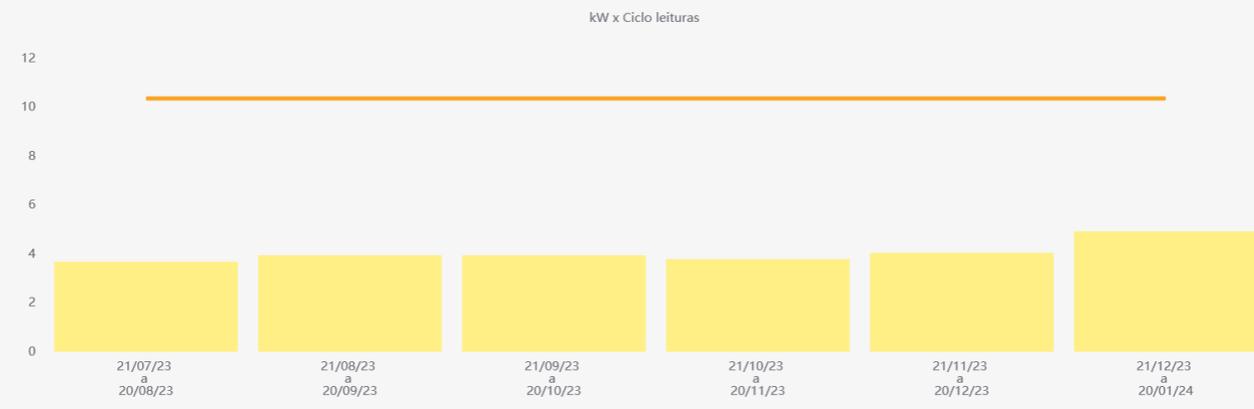
Services portal - client information

Load diagrams

- Consumption/injection
- Settlement of consumption/injection for billing data
- 15 minute periods
- 24 months history

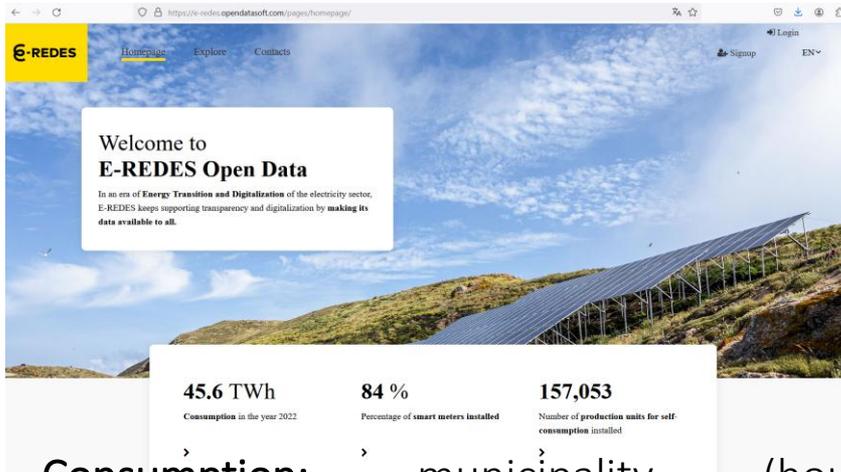


Potência máxima tomada mensal



Maximum used capacity per month

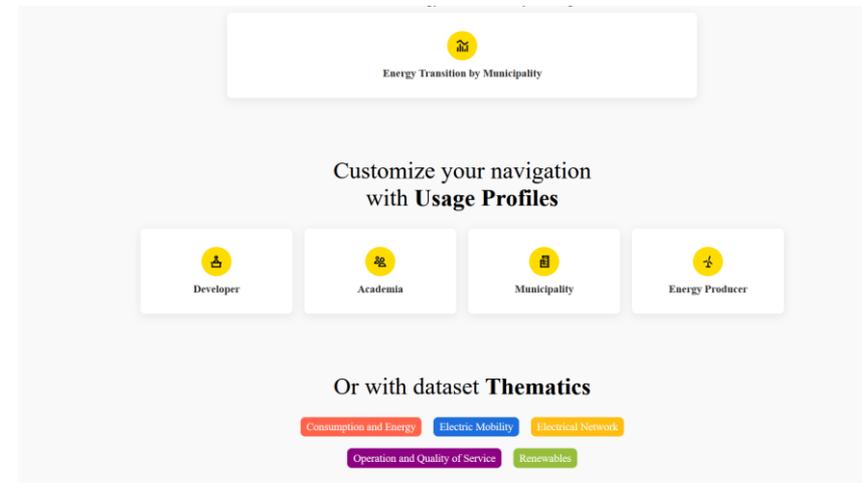
Data Hub



- **Electric mobility:** Charging stations, new connections



- **Renewables:** self-consumption units (number, capacity), new network connections (number, capacity)



- **Consumption:** municipality (hourly, monthly), postal code/street level (hourly, monthly)

- **Electrical networks:** public lighting, contracts by meter type, active delivery points, hosting capacity

- **Operation and quality of service:** service continuity indicators, network connections, active energy interruptions, LV delivery points with remote reading, LV delivery points with load diagrams, remote work orders



Thank you!

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