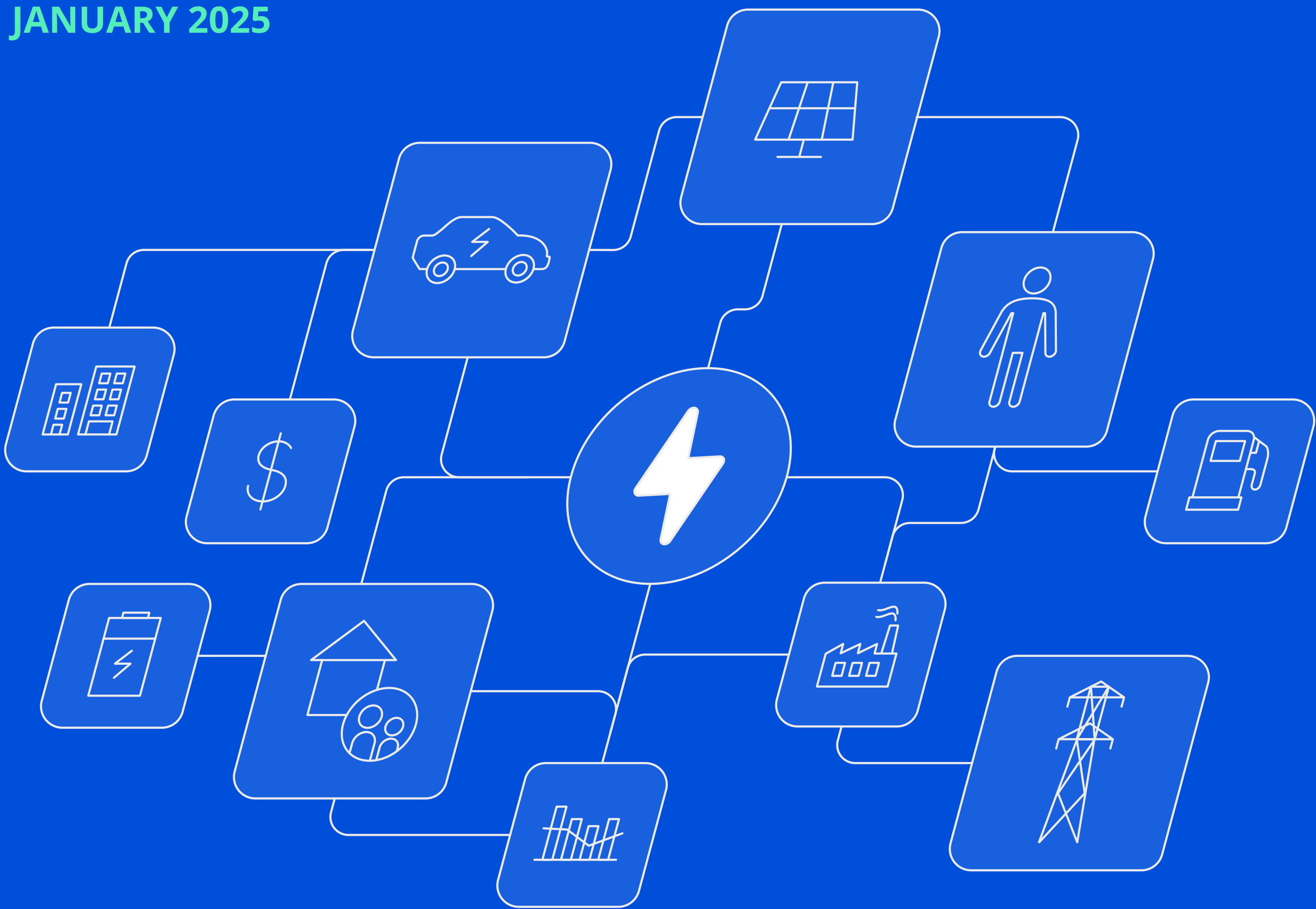
VPP Readiness Index

Assessing a country's readiness for virtual power plants

JANUARY 2025



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Authors & acknowledgements

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We also make sure the energy transition does not leave anyone behind. Through our energy access pro-bono work, we assist communities, start-ups and social entrepreneurs in developing countries with energy access and climate change solutions.

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Integrate to Zero (I2Z) is a not-for-profit global initiative bringing together civil society, governments and businesses to create Virtual Power Plants (VPPs) across the globe for the benefit of consumers, utilities and the climate.

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Executive Summary

The rapid transition towards electrification, renewable energy and decentralised energy systems has transformed power generation and distribution. Technological advancements and the reduced cost of Consumer Energy Resources (CERs), such as rooftop solar, energy storage systems, and electric vehicles, have encouraged customers to adopt CERs at a growing rate.

Within this context, Virtual Power Plants (VPPs) have emerged as a capital and cost-efficient choice to aggregate CERs and provide grid services.

The potential of VPPs

VPPs are aggregations of CERs, orchestrated by software, that can provide utility-scale and utility-grade grid services to grid or distribution system operators (GSOs / DSOs). They are an emerging capital and cost-efficient alternative to the traditional supply-side measures employed to manage the increasing penetration of variable renewable energy-based electricity generation in the grid.

In addition to providing grid services, VPPs can also create new revenue streams for consumers, and reduce overall system costs that ultimately need to be recovered through consumer tariffs. However, public and private sector deployment of VPPs depends on the commercial viability of the model, which in turn depends on the availability of adequate CER capacity, supportive governance frameworks, appropriate institutional structures and capacity, remunerative market models and energy pricing, and attractive financing options.

VPPs have emerged as a cost-efficient choice to aggregate CERs and provide grid services.

VPP Readiness Index

Given the potential economic and decarbonization value of VPPs, it is essential to understand the country models that are working well in incentivising the deployment of VPPs and the gaps in the countries not as effective. This understanding will support targeted reform programs and capacity-building design to ensure a wider uptake of VPPs that support accelerated electricity system modernisation.

To the above end, Integrate to Zero (I2Z) and Blunomy designed the 'VPP Readiness Index' presented in this report. The index provides a snapshot of a country's readiness for large-scale VPP deployment based on its technical, regulatory and commercial characteristics. This helps in understanding a country's performance drivers, make easy cross-country comparisons, and identifies the gaps to be addressed for lagging countries.

Applying the index to 12 countries

To aid in facilitating VPP adoption, the VPP Readiness Index was applied to 12 countries across five continents at varying economic and electricity market maturity levels: Kenya, South Africa, Nigeria, India, Indonesia, Malaysia, France, the United Kingdom, Australia, Brazil, Chile and Colombia. This report details the results.

It also details how VPPs work, their value proposition, and the method and criteria used to assess each country. Finally, it presents a comparative analysis of the results, and a detailed assessment for each country.

Criteria and readiness levels

Blunomy assessed each country against the 9 criteria within the five categories shown in Table 1 on the next page. Each criterion is scored on a scale of 0-10, for a maximum of 90 points. The resulting raw score is converted to a percentage for easy comparison across countries that are assessed.

Table 1 – VPP readiness index categories and criteria

CATEGORY		CRITERIA
VPP resource availability	1	Amount of CER capacity (as % of peak demand)
	2	Coverage of pro-CER regulations, policies, and incentives
Flexibility needs	3	System flexibility needs (as % of peak demand)
Market attractiveness	4	Power system structure and regulation: presence of unbundled power industry and/or retail competition
	5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets
Regulatory environment	6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives
	7	Presence of data protection and privacy considerations
Grid operation	8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)
	9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications

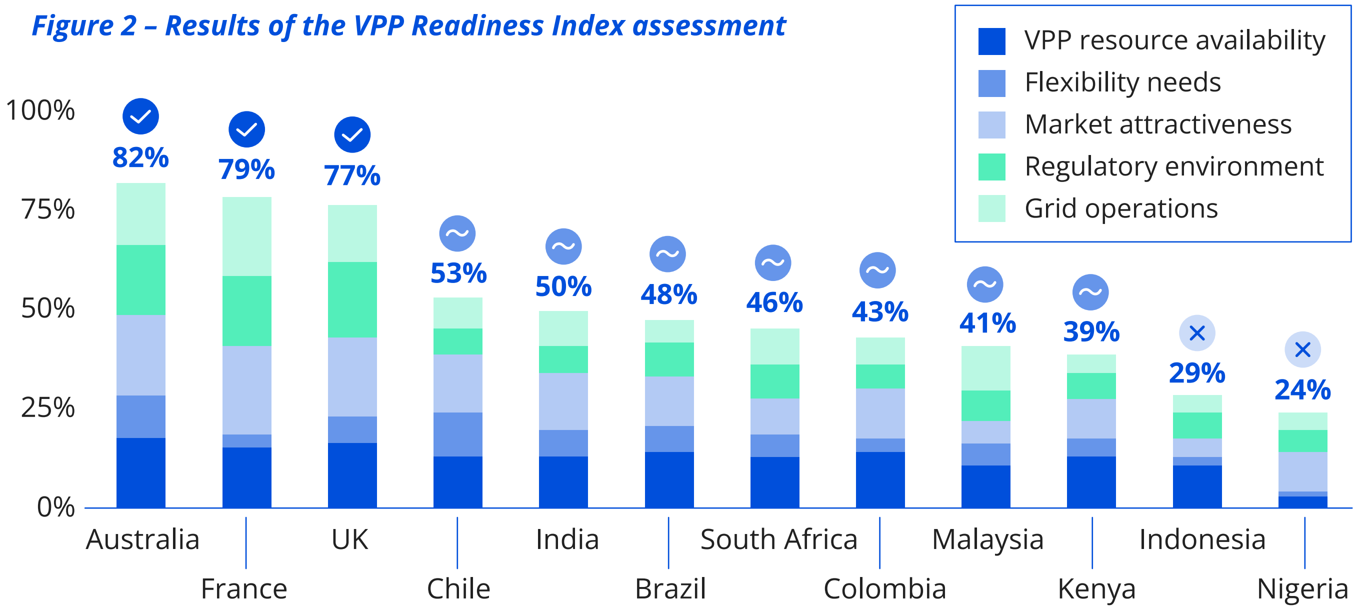
Based on the resulting % score, countries were then categorised into either low, moderate or high VPP readiness according to the spectrum shown in Figure 1 below.

Figure 1 – VPP readiness spectrum

LOW READINESS	MODERATE READINESS	HIGH READINESS
0 – 30%	31 – 60%	61 – 100%

In this initial exercise, the index targeted a sample of 12 countries selected to represent diversity in geography, economic achievement, and power sector development, with care taken to ensure that countries with significant uptake of VPPs were included to provide appropriate benchmarks.

Figure 2 – Results of the VPP Readiness Index assessment



Key findings

The VPP readiness index highlighted four key findings that describe current VPP deployment across the assessed countries:

Countries are supporting CER adoption and integration
Today, most assessed countries have made strides in implementing regulations, policies, and incentives to drive CER adoption and integration. However, most remain in the early stages of CER uptake and have yet to develop VPP-friendly frameworks.

CER capacity in most countries suggests untapped potential for VPPs
With flexible CER capacity representing at least 40% of peak demand in most countries, significant resource availability can be leveraged to address capacity needs. Countries can exploit this potential by developing and deploying VPPs to benefit the power system and enhance grid resilience.

Lack of adequate regulations and access to revenue streams hinders VPPs
The absence of dedicated policies and regulations for VPPs (except in a few countries) creates a significant regulatory gap. Without appropriate frameworks, countries are missing opportunities to fully realise the benefits of VPPs.

Additionally, the current lack of access to revenue streams for CERs and VPPs, including those from the wholesale energy market or ancillary services, significantly impacts the commercial viability of VPPs. This is substantiated by countries with commercially viable VPP providers (Australia and France) tending to have government or regulatory support and/or access to revenue streams through market participation or bilateral contracts with utilities.

Smart meter rollout remains insufficient

While most countries have plans for widespread smart meter installation, low current penetration (<30%) outside of France and the United Kingdom limits the immediate scalability of VPPs. Accelerating Advanced Metering Infrastructure (AMI) deployment is essential for enabling VPPs and real-time management of CERs.

The future of VPP uptake

The future of VPP uptake will depend on how quickly countries shift from focusing on CER adoption to creating comprehensive frameworks and commercial opportunities that support VPP deployment. This will require establishing clear regulations, market access, and revenue mechanisms for VPP providers.

As CER integration matures, countries that proactively build these frameworks will be better positioned to leverage the benefits of VPPs.

Critical insights

The VPP readiness index results underscore critical insights for energy regulators, solution providers and potential investors in VPPs:

- **For regulators,** the study reveals that while many countries have ample CER capacity, the **inadequacy of current regulations** designed at a time when the system was, and was supposed to remain, centralised is a **significant barrier** to unlocking the potential of these resources. Establishing clear regulatory frameworks and allowing VPPs to provide services, such as those for the wholesale electricity market or ancillary services, will be vital in unlocking VPPs' benefits to the power system.

- **For investors,** the index is a valuable tool to identify **markets that have reached maturity,** such as Australia and France, where market-driven VPPs are already viable.

- In addition, besides identifying the more mature markets, the index helps **solutions providers** focus their **sector-building efforts** on countries with **strong underlying drivers** (e.g. high VPP resource availability, high flexibility needs) but with regulatory gaps, limited revenue streams, and market access.

Contents

Glossary

AMI	Advanced Metering Infrastructure
BESS	Battery Energy Storage Systems
BTM	Behind-The-Meter
BEV	Battery Electric Vehicles
CER	Consumer Energy Resources
C&I	Commerce & Industry
DER	Distributed Energy Resources
DFS	Demand Flexibility Service
DSO	Distribution System Operator
EV	Electric Vehicle
FCAS	Frequency Control Ancillary Services
FiT	Feed-in-Tariffs
GDP	Gross Domestic Product
GSO	Grid System Operator
GW	GigaWatt
GWp	GigaWatt-peak
I2Z	Integrate to Zero
KPI	Key Performance Indicators
kW	kiloWatt
LCM	Local Constraint Market
LV	Low Voltage
NEM	Net Energy Metering / National Electricity Market
NESO	National Energy System Operator
OEM	Original Equipment Manufacturers
PV	PhotoVoltaic
STCs	Small-scale Technology Certificates
tCO_2e	tonnes of carbon dioxide equivalent
TOU	Time Of Use
VPP	Virtual Power Plant
VRE	Variable Renewable Energy
WEM	Wholesale Electricity Market

1. Introduction

The rapid transition towards electrification, renewable energy and decentralised energy systems has transformed the landscape of power generation and distribution from an analogue, centralised system to a complex, digitalised network of energy flows. Technological advancements and the steady cost reduction of Consumer Energy Resources (CERs), such as rooftop solar, energy storage systems, and electric vehicles, have encouraged customer adoption of CERs at a growing rate. Enabling technologies like smart metering, sensors, load control and computing have expanded the grid services that CERs can provide.

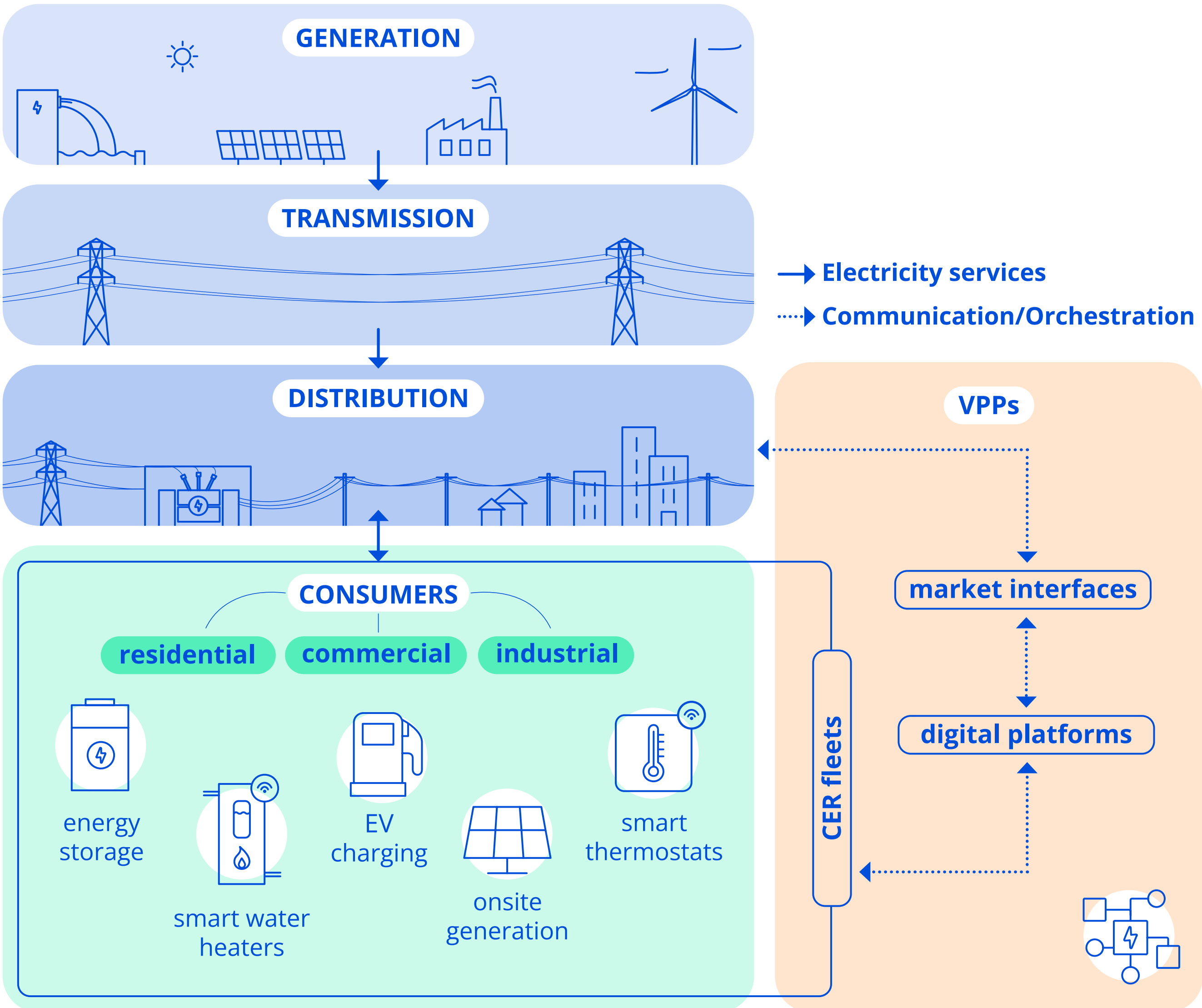
In this evolving energy environment, Virtual Power Plants (VPPs) have emerged as a capital and cost-efficient choice to aggregate CERs and provide grid services, creating new revenue streams that benefit consumers while reducing the overall cost of the electricity system. For VPPs to deploy successfully on a large scale, the availability of CERs, governance frameworks, institutional structures, market models, financing options, and energy pricing need to be appropriately aligned. This will ensure the commercial viability of the model and attract substantial participation from both the public and private sector.

1.1 Definition of VPPs and CERs

VPPs are aggregations of CERs working together, orchestrated by software, to participate in the electricity market to provide utility-scale and utility-grade grid services like a traditional power plant [1] [2]. CERs or Distributed Energy Resources (DERs) are equipment located at or near the site of end-use that can provide electricity demand flexibility, electricity generation or electricity storage at a sub-utility scale. They are connected behind-the-meter (BTM) or to the distribution grid [1].

The distinction between CERs and DERs primarily lies in the description of the energy resources: CER focuses on energy resources owned by the consumer, while DER remains a broader term covering distribution network-connected resources. There has yet to be a global consensus on the preferred term to describe these resources. For this report, the term 'CERs' will be adopted, and 'VPPs' designate solutions that collectively manage the CERs.

Figure 3 – How VPPs fit into the power system



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There are three broad categories of CERs, with each category offering different contributions to the grid:

Distributed generation

Electricity generated at or close to the site of use, reducing consumer reliance on central power plants, improving energy resilience and lowering transmission losses by reducing electricity demand on the grid. In certain jurisdictions, distributed generation can also supply excess electricity back to the grid, supporting local grid stability and meeting demand. Examples include rooftop solar, micro-combined heat and power, and fuel-based generators.

Energy storage

Capturing excess electricity produced during periods of high generation and low demand, for use later in different applications or during peak demand. Energy storage can also respond quickly to fluctuations in the grid and provide frequency regulation and balancing services. Electricity can be stored in chemical or other forms. Examples include batteries, and electric vehicles (EVs) with bi-directional charging.

Flexible load

Appliances or machines that can have their time of use altered passively (e.g. through a timer) or dynamically in response to local or external signals. Flexible load can adjust electricity demand based on grid needs or signals, helping to balance supply and demand and lowering peak demand. Examples include EV chargers, electric water heaters, electric heaters and air conditioning.

1.2 How VPPs work

VPPs can contribute to the grid differently and provide different benefits depending on the categories of CERs they aggregate and orchestrate (distributed generation, energy storage or flexible load). VPPs can comprise a single type of asset, such as EVs, or a heterogeneous mix of assets, such as batteries, EVs, and solar PV. For instance, most VPPs in the USA today are primarily influencing demand on the grid through orchestrating flexible load and/or distributed generation with energy storage that stays behind the meter, with only a minority of VPPs supplying electricity back to the grid [1].

Most VPPs operate by combining three elements: aggregating physical CER assets into a CER fleet, orchestrating the aggregated CERs via a digital platform, and providing grid services either through market interfaces, when a market is available, or bilateral contracts. In some cases, operators manage VPPs without price signals, such as timed control of water heating. Although VPP owners can operate all three elements, partnering with third-party service providers is not uncommon.

CER fleet

A VPP first aggregates CERs into a CER fleet. They do this by contracting with consumers for access to their CER, typically either when specific conditions are met (for example, selling energy to the grid when wholesale energy prices are high or flexing demand to periods when wholesale energy prices are low), for a maximum number of times a year, or unrestricted access. Contractual arrangements will continue evolving as VPP uptake increases globally.

Depending on the VPP owner, there are three main types of CER fleets:

- **Utility fleet**

  Utilities enrol CER-owning customers that they are currently serving. Utilities may operate the platform in-house or partner with a third-party service provider.

- **Original equipment manufacturers (OEM) fleet**

  OEMs enrol customers at the point of sale. Typically, the platforms operated by CER equipment manufacturers tend to comprise a single type or brand of CER.

- **Independent CER fleet**

  VPP operators can enrol customers directly or through partnerships. These types of CER fleets tend to aggregate various types or brands of CERs.

Digital platforms

VPPs use digital platforms to optimise the operation of CERs through real-time data analysis and orchestration. VPPs collect, process, and analyse data from connected CERs to optimise energy generation, storage, and consumption. This platform ensures the efficient orchestration of CERs to meet grid and market requirements while ensuring the consumers' local electricity supply.

Orchestration requires CER management systems that can balance the demand and supply of electricity in real time, utilising a mix of hardware and software like smart inverters and energy management systems.

Market interfaces

Market interfaces allow the VPP to interact with and respond to market conditions, allowing it to participate in buying and selling electricity in energy markets. The VPP receives price or dispatch signals from these markets and responds by adjusting the output of CERs or shifting loads to maximise revenue or reduce costs.

Market interfaces are optional and are not a requirement for VPPs to provide grid services – the need for market interfaces is highly dependent on how the power system is structured and how the grid operator procures system services.

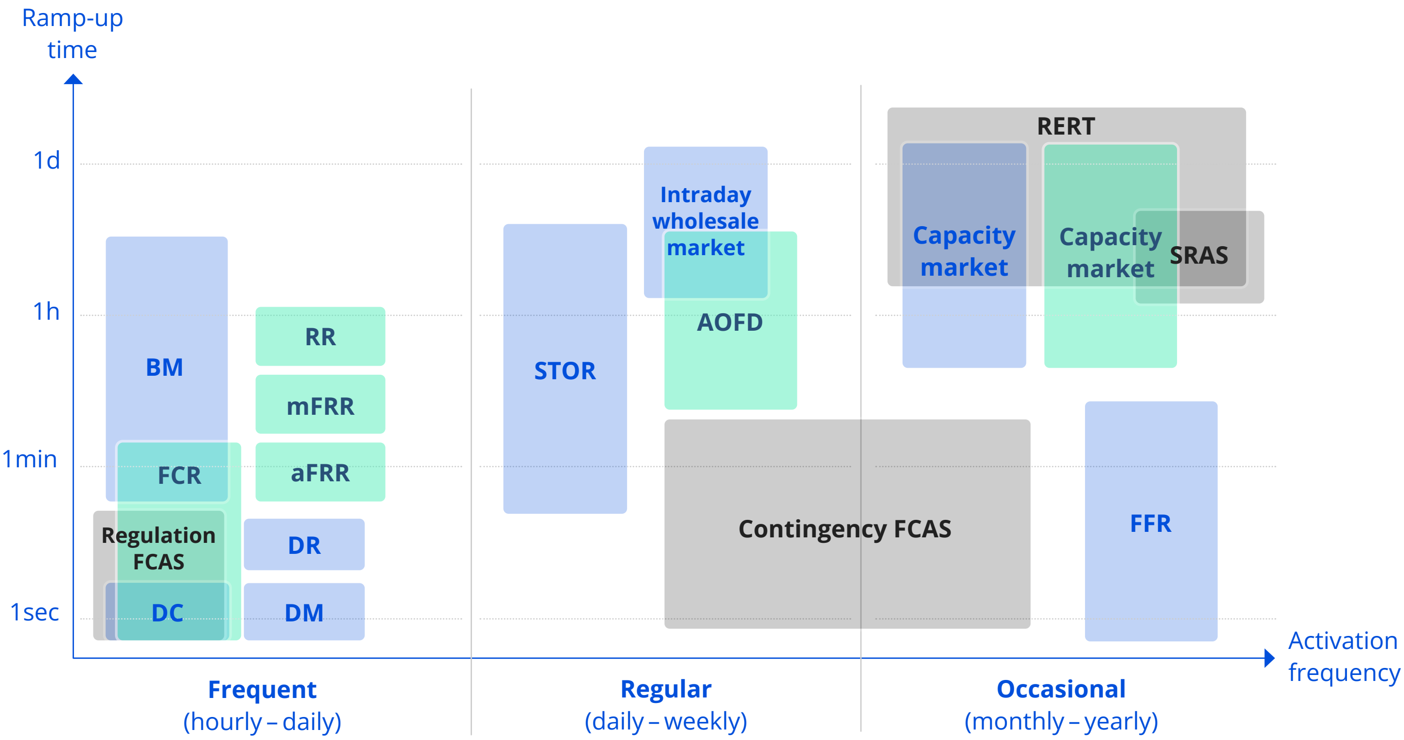
1.3 Value proposition of VPPs

1.3.1 VPP value streams

By dynamically altering demand and generation, VPPs can provide services across the entire power system (generation, transmission and distribution).

As an illustration, Figure 4 maps the different markets and services VPPs can provide in the United Kingdom, Australia and France.

Figure 4 – Examples of value streams/markets VPPs can access [3]



UK

BM	Balancing Mechanism
DC	Dynamic Containment
DM	Dynamic Moderation
DR	Dynamic Regulation
FFR	Firm Frequency Response
STOR	Short-Term Operating Reserve

FR

aFRR	Automatic Frequency Restoration Reserve
AOFD	Carbon-free flexibilities
FCR	Frequency Containment Reserve
mFRR	Manual Frequency Restoration Reserve
RR	Rapid Reserve

AU (NEM)

FCAS	Frequency Control Ancillary Services
FFR	Fast Frequency Response
RERT	Reliability and Emergency Reserve Trader
SRAS	System Restart Ancillary Services

There are some grid services that VPPs do not provide today, such as inertial response, ramping, and reactive power and voltage support to the bulk power system. The ability of VPPs to provide these services also depends on the types of CERs in the operator's fleets, as different kinds of CERs provide different grid services.

1.3.2 VPP revenues

The power system can be unbundled, where different entities own and operate generation, transmission and distribution, or vertically integrated, where a utility owns and operates all three functions. System operators can procure grid services through wholesale energy, capacity, ancillary services markets or bilateral contracts.

There are three main ways VPPs can participate in providing grid services:

- VPPs can participate in the electricity market by **submitting bids for energy, capacity or ancillary services** (only when markets are accessible to VPPs).
- VPPs can **contract bilaterally with utilities** (more prevalent in vertically integrated power systems), transmission and/or distribution networks.
- VPPs owned by vertically integrated utilities can **provide grid services through their parent utility.**

The specific revenues and economics of a VPP vary depending on the CER mix, type of ownership, and level of accessible revenue streams. Depending on the service rendered and the contractual arrangements, VPP revenues may be a function of the energy delivered (e.g. avoided, shifted, exported) ($/MWh) or the flexible capacity procured ($/MW or $/MW/year).

1.3.3 VPP costs

The costs of deploying and operating VPPs fall across three main categories: acquisition, incentive, and implementation. The weight of each of these costs varies greatly depending on the type of VPP (e.g. control-based vs. price incentive-based).

The three cost categories are:

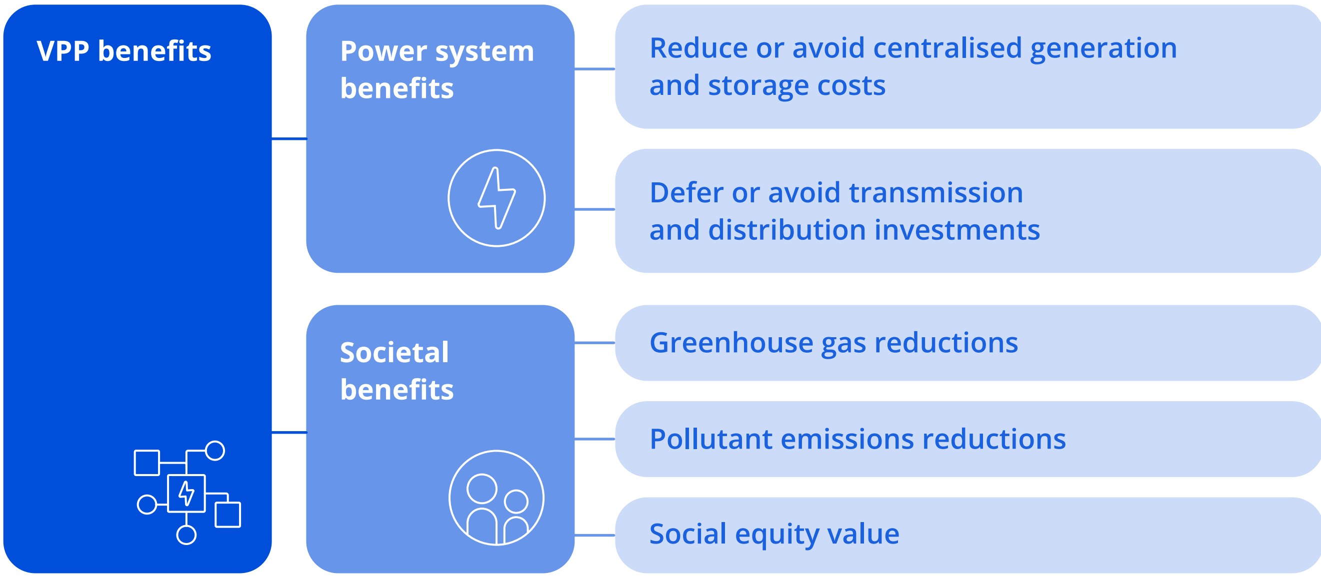
- **Participant acquisition costs:** Marketing, consumer education and recruitment associated costs, including potential CER software integration fees paid to CER manufacturers.
- **Participant incentives:** One-time, periodic, per-kWh payments, or a combination of the three payment methods, from the VPP to participants.
- **Project implementation and administration costs:** CER management data and trading platforms, IT and personnel costs, as well as ongoing administrative costs.

1.3.4 VPP benefits

By providing grid services, VPPs can bring both power system benefits and broader societal benefits. Power system benefits include reducing or avoiding centralised generation and storage, reducing wholesale energy costs and deferring or avoiding transmission and distribution investments. VPPs also contribute to greenhouse gas and pollutant emission reductions.

The benefits listed here are specific to the operation of VPPs and do not include the standalone benefits that individual CERs may offer independently.

Figure 5 – VPP benefits [3]



Power system benefits

Reducing or avoiding centralised generation and storage costs

As VPPs typically reduce the net demand on the network at system peak time, they defer or avoid the capital investments required for centralised generation and storage. The system also benefits from overall reduced wholesale energy cost, as higher marginal cost generators are pushed out of merit.

Deferring or avoiding transmission and distribution investments

VPPs can help flatten the load curve by providing power or voluntarily reducing demand during peak demand periods. This reduces net load growth, resulting in deferring or avoiding the need for transmission and distribution investments.

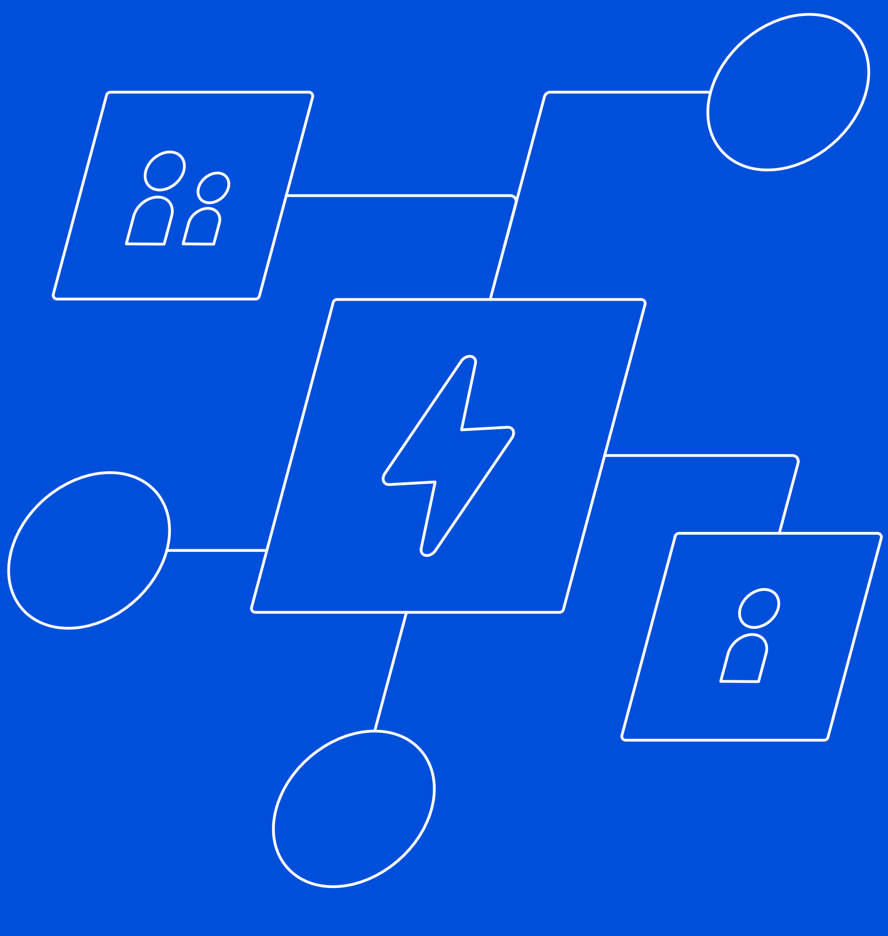
Societal benefits

- **Greenhouse gas reductions –** VPPs can enable the system to reduce its carbon footprint by moving load to periods of high variable renewable energy (VRE) generation and replacing centralised generation from fossil fuel sources, allowing for increasing VRE integration and avoiding fossil-based peaking plants.
- **Pollutant emission reductions –** VPPs can be used to provide grid services in place of fossil fuel-based sources, reducing primary pollutant emissions such as nitrogen oxides, sulphur dioxide, carbon monoxide, particulate matter, heavy metals and volatile organic compounds.
- **Social equity –** VPPs can allow for state or federal governments to fulfil social equity goals, for example, by requiring or encouraging grid operators and utilities to actively procure VPP grid services from underserved communities.

As countries worldwide seek to decarbonise their power systems and enhance grid resilience, VPPs are becoming an increasingly attractive solution. However, the pace at which countries adopt and capitalise on the benefits of VPPs varies significantly. The following chapters examine how underlying regulatory, technical and market factors in the power system affect a country's readiness to implement VPPs successfully.

By providing grid services, VPPs can bring both power system benefits and broader societal benefits.

2. VPP Readiness Index



Although there have been preliminary studies about VPPs and how they can be deployed to benefit utilities and consumers by reducing system costs and accelerating the power system's decarbonisation, there has not been an assessment of the readiness of different countries to adopt VPPs at scale. This assessment is crucial in identifying leading countries, their best practices and exploring the residual actions required, as well as the obstacles and challenges countries face in the early stages of growing and integrating VPPs.

To this end, I2Z and Blunomy have developed a VPP Readiness Index that intends to strike a balance between:

- Its **applicability** to many countries, including countries with limited data availability; and
- Its **utility,** to ensure the index gives an accurate view of the countries' readiness to scale VPP deployment.

The VPP index aims to be useable, accessible and replicable and provides a snapshot of a country's readiness based on its current technical, regulatory and commercial characteristics. The index allows for comparing country readiness and attractiveness and identifying best practices to facilitate the widespread adoption of VPPs.

Blunomy has applied the VPP Readiness Index to twelve countries across five continents and at varying economic and electricity market maturity levels:

Table 2: List of countries assessed in the VPP Readiness Index

AFRICA	ASIA	EUROPE	OCEANIA	AMERICAS
Kenya South Africa Nigeria	India Indonesia Malaysia	France United Kingdom	Australia	Brazil Chile Colombia

The VPP index aims to be useable, accessible and replicable.

2.1 Index method

VPP readiness refers to the conditions within a country's power system and electricity markets that support VPPs to be technically and commercially viable. There are five categories considered when assessing a country's VPP readiness, ensuring a comprehensive evaluation:

VPP resource availability – This refers to the presence and accessibility of CERs like rooftop solar systems, EVs and their charging infrastructure, batteries, and flexible load that VPPs can aggregate and orchestrate. Without adequate flexible CER capacity, a VPP cannot function effectively. Mechanisms specifically favouring CER adoption in a country, such as supportive regulations, policies and incentives, or obligations and penalties that disincentivise fossil fuels, demonstrate state interest and support in growing VPP resources.

Flexibility needs – Power systems need to quickly and efficiently balance supply and demand to maintain grid stability and reliability of supply. However, ensuring grid stability can become challenging in countries where the energy system increasingly relies on VRE.

For this index, flexibility needs are defined by the level of difficulty to ensure system balance, which is driven by several drivers including VRE penetration, shape of load, etc. Countries with higher system flexibility needs will benefit from the services provided by VPPs.

The index currently focuses on daily/weekly flexibility needs at system level, and Blunomy has developed a top-down system flexibility needs model to estimate the daily/weekly flexibility for each country. The model uses a regression analysis by taking publicly available data as inputs, including daily/weekly flexibility needs in European countries, energy demand, generation capacity, and solar and wind power generated.

Seasonal flexibility needs and local (e.g. distribution network) flexibility needs, which refers to the need to manage local network constraints or congestions on the distribution network, are not considered in this index due to the challenges in obtaining representative flexibility needs data. Where possible, these needs are discussed qualitatively in the detailed assessments in Appendix B. Daily/weekly system flexibility needs are used as a proxy to represent the flexibility needed for a country.

Market attractiveness – This involves assessing the power industry structure and access to revenue streams that make a country appealing for VPP investments. An unbundled power industry structure and retail competition lower the barriers to entry and ease access for private-sector VPPs to customers. Conversely, a bundled power structure may see only the integrated utility developing and operating VPPs, limiting the pace of VPP deployment. Existing electricity markets or revenue mechanisms, such as access to the wholesale energy, capacity and ancillary services markets, support VPPs commercial viability.

Regulatory environment – Regulations and policies specifically in favour of VPP deployment are an indicator of the government interest and support in driving VPP deployment. These can include VPP or CER aggregation roadmaps, targets and frameworks, communication material around VPPs, the services and benefits they provide, and financial support for VPP providers. Addressing data and privacy can also relieve customer concerns and improve consumer participation in VPP programs.

Having supportive and clear regulatory frameworks is essential for VPPs to operate legally and efficiently. Without an appropriate regulatory framework, VPPs will face barriers that hinder their implementation.

Grid operations – This refers to the technical and operational capacity of the electricity grid to integrate and manage the variable output from CERs. Utilities and regulators with clear CER and VPP integration strategies and capabilities can help lower technical and commercial barriers to entry by easing connection processes and informing technology choices and roll-out strategies for VPP operators. Widespread deployment of advanced metering infrastructure (AMI) supports network and voltage visibility, providing data that allow for improved VPP planning and orchestration.

Scoring criteria

To assess each country's VPP readiness, I2Z and Blunomy identified nine qualitative and quantitative criteria from the five categories and a set of (KPI) for each criterion. These were used to score the country based on its state of development today.

Each criterion is scored from 0 to 10, with the total out of 90 converted into a percentage for easier comparison. Appendix A details how each KPI is assessed and the assumptions made.

Table 3 on the next page details how the categories are broken down into criteria, their KPIs, and how these combine into a percentage score.

Table 3 – VPP Readiness Index

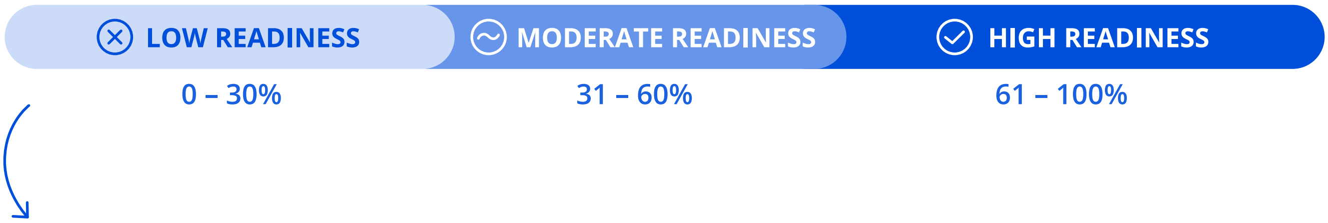
Category	Criteria	KPI (assess current state)	0 – 2	3 – 4	5 – 6	7 – 8	9 – 10
VPP resource availability	1 Amount of CER capacity (as % of peak demand)	The sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	≤25%	26 – 50%	51 – 75%	76 – 100%	>100%
	2 Coverage of pro-CER regulations, policies, and incentives	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions; loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes, codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	0/6 regulatory, policy or incentive categories covered	1/6 categories covered	2 – 3/6 categories covered	4 – 5/6 categories covered	6/6 categories covered
Flexibility needs	3 System flexibility needs (as % of peak demand)	System flexibility needs in GW as a percentage of peak demand in GW. See Appendix A for details on the approach used.	≤10%	11-15%	16-20%	21-25%	>25%
Market attractive-ness	4 Power system structure and regulation: presence of unbundled power industry and/or retail competition	Presence of unbundled power industry and/or retail competition.	Fully integrated utility, no retail competition	Fully integrated utility, selective retail competition	Partially unbundled or with some retail competition	Fully unbundled power industry and limited retail competition	Fully unbundled power industry and high retail competition
	5 VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	Access to energy, capacity and/or ancillary services markets.	No markets available	Accessible via bilateral contracts to selected sources	Accessible via bilateral contracts to all sources including VPPs	Wholesale markets accessible to VPPs; limited price signals	Wholesale markets accessible to VPPs; clear price signals

Category	Criteria	KPI (assess current state)	0 – 2	3 – 4	5 – 6	7 – 8	9 – 10
Regulatory environ-ment	**6** Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes, codes, standards, certifications).	**0/4** regulatory, policy or incentive categories covered	**1/4** categories covered	**2/4** categories covered	**3/4** categories covered	**4/4** categories covered
	7 Presence of data protection and privacy considerations	Presence of data protection and privacy laws or guidelines.	None present	National policy in drafting	General framework and redressal mechanisms	Energy sector framework and redressal mechanisms	Addressed directly in state-published CER/VPP reports
Grid operation	**8** Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.).	No advertised / known capabilities	Capabilities being implemented	Some capabilities in place	Region leading capabilities	World-leading capabilities
	9 Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	Smart meter penetration in %.	No smart meter/ LV devices	Smart meter penetration >30% - no voltage data	Smart meter penetration >50% - no voltage data	Smart meter penetration >70% - w/ voltage data	Smart meter penetration >90% - w/ voltage data

2.2 Scoring criteria

Based on the final score, countries were categorised into low, medium or high VPP readiness.

Figure 6 – VPP readiness spectrum



LOW READINESS

These are countries that are in the early stages of CER adoption and integration. They have low levels of CER deployment, regulatory support, market conditions, and grid capability for VPP implementation, and a minimal need for system flexibility. Significant gaps and barriers exist, making VPP deployment in such countries highly challenging. Meaningful power sector reforms must be implemented to make these countries attractive markets for VPP deployment.

MODERATE READINESS

These are countries that have made some progress towards VPP readiness but require further development. The countries have some foundational elements for VPPs, with availability of CER resources, emerging regulatory frameworks, and growing market interest. Some countries also have state-led VPP pilots. Within this group, there are countries with significant score disparities, excelling in certain criteria while scoring much lower in others. A targeted reform program to address the specific gaps is required to make such countries attractive markets for VPP deployment.

HIGH READINESS

These are countries that are well-equipped for VPPs or may already have a VPP industry, have abundant CER resources, a strong need for flexibility, attractive market conditions, supportive regulations, and CER capabilities within utilities and regulators. These countries tend to score highly across most criteria, with only one or two areas showing lower scores. Further progress in VPP deployment in these countries will require less significant changes to the existing power industry.

2.3 Index exclusions

In keeping with the spirit of making an index that is readily useable, accessible, and replicable, we considered the following factors but ultimately did not include them as part of the VPP Readiness Index:

- **Local (distribution network) flexibility needs**

  Local flexibility needs, as part of the flexibility needs of a country, are not considered in the flexibility needs criteria due to the challenges in obtaining representative local flexibility needs data.

- **Forward-looking plans and projections**

  Since the index aims to provide a snapshot of the current state of VPP readiness in countries, forward-looking projections and plans, such as projected CER capacity or peak demand forecasts, are not included in the final score.

- **Regional variations**

  The index evaluates each country's overall VPP readiness and does not account for regional variations within countries. For example, certain islands in Indonesia may be more prepared for VPPs than others but the final score is only for the country as a whole.

- **Criteria weightage**

  Each criterion is weighted equally in assessing a country's VPP readiness. While some criteria may have a greater impact on VPP deployment attractiveness than others, the significance of these factors can differ from country to country. Therefore, equal weighting is used to maintain the index's replicability across a wide range of countries.

3. Comparative analysis of results

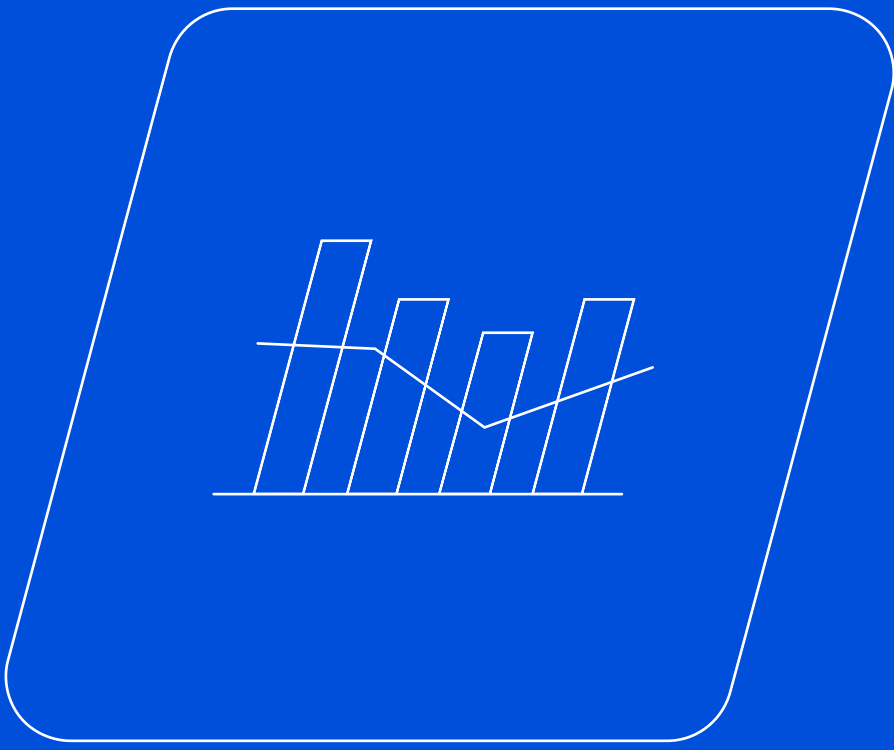


Table 4 below shows the final index and scores for the 12 countries.

Table 4: VPP Readiness Index score by country*

Category	Criteria	AUS	FRA	GBR	CHL	IND	BRA	ZAF	COL	MYS	KEN	IDN	NGA
VPP resource availability	1 Amount of CER capacity (as % of peak demand)	8	6	7	4	4	6	4	5	4	5	4	0
	2 Coverage of pro-CER Regulations, policies, and incentives	8	8	8	8	8	7	8	8	6	7	6	3
Flexibility needs	3 System flexibility needs (as % of peak demand)	10	3	6	10	6	6	5	3	5	4	2	1
Market attractiveness	4 Power system structure and regulation: presence of unbundled power industry and/or retail competition	10	10	10	7	7	7	5	7	1	6	1	6
	5 VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	8	10	8	6	6	4	3	4	4	3	3	3
Regulatory environment	6 Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	8	8	9	0	0	2	2	0	2	0	0	0
	7 Presence of data protection and privacy considerations	8	8	8	6	6	6	6	6	5	6	6	5
Grid operation	8 Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	10	9	7	5	6	3	6	4	6	3	3	3
	9 Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	4	9	6	2	2	2	2	2	4	1	1	1
	Total	82%	79%	77%	53%	50%	48%	46%	43%	41%	39%	29%	24%
	2023 GDP per capita (US$) [4]	65K	44K	49K	17K	2.5K	10K	6.3K	7K	12K	2K	5K	1.6K

HIGH READINESS 61 – 100%

MODERATE READINESS 31 – 60%

LOW READINESS 0 – 30%

*AUS: Australia, FRA: France, GBR: United Kingdom, CHL: Chile, IND: India, BRA: Brazil, ZAF: South Africa, COL: Colombia, MYS: Malaysia, KEN: Kenya, IDN: Indonesia, NGA: Nigeria

General trends

Most countries fall within the moderate-readiness category, with only two nations, Indonesia and Nigeria, classified as low-readiness. Countries in the moderate and low readiness categories are primarily focused on CER adoption and integration. Since VPPs depend on the aggregation of CERs, these countries show limited support for VPPs.

VPP resource availability

Figure 7 – VPP resource availability score, out of 20

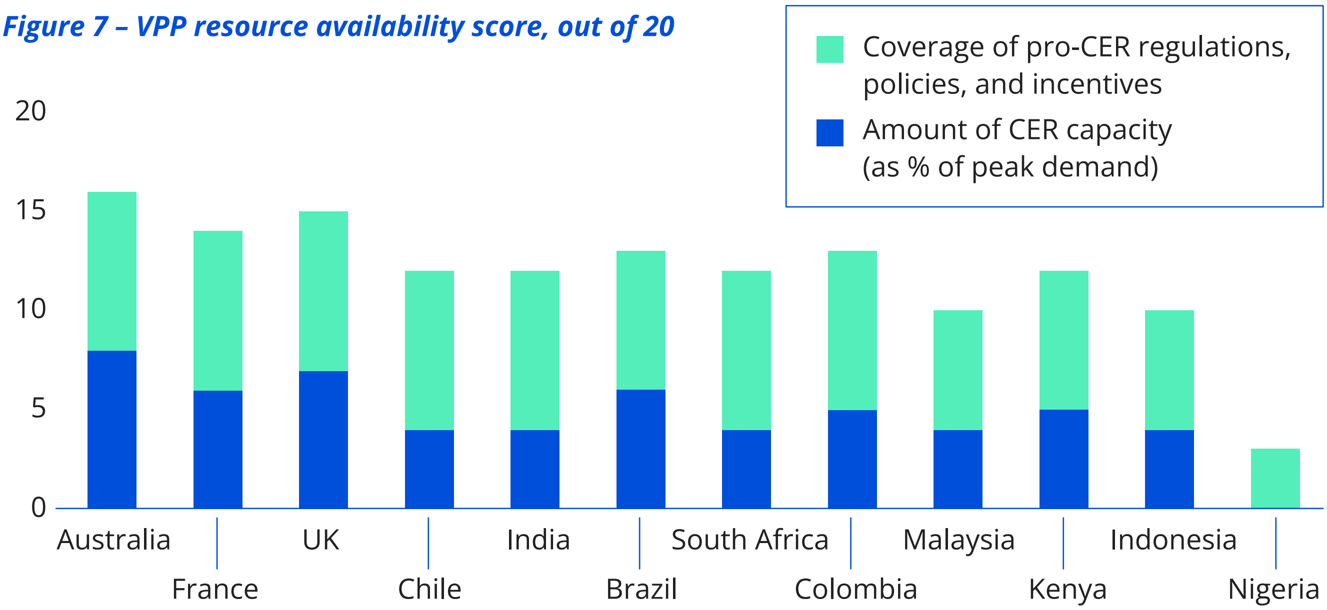
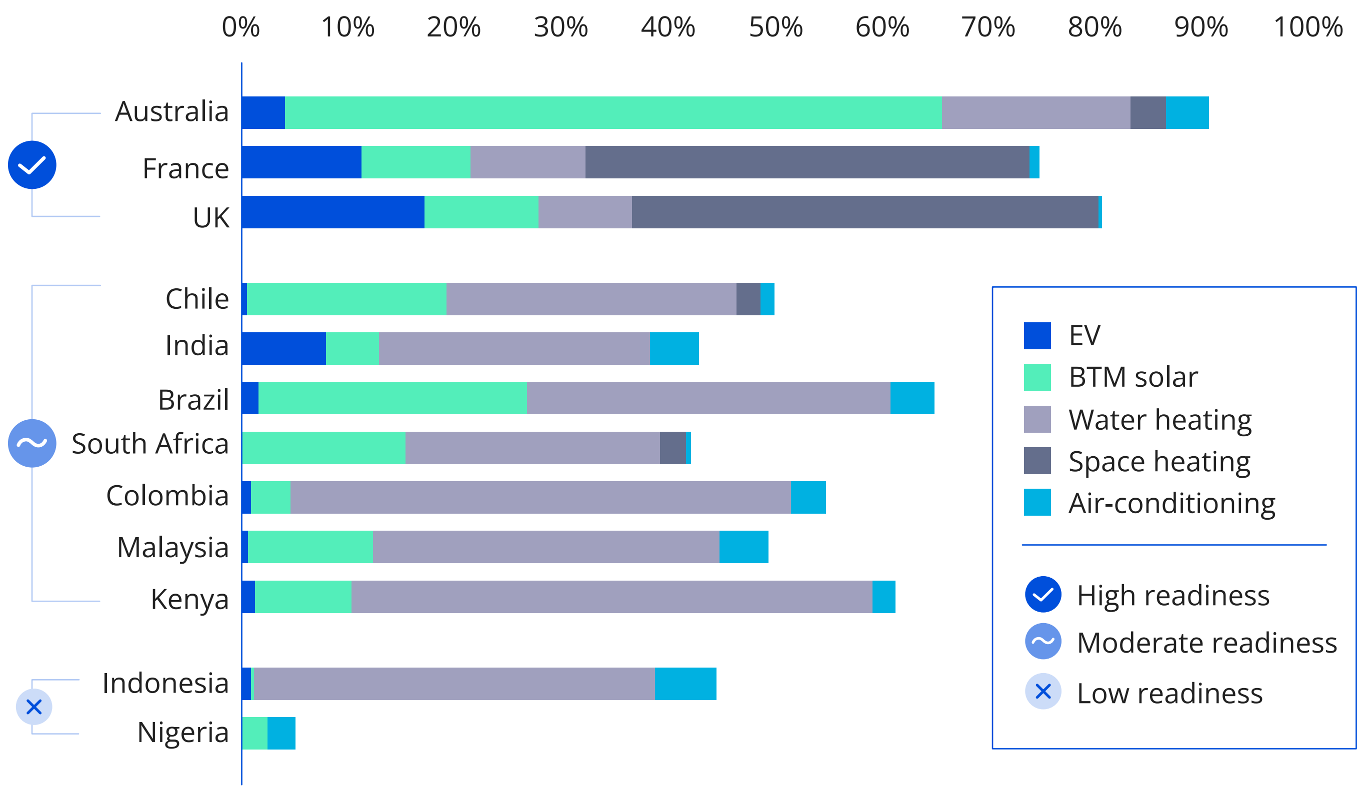


Figure 8 – Amount of CER capacity as a percentage of peak demand by technology



The amount of CER capacity as a percentage of peak demand varies significantly across countries, and there is no strong correlation between CER capacity against the total final scores. The contribution of each CER type to the total flexible CER capacity also differs by country, with space heating contributing significantly to France's and United Kingdom's capacities, BTM solar being the main contributor for Australia and water heating and air-conditioning being the main contributor for the remaining countries. Countries with temperate climates have an additional resource in electric space heating capacity.

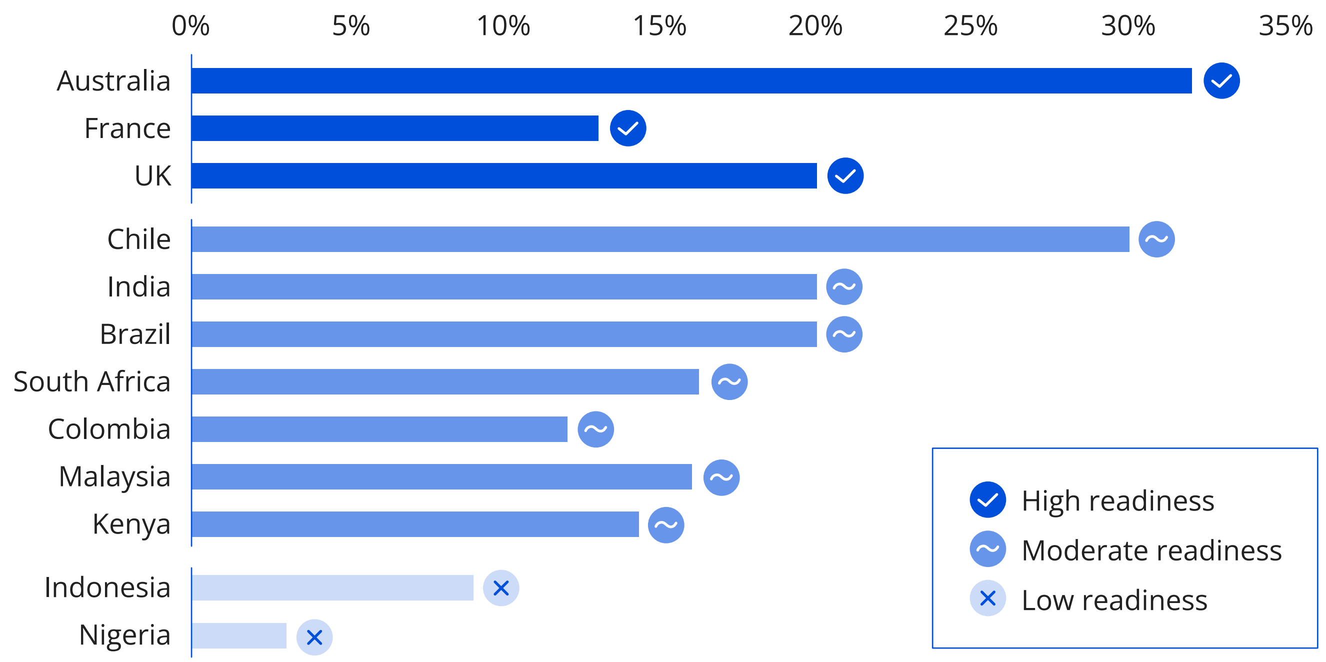
Except Nigeria, all countries have policies, regulations and incentives that support CER adoption, most notably for rooftop solar. Higher-scoring nations typically have regulations, policies, and incentives in place that actively support CER development, with clear roadmaps, targets and financial support in the form of tax exemptions and subsidies or options to monetise CER, including Net Energy Metering (NEM) and Feed-in-Tariffs (FiT). Currently, most countries support rooftop solar, with some backing EVs and Battery Energy Storage Systems (BESS), while flexible demand receives less attention.

Public and consumer education and CER governance are mixed across the countries. Most regulators or utilities have dedicated sections of their websites on CER or renewable energy, with some countries like United Kingdom, France and Australia regularly soliciting public input on CER topics. Most countries also have standard connection procedures and codes for solar installations, with Australia and United Kingdom having broader CER connection procedures.

A meaningful number of countries have carbon pricing mechanisms, with France and United Kingdom having an emissions trading system, and South Africa, Chile and Colombia having a carbon tax.

Flexibility needs

Figure 9 – System flexibility needs as a percentage of peak demand

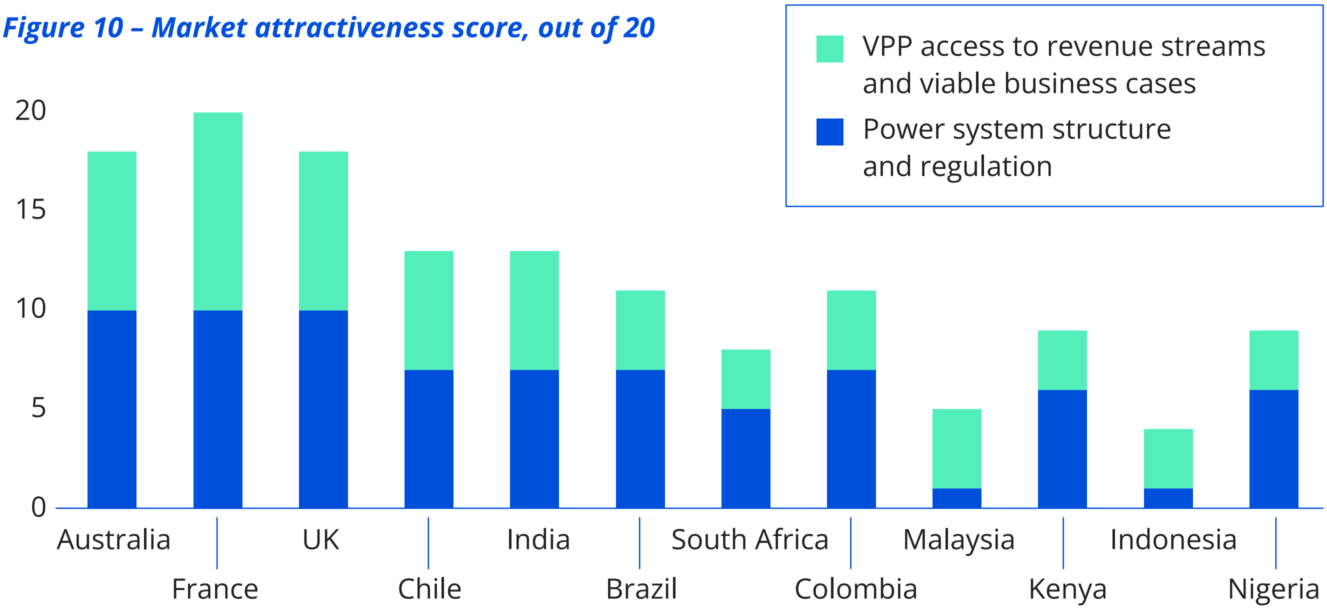


Australia and Chile score highly for system flexibility needs due to over 30% of their generation coming from large-scale solar and wind, which account for around 30% of their energy generation. The United Kingdom also has 30% VRE contribution, mainly from wind. However, due to its higher peak demand, its system flexibility needs compared to its peak demand are not as high as those of Australia and Chile.

In contrast, Nigeria, Indonesia and Colombia have low VRE penetration in their energy mix, reducing the need for system flexibility. France scores low in this category because its VRE share relative to peak demand is not substantial. It should be noted that flexibility needs can be met by large-scale storage and VPPs.

Market attractiveness

Figure 10 – Market attractiveness score, out of 20



Countries with high VPP readiness, such as Australia, France, and the United Kingdom, have strong market attractiveness for VPPs, with an unbundled power industry, high retail competition, and established wholesale energy and ancillary services markets. However, Australia has limited VPP participation in the frequency control ancillary services (FCAS) market wholesale demand response mechanism, and in pilot projects providing distribution network support services. Both France and the United Kingdom have markets that allow CERs like demand-side response to participate, with the United Kingdom recently opening up the wholesale market, in addition to the Balancing Mechanism which was already accessible, to VPPs. In the United Kingdom, the National Energy System Operator (NESO) introduced the Demand Flexibility Service (DFS) in winter 2022 to access additional capacity during times of high national demand all year round. NESO is also trialling a new Local Constraint Market (LCM) to access new sources of flexibility to help manage transmission constraints and avoid curtailment.

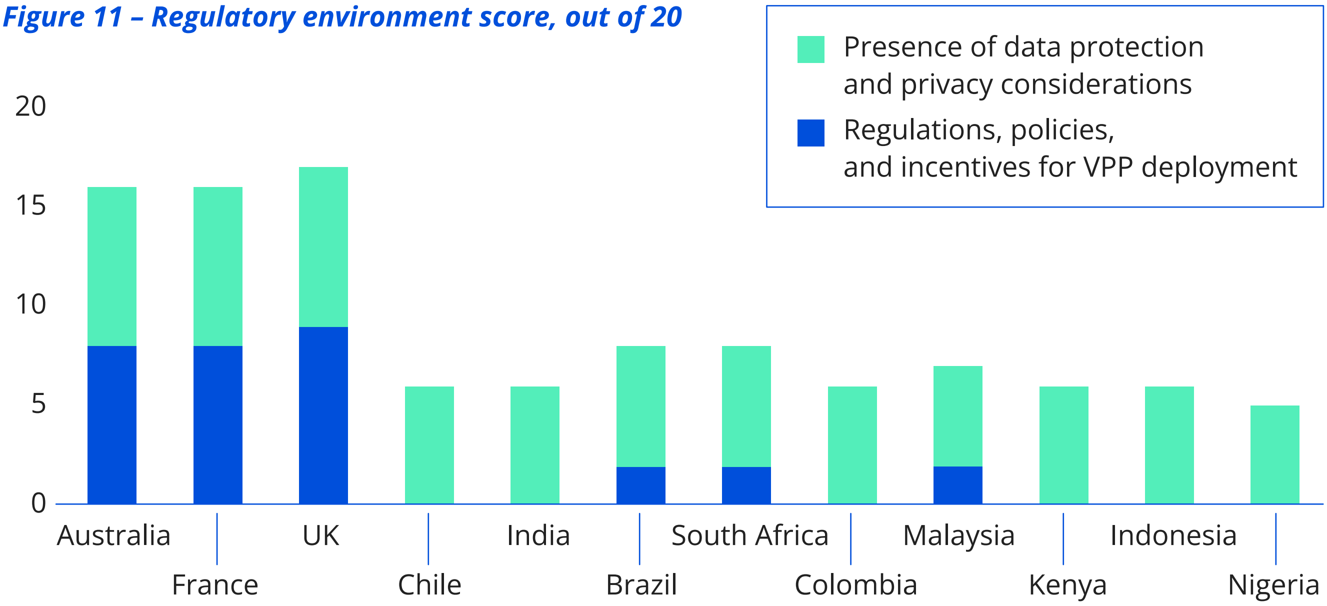
All countries, except South Africa, Malaysia and Indonesia, have unbundled power structures, where generation, transmission, and distribution are managed by separate entities. South Africa, historically run as a vertically integrated system by Eskom, is currently unbundling into three divisions – generation, transmission and distribution. Malaysia and Indonesia retain a vertically integrated system, with the state-owned utility Tenaga Nasional Berhad (TNB) in Peninsular Malaysia and Perusahaan Listrik Negara (PLN) in Indonesia overseeing generation, transmission, distribution, and retail.

Brazil and Malaysia have wholesale energy markets that are open to select generators but lack ancillary services markets. Kenya, Nigeria, South Africa and Indonesia lack wholesale energy, capacity, and ancillary services markets, limiting VPP revenue streams. Energy, capacity and ancillary services in these countries are managed through bilateral contracts with major power generators. South Africa is in the process of setting up a wholesale energy market as part of its unbundling efforts.

Aside from Australia, France and United Kingdom, all other countries have limited to no avenues for VPPs to access revenue streams.

Regulatory environment

Figure 11 – Regulatory environment score, out of 20



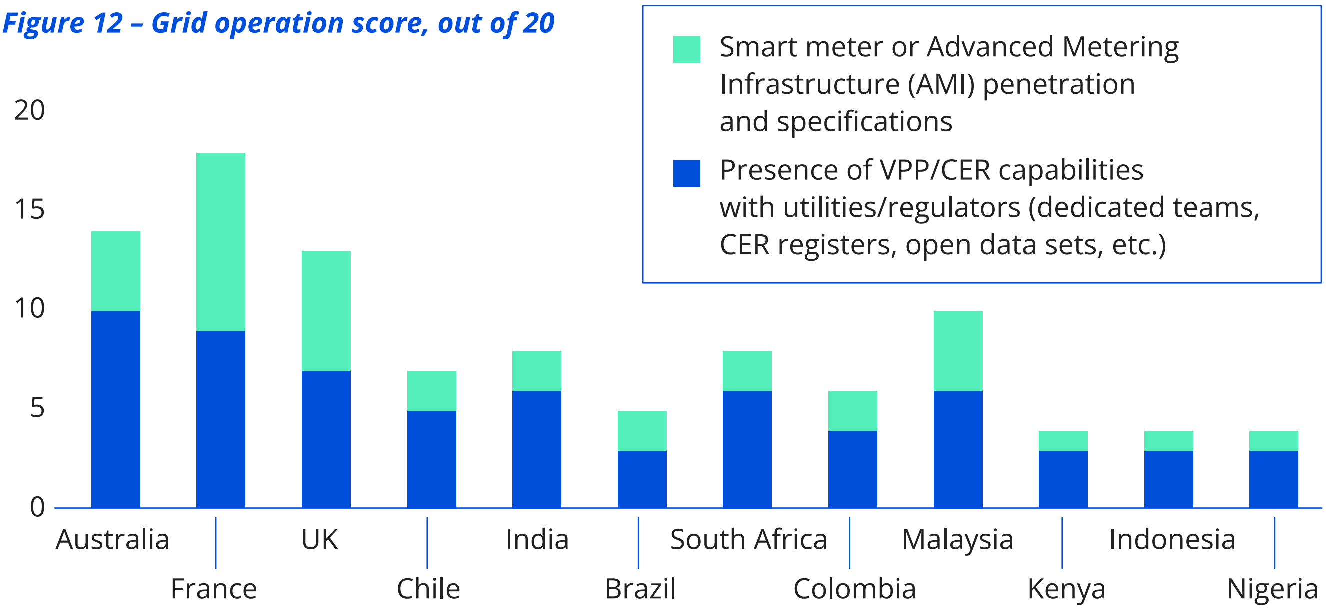
Policies that support VPP development and CER aggregation services, or already have commercial VPP providers, result in high ratings for the regulatory environment. For example, Australia and France already have active VPP providers. The United Kingdom has specific policies supporting 'flexibility services', which are services provided by aggregated CERs. In addition, the United Kingdom government is exploring a new regulatory regime for directly controlling loads and setting common standards for smart devices to ensure interoperability.

In contrast, other countries lack VPP-specific policies, as many are still developing broader CER support frameworks. Brazil and South Africa are currently running VPP pilot programs, although the results of the pilots have yet to be announced. Malaysia ran a VPP pilot in collaboration with South Korea in 2019, but did not publicly share the trial results. The pilots in Brazil and Malaysia are government-supported, while South Africa's are privately operated.

All countries have consumer data protection and privacy regulations. Australia, France, and the United Kingdom go further, with energy-specific regulations that safeguard smart meter data or manage consumer data held by electricity retailers.

Grid operation

Figure 12 – Grid operation score, out of 20

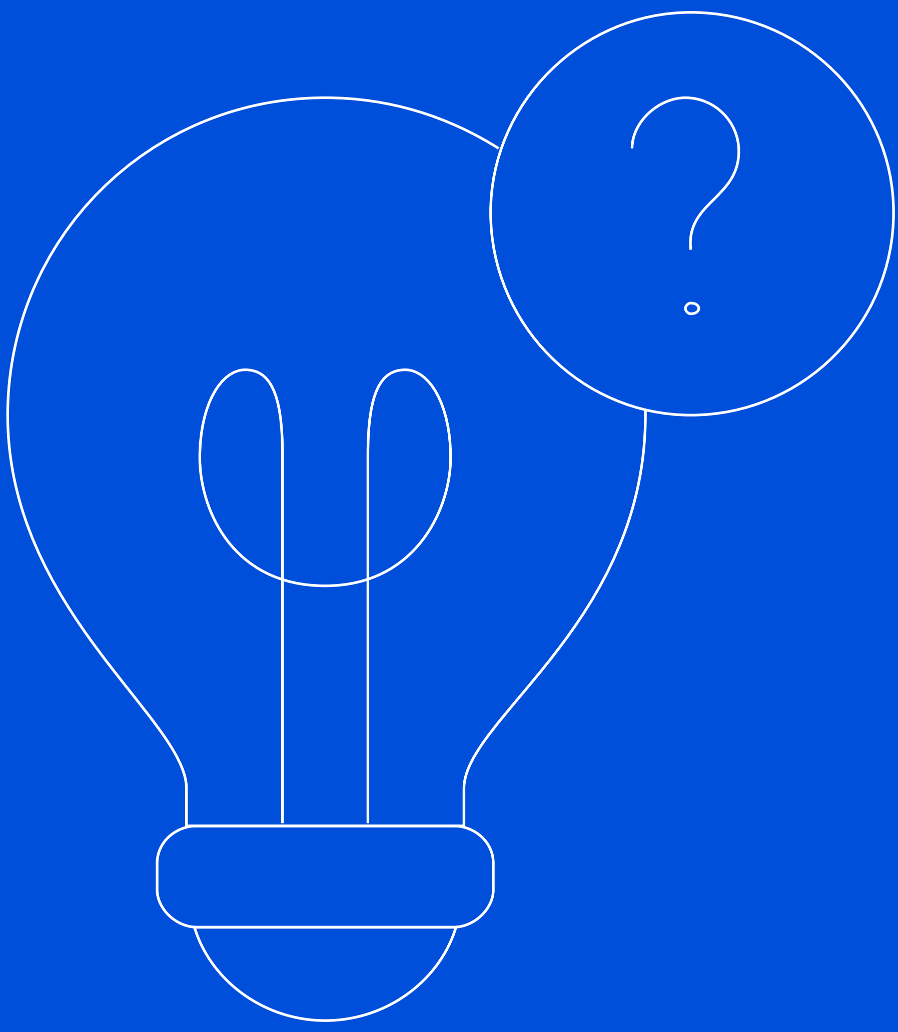


Utilities, networks and regulators in most countries have demonstrated progress in integrating CER within their power systems, often featuring dedicated CER sections or registers on their websites or by publishing smart grid or CER integration plans. Some countries, like Brazil, Kenya, and Nigeria, focus on specific types of CERs, such as distributed generation and microgrids. Some countries like Australia, France and the United Kingdom have conducted several VPP demonstration projects but utilities, networks and regulators in most other countries have not yet developed substantial VPP-specific capabilities.

Advanced Metering Infrastructure penetration remains a challenge as it remains low across most nations despite roll-out programs and targets. France leads with 88% penetration, followed by the United Kingdom at 54%. Australia has a moderate overall penetration of 45%, though Victoria has achieved a 100% roll-out. All moderate and low-readiness countries have smart meter penetration rates below 10%, except Malaysia, which has reached 25%.

Appendix A

– Method and assumptions



Method and assumptions of VPP Readiness Index assessment

Table 5 details how each KPI is assessed and the assumptions made.
In determining the scoring for each KPI, we prioritised publicly available data sources from governments, regulators and stakeholders within the power system. When not available, especially in countries where English is not the primary language, secondary sources, including international and independent consultancy reports, academic papers, and public news sites, were considered for the assessment of performance.

Table 5: Detailed method and assumptions of VPP Readiness Index

Criteria	KPI (assess current state)	Method	Assumptions
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	The available reported capacity in 2023 in GW for five types of CERs are considered: EVs, Behind-the-meter (BTM) solar, air-conditioning units, water heating systems and space heating systems. Only domestic air-conditioning units and electric water heating and space heating systems were considered due to the challenges in obtaining official commercial and industrial heating capacities in most countries, and the difficulty in determining an average air-conditioning or heater size for estimations. Where a country uses both space heating and cooling, the higher capacity of the two is considered when calculating the flexible CER capacity. Despite their importance, BTM battery capacities are not widely reported nationally and so have been excluded from the estimates. When capacity data in GW is not publicly available, it is estimated using the total number of units multiplied by an average power unit in. If the capacity or number of units is not available, especially for water and space heating, capacity is estimated using figures from countries with similar climates and economic maturity where data is available and taking the ratio between the population of the two countries. The flexible CER capacity is then estimated by dividing the total CER capacity with national peak demand in 2023.	▪ **EV:** Considers the 2018 – 2023 stock of battery electric vehicles (BEV), assumes Type 2 single phase charging at 7.6kW, unless otherwise specified by the country. ▪ **Solar:** As visibility over BTM solar capacity varies across countries, BTM solar capacity is prioritised if available, and if not, grid-connected rooftop solar capacity is considered instead. Considers the nameplate capacity of solar i.e. using GWp. ▪ **Water heating:** Only electric water heating capacity is included, domestic water heater size of 1.5kW [5]. ▪ **Space heating:** Assumes domestic space heater size of 1.5kW per 200sqft [6]. For countries with tropical climates, assumes no space heating. ▪ **Air-conditioning:** Assumes average aircon unit power demand is 1kW [7]. ▪ When capacity figures are reported as a range, the lower range figure was considered to provide a conservative estimate.

Criteria	KPI (assess current state)	Method	Assumptions
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ Presence of nationally announced roadmaps and targets on CER broadly or on individual types of CERs (e.g. rooftop solar PV, demand response, batteries, etc); ▪ Presence of government subsidies, grants, tax exemptions, favourable loans on CER broadly, or individual types of CERs; ▪ Presence of net metering, feed-in-tariff programs and/or presence of time-of-use tariffs; ▪ Presence of public websites on CERs, and/or public consultation/workshops by energy commissions, regulators and government bodies; ▪ Presence of available information on application and connection processes, and/or presence of national standards and codes on design and installation of CER; ▪ Presence of carbon tax, tariffs on fossil fuels and/or requirements on renewable energy portfolio standards.	None.
3 **System flexibility needs (as % of peak demand)**	System flexibility needs in GW as a percentage of peak demand in GW.	Blunomy has developed a top-down system flexibility needs model to estimate the daily/weekly flexibility for each country. The model uses a regression analysis by taking publicly available data as inputs, including daily/weekly flexibility needs in European countries, energy demand, generation capacity, and solar and wind power generated. The regression factors, together with the energy demand, solar and wind generation for each country [8] are then used to estimate the daily flexibility needs of the country. The system flexibility needs in GW are then estimated by dividing the daily flexibility needs by the national peak demand in 2023.	▪ 6 hours per day of flexibility utilisation time; ▪ Regression analysis takes European inputs and applies them globally [9] [10] [11] [12]; ▪ Flexibility needs are estimated for the entire country and do not account for intra-country regional differences.
4 **Power system structure and regulation: presence of unbundled power industry and/or retail competition**	Presence of unbundled power industry and/or retail competition.	Assess the state of liberalisation of the power industry and the extent of electricity retail competition.	That more unbundled systems will reduce barriers to the technical and commercial viability of VPPs.

Criteria	KPI (assess current state)	Method	Assumptions
5 **VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets**	Access to energy, capacity and/or ancillary services markets.	Presence of wholesale energy, capacity and or ancillary services markets. Consider types of contracting and access to the markets (e.g. bilateral contracts vs open markets, types of technology that can participate).	None.
6 **Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives**	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications).	▪ Presence of nationally announced roadmaps and/or targets on VPP adoption; ▪ Presence of government subsidies, grants, tax exemptions, and favourable loans for VPP programs; ▪ Presence of public websites on VPPs, and/or public consultation/workshops by energy commissions, regulators and government bodies; ▪ Presence of available information on application and connection processes, and/or presence of national standards and codes on VPP set-ups.	Countries that already have commercially operational VPPs will score highly for this criterion.
7 **Presence of data protection and privacy considerations**	Presence of data protection and privacy laws or guidelines.	Presence of a national data protection and privacy law or regulation. Considers if there are energy-specific data protection laws or regulation.	That data protection laws will reduce barriers for VPP deployment.
8 **Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	Presence of VPP/CER teams/plans/ roadmaps within regulators market operators, distribution network operators and/or utilities. Presence of CER asset registers and open data on VPP/CER.	That the presence of CER asset registers and data on CER and VPP deployment indicates awareness and support for VPPs by energy regulators, utilities and others.
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	Assess smart meter penetration rate in %. The penetration rate is calculated by dividing the number of installed smart meters as of 2023 by the total number of smart meters that could be installed or announced as part of the smart meter rollout plan.	None.

Appendix B
– Detailed assessment by country

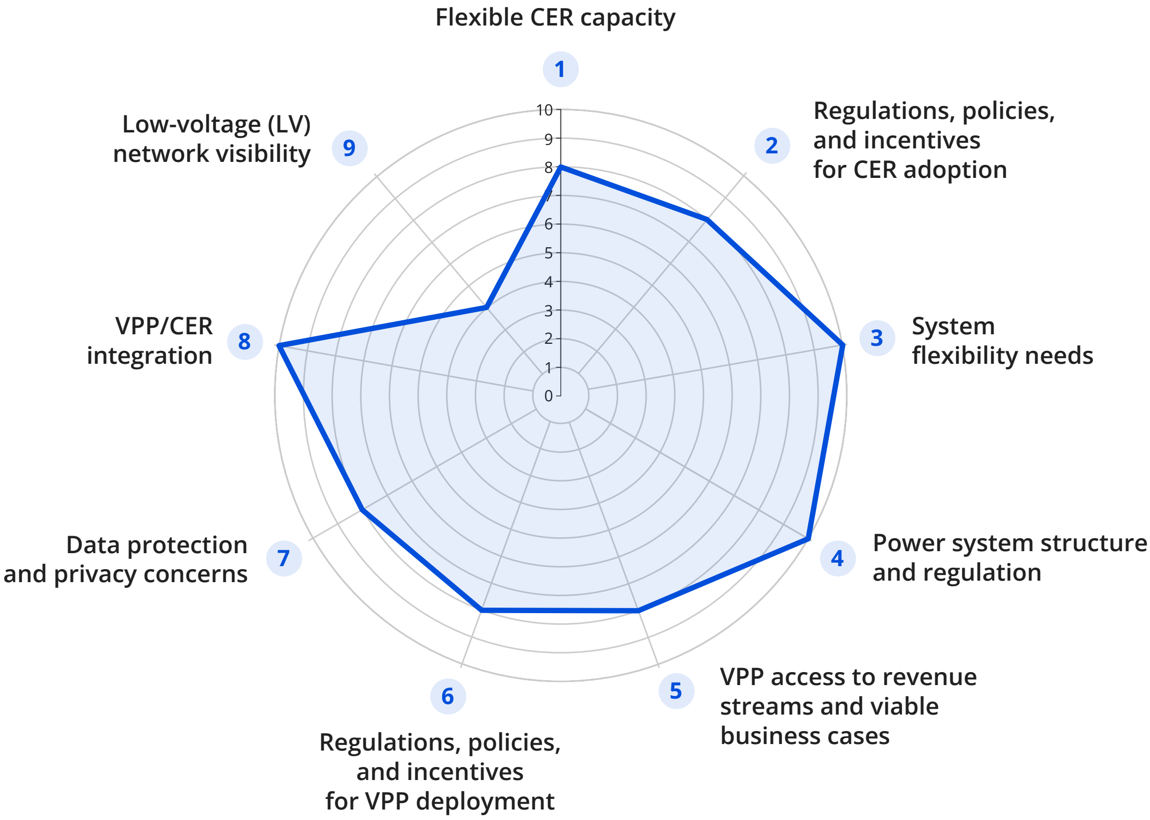
Detailed assessment results are presented in the following order:

Map source: vecteezy.com

Australia | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
26.64 million	**US$1,724 billion**	**US$64,712**

	Criteria	**Score**
1	Amount of CER capacity (as % of peak demand)	8
2	Coverage of pro-CER Regulations, policies, and incentives	8
3	System flexibility needs (as % of peak demand)	10
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	10
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	8
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	8
7	Presence of data protection and privacy considerations	8
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	10
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	4
	Total	**82%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** According to the Electric Vehicle Council of Australia, there are 180,000 EVs in Australia in 2023, which puts the total EV capacity at an estimated 1.37GW [13]. ▪ **BTM solar** From the Rooftop solar and storage report published by the Clean Energy Council, there is a total installed capacity of 20GWp of rooftop solar in Australia [14]. ▪ **Space and water heating** In a government report on the Energy Rating website, it is estimated that there would be ~700,000 electric space heating units in 2023, which puts the space heating capacity at 1.05GW [15]. The Australian Renewable Energy Agency published a domestic hot water and flexibility report. The report estimated the flexible capacity of domestic electric hot water systems to be ~5.3GW in 2020 and ~6.8GW in 2030. Assuming a linear increase across the years, the capacity for 2023 is taken as ~5.75GW [16]. ▪ **Aircon capacity** The number of stationary air-conditioning units in Australia in 2023 stands at 1.3 million units [17]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 1.3GW. As the National Electricity Market (NEM) in the east coast of Australia is significantly larger than the Wholesale Electricity Market (WEM) in the west coast, we will consider the peak demand of the NEM. With the NEM peak demand of 32.5GW in 2023 [18], the flexible CER capacity as a percentage of peak demand for Australia is (1.37+20+5.75+1.3)/32.5 = 87%.

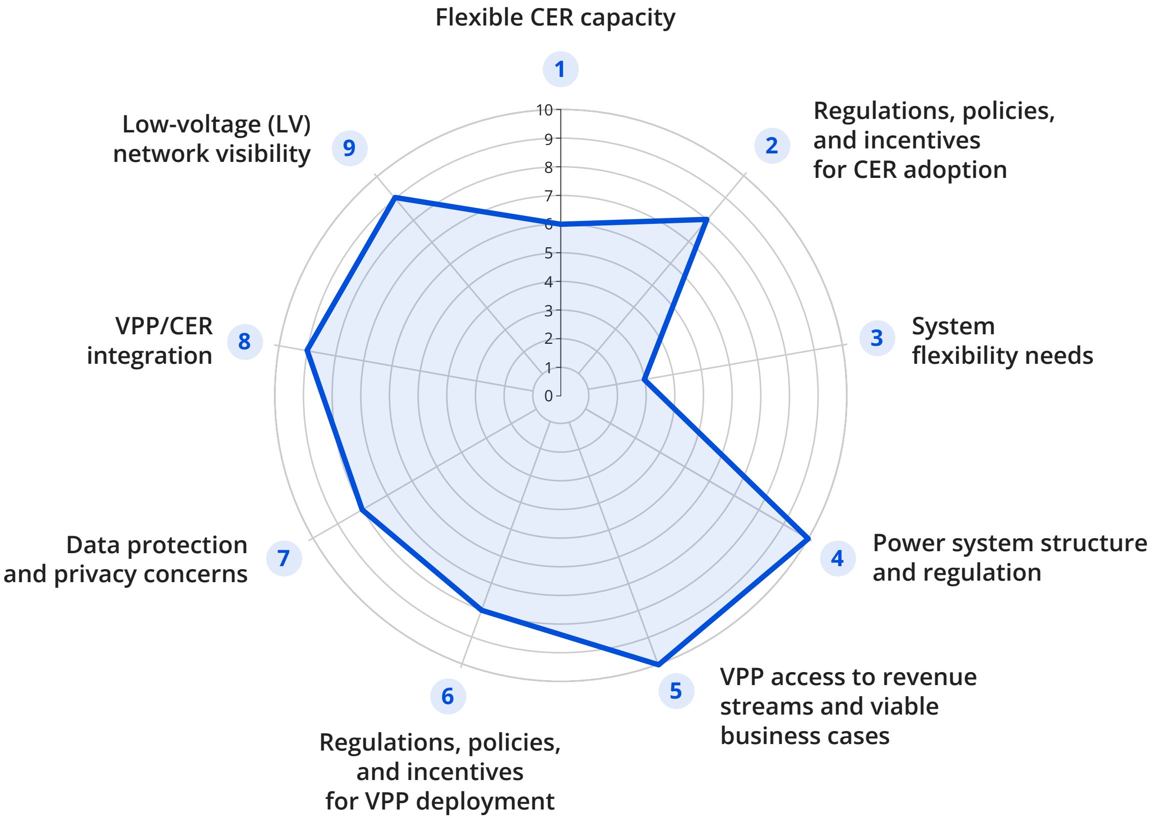
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ **CER roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Price mechanisms (net metering, TOU, FiT);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications);** ▪ **Obligations and penalties (carbon pricing, portfolio standards, energy levies).**	▪ The Department of Climate Change, Energy, the Environment and Water (DCCEEW) published a National CER Roadmap on Jul 2024, with an overarching plan to scale CER across Australia [19]. The Western Australian Government, which operates in the Wholesale Electricity Market (WEM), published a DER roadmap in 2020 as part of the state's Energy Transformation Strategy [20]. The Distributed Energy Integration Program (DEIP), which is a collaborative effort among government agencies, market authorities, industry and consumer associations, was set up in Australia to maximise the value of CER for all users in the National Electricity Market (NEM) [21]. ▪ The Clean Energy Regulator runs the small-scale renewable energy scheme to incentivise small-scale renewable generation (under 100kW) that runs up to 2030. Consumers can sell their small-scale technology certificates (STCs) to energy retailers in exchange for a discount or delayed cash payment [22]. ARENA provides funding for CER research and demonstration projects across Australia [23]. ▪ Australia has retailer feed-in-tariffs for exports of rooftop solar and some TOU tariffs, including solar soaker network tariffs, but TOU tariffs are at an early stage of adoption [24]. ▪ Public reports and information about CER are widely available on the Australian Energy Market Operator (AEMO), Australian Energy Regulator (AER) and Australian Renewable Energy Agency (ARENA) websites. ▪ The Australian Energy Market Commission (AEMC) updated the National Electricity Rules in 2021 to give clear obligations to distribution networks to manage CER exports and integration [25]. AEMO has set up a DER standards and connections workstream, which focuses on the basic minimum levels of capability required to enable consumers to engage in new markets for CER [26]. ▪ There is no carbon tax in Australia. However, there is an interim value of greenhouse gas emissions reduction (VER) issued by the Ministerial Council of Energy (MCE) that the government or energy regulatory entities (including the AEMC, AER, AEMO, MCE, ESB and the Reliability Panel) are required to use in considering or applying the national energy objectives, and Australia does have the Australian Carbon Credit Unit (ACCU) scheme that supports projects that avoid the release of greenhouse gas emissions or remove and sequester carbon from the atmosphere. Credits can be sold on the secondary market or to the Australian Government [27]. The initial VER is priced at the generic ACCU spot price of USD22.70/ tCO_2e, with a 10% increment per annum [28].
3 **System flexibility needs (as % of peak demand)**	**System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.**	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Australia, the daily flexibility needs are estimated to be 10.5GW, which gives a system flexibility need of (10.5/32.5) = 32%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	**Presence of unbundled power industry and/or retail competition.**	Australia has two electricity markets and power systems that are largely unbundled with multiple independent power generators, transmission and distribution operators, and has liberalised electricity retail markets, where consumers have the right to choose their preferred electricity and Tasmania, and the WEM in Western Australia [29].

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	**Access to energy, capacity and/or ancillary services markets.**	Both the NEM and WEM have a competitive wholesale energy and ancillary services market. The WEM has a Reserve Capacity Mechanism but there is no capacity market in the NEM [29]. VPPs today can participate in contingency FCAS and wholesale demand response mechanisms [30].
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ **VPP roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications).**	▪ The government has yet to publish a VPP roadmap or targets for Australia, but commercial VPP providers already exist, these include Energy Locals, AGL, sonnen, ShineHub and Simply Energy [30]. ▪ Australia has funded VPP projects and demonstrations through ARENA. ▪ ARENA publishes the results to the public through knowledge sharing reports [31]. ▪ AEMO has requirements for VPP participation in contigency FCAS and the wholesale demand response markets but currently participation is at relatively low levels [32].
7 **Presence of data protection and privacy considerations**	**Presence of data protection and privacy laws or guidelines.**	Australia has robust data protection and privacy laws, through the 13 Australian Privacy Principles (APPs) contained in the Privacy Act (1988) [33]. Consumer data sharing in the energy sector began on 15 November 2022. Energy retailers that operate through the NEM and have more than 10,000 customers are required to participate in the Consumer Data Right for Energy (CDR), which enables consumers to authorise third parties to access energy-specifc data [34].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	**Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).**	AEMC has been active in proposing rule changes and drafting papers on VPP participation and competing with large-scale generators [35]. The market and system operator, AEMO, has a NEM CER program dedicated to understanding and integrating high levels of CER into Australia's energy system and markets [36]. As part of the DER program, AEMO also has a DER register which is a database of information about DER devices installed in both the NEM and WEM at residential or business locations. AEMO also has a dedicated section of the website with information on its VPP Demonstrations project conducted in 2021, with knowledge sharing reports publicly available [37]. Distribution networks such as South Australia Power Networks (SAPN) have trialled VPP grid integration pilots, which will see a 500MW VPP comprising 50,000 solar and battery systems integrated into the South Australian grid [38].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	**Smart meter penetration in %.**	As of Oct 2020, the 5 NEM markets (NSW, QLD, SA, ACT, TAS) had a 17.4% smart meter penetration (excluding Victoria, which has a 100% smart meter rollout). Assuming a consistent uptake rate in smart meter uptake (2% in 2016 and 17% in 2020), a forward linear extrapolation into 2023 would give a 26% penetration in the 5 NEM markets. Using households as a proxy to the total number of smart meters deployed, and the Victorian population comprising 26% of the total population in Australia, the smart meter penetration in Australia can be estimated to be (0.26*1 + 0.74*0.26) = 45% [39].

France | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
68.17 million	**US$3,031 billion**	**US$44,461**

	Criteria	Score
1	Amount of CER capacity (as % of peak demand)	6
2	Coverage of pro-CER Regulations, policies, and incentives	8
3	System flexibility needs (as % of peak demand)	3
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	10
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	10
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	8
7	Presence of data protection and privacy considerations	8
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	9
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	9
	Total	**79%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** The number of available EVs in France between 2018 – 2023 is 1,260,270, which puts the total EV capacity at an estimated 9.58GW [40]. ▪ **BTM solar** From data published by Enedis, the primary distribution company in France, there is a total installed capacity of 8.49GWp of BTM solar in 2023, which considers solar PV connected to the LV network <250kW [41]. ▪ **Space and water heating** In a study published by RTE on heating demand, in 2018, there are approximately 10 million households out of 29 million using electric space heating [42]. Assuming the ratio of households using electric space heating stays the same at (10/29)=34%, the current number of households in 2023 at 38 million [43] and an average heating capacity of 3.4kW/household, the total space and water heating capacity is (0.34*38,000,000*3.4/1,000,000) = 43.9GW. In a study published by HAL, there are ~13 million electric water heater systems installed in France, 46.5% of them in the residential sector [45]. Using a power capacity of 1.5kW for water heating, the total capacity is (0.465*13,000,000*1.5/1,000,000) = 9.07GW. This puts the space heating capacity at 34.8GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in France in 2023 stands at 800,000 units [46]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 0.80GW. With a national peak demand of 83.876GW in 2023 [47], the flexible CER capacity as a percentage of peak demand for France is (9.58+8.487+43.9)/83.876 = 74%.

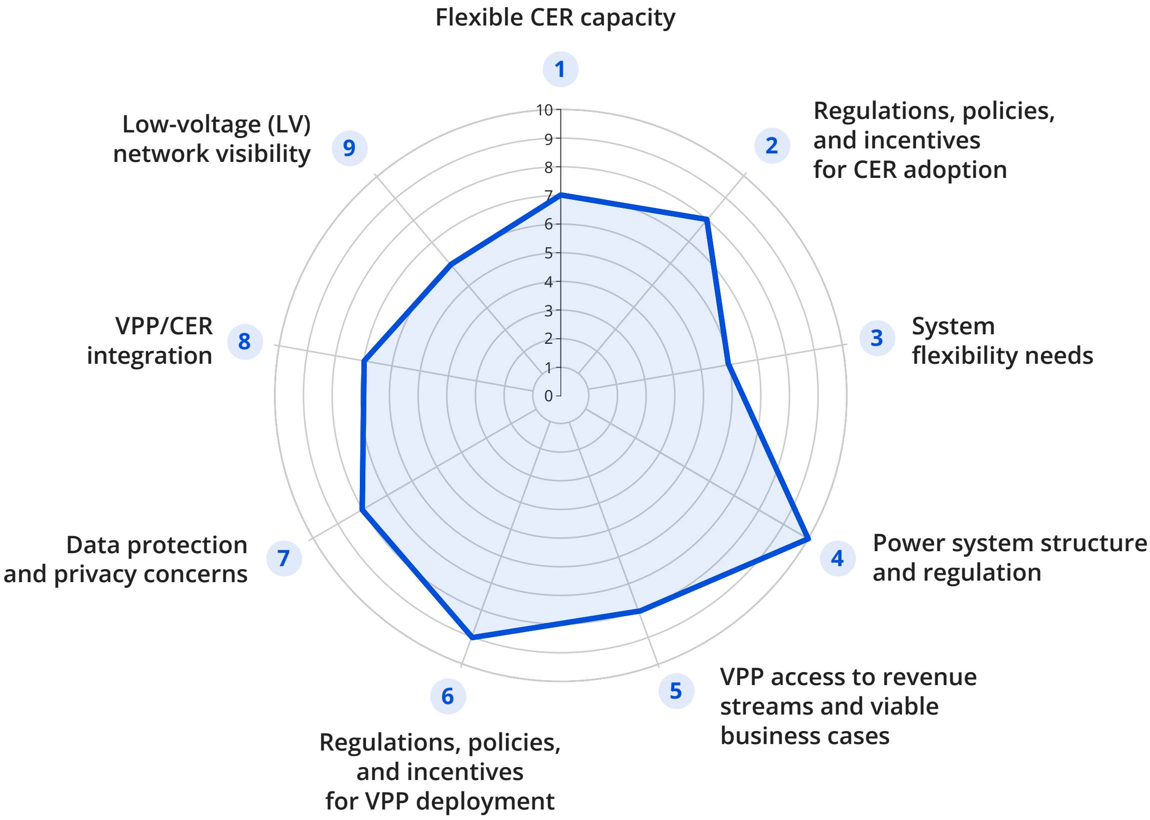
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ In 2020, France launched the multiannual energy plan (PPE), which aims to double the installed capacity of renewable energy by 2028 compared to 2017. France has also set demand side flexibility targets. There are no CER specific targets [48]. ▪ There is some financial support for solar installation, in the form of home renovation scheme, which subsidises upfront costs, and VAT reduction for combined solar thermal and PV systems [49]. The Eco-interest-free loan (eco-PTZ) loan supports combined solar systems. There is a EUR5000-7000 subsidy for EVs but has been curbed for higher-income buyers [50]. ▪ France has a FiT program for solar PV, but is being gradually reduced. France has a NEM, allowing self-consuming customers to export excess energy to the distribution network and be paid for it [51]. TOU tariffs are available to all consumers and is also reflected in the regulated tariff [52]. ▪ The French Energy Regulatory Commission, CRE, has a dedicated section on CER (collective self-consumption) [53]. CRE and Enedis regularly solicit public feedback and consultations on their future plans. There are no CER specific campaigns targeted at consumer education [54]. ▪ Enedis has a standard connection procedure for rooftop solar PV. Connections for batteries and EV chargers are currently undergoing a regulatory sandbox program [55]. ▪ France is part of the EU-Emissions Trading System (EU ETS), which imposes a carbon price on large emitters. The EU ETS is a cap-and-trade system that sets a limit (cap) on the total amount of certain greenhouse gases that can be emitted by covered sectors. Companies receive or purchase emission allowances, which they can trade with one another as needed.
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In France, the estimated daily flexibility needs are estimated to be 11.07GW, which gives a system flexibility need of (11.07/83.88) = 30%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	Presence of unbundled power industry and/or retail competition.	France has an unbundled electricity system with full retail competition and is regulated by the French Energy Regulatory Commission (CRE). There are several power generators in France, including Électricité de France (EDF), the largest electricity producer in France which accounts for about 70% of France's electricity generation, ENGIE, which focuses on renewable energy sources and other players including TotalEnergies and various independent power producers (IPPs) focusing on renewables like wind, solar, and hydro. RTE (Réseau de Transport d'Électricité) is the national transmission system operator (TSO) and owns and operates the transmission lines. Municipalities in France own the public distribution networks and delegate operations of the distribution networks. Enedis, a subsidiary of EDF, operates most (95%) of the medium and low-voltage distribution networks in France. There are also smaller local distribution companies operating in specific regions. Retail is fully liberalised since 2007, all consumers can choose between retail tariffs or regulated tariffs. Despite market liberalisation, EDF remains the dominant retail supplier in France, offering regulated tariffs and market-based offers [56].

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	Access to energy, capacity and/or ancillary services markets.	France has a wholesale energy market where electricity is traded on the day-ahead and intraday markets. This market plays a crucial role in balancing supply and demand in real-time. France operates a capacity market to ensure security of supply, especially during peak demand periods. Generators are remunerated for providing available capacity, and demand-side response (DSR) can also participate [57]. RTE manages the ancillary services market, which includes services like frequency regulation, voltage control, and reserves, which are open to all technologies [58]. VPPs today can participate in all three markets.
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications).	The government has yet to publish a VPP-specific roadmap or targets for France, but commercial VPP providers already exists, with private players such as Voltalis, with a portfolio of 200,000 homes and business as part of its program, and Agregio Solutions, a subsidiary of EDF [59] [60]. Commercial VPPs leverage demand response, and there are no major VPPs leveraging distributed generation and energy storage.
7 **Presence of data protection and privacy considerations**	Presence of data protection and privacy laws or guidelines.	Data protection and privacy in France is governed by both the EU General Data Protection Regulation (GDPR) as well as France's own data protection law, the French Data Protection Act, 1978, which is regulated by the French Data Protection Authority (CNIL). CNIL has published a compliance package governing smart meter data [61].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	CRE manages a collaborative website dedicated to smart grids and CER integration and education. This is a dissemination tool for research and experimental work conducted in France [62]. It also organises forums every three years, an information meeting and discussions on smart grid-related topics. It also publishes reports on subjects such as advanced metering, electric vehicles, the development of flexibilities, storage, data. Enedis, the primary distribution company, has published a Network Development Plan for electricity distribution, detailing its efforts and investments in flexibility, CER integration and grid modernisation [63].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	CRE published a status report on the smart meter rollout program, which is being executed by the distribution companies. As of 2022, the rollout is ~88% complete. This was estimated based on the market share of each distribution company and the deployment % reported. As Enedis has a 95% market share with a 90% rollout, and the remaining 6 distribution companies have a total market share of 5% with an average rollout of 42.5%, the smart meter penetration in France is (0.95*0.9 + 0.05*0.425) = 88% [64].

United Kingdom | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
68.35 million	**US$3,340 billion**	**US$48,867**

	Criteria	**Score**
1	Amount of CER capacity (as % of peak demand)	7
2	Coverage of pro-CER Regulations, policies, and incentives	8
3	System flexibility needs (as % of peak demand)	6
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	10
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	8
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	9
7	Presence of data protection and privacy considerations	8
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	7
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	6
	Total	**77%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** According to the Society of Motor Manufacturers and Traders, there are 1,000,000 registered EVs in the United Kingdom as of Jan 2024, which puts the total EV capacity at an estimated 7.6GW [65]. ▪ **BTM solar** From the official government statistics on solar PV deployment, there is a total installed capacity of 4.7GWp of rooftop solar deployment [66]. ▪ **Space and water heating** In the 2021 Census, the government estimates 9% of households use electric heating. In 2023, the number of households in United Kingdom is 28.4 million, which puts the number of households using electric heating at 2.56 million. Assuming an average dwelling floor area of 1000sqft [67] and a power capacity range of 1.5kW per 200sqft for space heating and 1.5kW per household for water heating, the total space heating capacity is 19.2GW and total water heating capacity is 3.84GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in United Kingdom in 2023 stands at 130,000 units (Statista, 2024). Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 0.13GW. With a national peak demand of 44GW in 2023, the flexible CER capacity as a percentage of peak demand for United Kingdom is (7.6+19.2+3.84+4.7)/44= 80%.

Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ The United Kingdom has a Smart Systems and Flexibility plan that was developed in 2021 by the government and the Office of gas and electricity markets (Ofgem), the regulator for the electricity and gas markets. The plan aims to support flexibility from consumers, remove barriers to flexibility on the grid, reform markets to reward flexibility and monitor flexibility across the system, which supports CER adoption [68]. The new United Kingdom government has a Clean Power 2030 Mission that will require a massive increase in renewables in the next 5 years. Within it, the National Energy System Operator (NESO) highlights 10-12GW of demand flexibility opportunities by 2030 that can be unlocked to meet this Mission [69]. ▪ The United Kingdom has in place multiple residential grants, including the Energy Company Obligation fourth iteration and Local Authority Flexible Eligibility (ECO4 LA Flex) which applies to solar panels, boilers and heat pumps, the Solar Together scheme, the Home Upgrade Grant Phase 2 and the Boiler Upgrade Scheme (BUS). Solar panel purchases are also exempt from VAT [70]. ▪ The Smart Export Guarantee (SEG) scheme has replaced the FiT scheme as of 2020, where owners of solar panels up to 5MW are paid for excess energy exported to the grid [71]. TOU tariffs are common across the United Kingdom, with recent TOU tariffs aimed at EVs and heat pump owners. In some cases, 'smart' tariffs are introduced, where the supplier will remotely control the device in return for cheaper tariffs. ▪ Ofgem has a dedicated section of its website on flexibility, including public reports, forums and consumer engagement programs [72]. ▪ The United Kingdom government has passed legislation to reform the Code Governance Framework, to streamline processes and provide a strategic direction to newly empowered Code Managers who can drive change more quickly and respond to changes in the energy market [73]. The United Kingdom Power Networks and NationalGrid have published a CER technical requirements report to provide standard technical requirements on CER connections to the grid [74]. ▪ United Kingdom adopts the United Kingdom ETS, which succeeded the EU ETS in 2021. The United Kingdom ETS is a cap-and-trade system that sets a limit (cap) on the total amount of certain greenhouse gases that can be emitted by covered sectors. Companies receive or purchase emission allowances, which they can trade with one another as needed [75]. There is also a green gas levy on licensed fossil fuel gas suppliers [76].
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In United Kingdom, the estimated daily flexibility needs are estimated to be 8.8GW, which gives a system flexibility need of (8.8/44) = 20%.

Criteria	KPI (assess current state)	Rationale
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	**Presence of unbundled power industry and/or retail competition.**	The United Kingdom has an unbundled electricity market and a highly competitive retail market, with Great Britain and Northern Ireland having distinct energy systems. Generation is provided by major players including EDF Energy, SSE, RWE, Drax Group, and Iberdrola (via ScottishPower), as well as Independent Power Producers (IPPs). National Grid Electricity Transmission (NGET) operates the high-voltage electricity transmission network in England and Wales. In Scotland, the transmission network is managed by SP Energy Networks (a subsidiary of Iberdrola) and SSEN Transmission (a subsidiary of Scottish and Southern Electricity (SSE)). Great Britain is divided into regions, each served by a different Distribution Network Operator (DNO). The DNOs are United Kingdom Power Networks, National Grid Electricity Distribution, Northern Powergrid, Scottish and Southern Electricity Networks (SSEN), and Electricity North West. In Northern Ireland, the Northern Ireland Electricity (NIE) Network owns and operates the transmission and distribution networks. The retail market is highly competitive, with major suppliers like Octopus Energy, British Gas, EDF Energy, E.ON United Kingdom, ScottishPower and OVO Energy (which acquired SSE's retail business). In addition, many smaller, independent suppliers have entered the market, increasing competition [77] [78]. The independent NESO oversees the electricity system in Great Britain, and NIE Network oversees the electricity system in Northern Ireland. The NESO was recently separated out from the Transmission grid company and is now publicly owned. Aside from its existing system operations role, it now has a strategic advisory role as well.
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	**Access to energy, capacity and/or ancillary services markets.**	The United Kingdom has a well-established wholesale electricity market where electricity is traded on day-ahead and intraday markets [79]. The market is highly liquid and interlinked with European power markets. The United Kingdom operates a capacity market to ensure the security of supply during peak demand periods. Generators, including demand-side response providers, are paid to be available when needed [80]. NESO introduced the Demand Flexibility Service (DFS) in winter 2022 to access additional capacity during times of high national demand all year round [81]. NESO is also trialling a new Local Constraint Market (LCM) to access new sources of flexibility to avoid curtailment and defer the need for transmission investments [82]. NESO procures ancillary services to maintain system stability, including frequency response, reserve services, and reactive power, some of which are open to VPPs, though with practical barriers [83]. VPPs today can offer services to the NESO via the Balancing Mechanism and will be able to access the wholesale electricity markets from November 2024 [84].

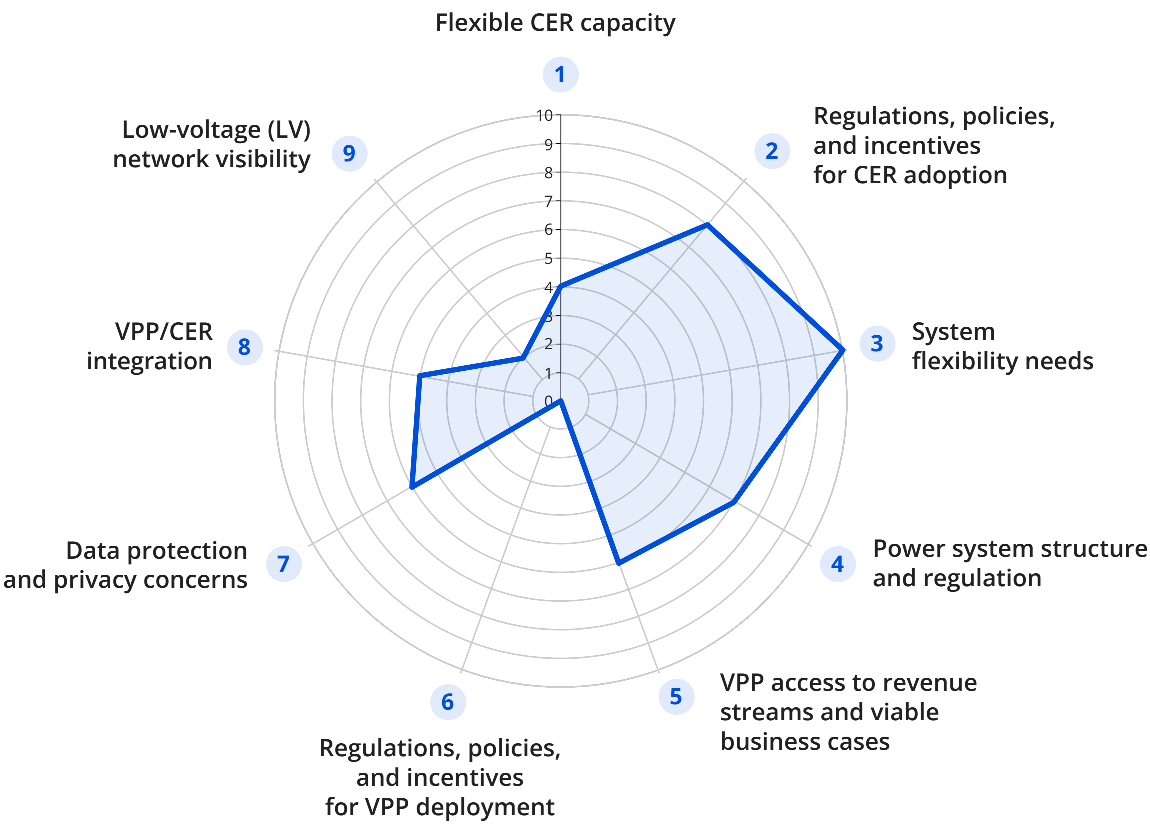
Criteria	KPI (assess current state)	Rationale
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ **VPP roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications).**	▪ The United Kingdom government and Ofgem published the Smart Systems and Flexibility Plan in July 2021, which includes plans to better support aggregation of CER, including lowering the balancing mechanism minimum threshold for participation from 100MW to 1MW as well as opening access to BTM CER [68]. The United Kingdom government also published the Smart Secure Electricity System publication, which explores a new regulatory regime for directly controlling loads and setting common standards (Energy Smart Appliance standards) for smart devices to ensure interoperability [85]. ▪ The United Kingdom has set up the Flexibility Innovation Programme, with up to £65 million made available. This overarching programme will fund innovation across a range of key smart energy applications which includes, smart meters, demand side response, V2X and flexibility [86]. ▪ Ofgem and the United Kingdom government publish public reports on Flexibility, and Ofgem organises engagement sessions with domestic consumers on energy flexibility [87]. ▪ The Energy Network Association in the United Kingdom, which is an association for all T/DSOs in United Kingdom, published a common Flexibility Services Standard Agreement for Flexibility service providers (CER aggregators) [88]. ▪ It should be noted that United Kingdom refers to the aggregators of CERs that offer market services as 'Flexibility service providers' as opposed to VPPs.
7 **Presence of data protection and privacy considerations**	**Presence of data protection and privacy laws or guidelines.**	The two main governance frameworks consist of the General Data Protection Regulation (GDPR) – implemented through the United Kingdom Data Protection Act (DPA) – and the Data Access and Privacy Framework (DAPF). Both frameworks encompasses data protection and privacy, including for CERs. The Data Access and Privacy Framework (DAPF) additionally governs access to smart meter data [89].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	**Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).**	The regulatory bodies and utilities in the United Kingdom power system possess CER capabilities. Ofgem is developing a Flexibility Digital Infrastructure and is conducting public and industry consultations on delivering a common Flexibility Market Asset Registration [90]. Ofgem has also set out requirements on regulated companies around Data Best Practice (DBP) with a view to opening up energy data that will make it easier for energy sector participants, organisations with interest in the energy sector, and incoming innovators to access and utilise network data to bring market solutions that will optimise the system for the consumer [91]. Distribution network operators (DNO) have CER registers and flexiblity roadmaps and plans. United Kingdom Power Networks has an embedded capacity register for CER and the Scottish & Southern Electricity Networks has a Flexibility roadmap [92]. The NESO has a dedicated flexibility department and roadmap, and is in the process of developing a Flexibility market Strategy [93]. Elexon was appointed by Ofgem in July 2024 as the Market Facilitator for local flexibility, to spearhead and enable greater flexible energy use across Great Britain's electricity distribution networks and to drive alignment between local and national flexibility markets and remove barriers [94].

Criteria	KPI (assess current state)	Rationale
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	**Smart meter penetration in %.**	As of 2023, the official smart meter statistics indicate that 54% of all meters are smart meters in 'smart mode' (there are smart meters running on traditional mode) [95]. United Kingdom has mandated electricity suppliers to rollout smart meters by end 2025 [96].

Chile | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
19.63 million	**US$336 billion**	**US$17,093**

	Criteria	Score
1	Amount of CER capacity (as % of peak demand)	4
2	Coverage of pro-CER Regulations, policies, and incentives	8
3	System flexibility needs (as % of peak demand)	10
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	7
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	6
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	0
7	Presence of data protection and privacy considerations	6
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	5
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	2
	Total	**53%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** According to data from the National Automotive Association of Chile (ANAC) the number of available EVs in Chile between 2018 – 2023 is 8,454, which puts the total EV capacity at an estimated 0.064GW [97]. ▪ **BTM solar** From the Monthly Energy Sector report published by CNE, the energy commission of Chile, there is a total installed capacity of 2.16GWp of BTM solar in 2023, including both small distributed generation means (PMGD) and small generation means (PMG) installed capacity [98]. The PMG are projects with installed capacity between 500kW and 9 MW, and are connected to the main transmission, sub-transmission or additional transmission grid while the PMGD are also projects with installed capacity up to 9 MW, but unlike the PMG, are connected to the distribution grid or to installations of a company that owns electric power distribution lines that make use at least partially of state property. ▪ **Space and water heating** As there are no public reports on the total space heating demand, we take an approximation using the space heating demand in South Africa and the ratio of the population between South Africa and Chile. Taking a ratio gives a space heating capacity of (0.8GW * (19.6/59.9)) = 0.26GW. As there are no public reports on the total number of water heaters in Chile, we take an approximation using the total water heating capacity in Brazil and the ratio of the population between Brazil and Chile. Brazil's population is 216.42 million and Chile's population is 19.63 million. Taking a ratio gives a water heating capacity of (34.5GW * (19.63/216.42)) = 3.13GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in Chile in 2023 stands at 150,000 units [99]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 0.15GW. With a national peak demand of 11.54GW in 2023 [98], the flexible CER capacity as a percentage of peak demand for Chile is (0.064+2.16+3.13+0.26)/11.54 = 49%.

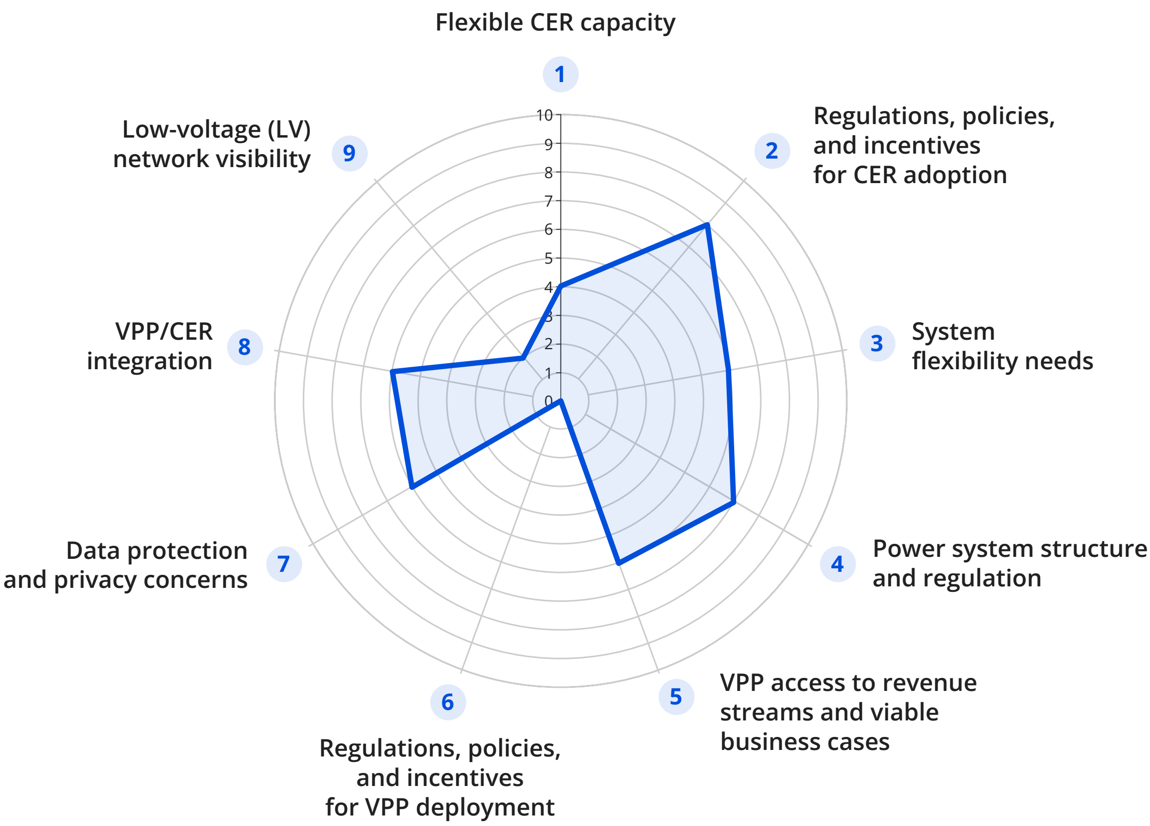
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ As part of the national Energy Policy 2050, Chile has set an ambitious goal of converting 70% of its total energy consumption to renewables by 2030 and pledged to become carbon neutral by 2050. There are also ambitions to advance flexibility at the level of centralised production and to have decentralised production and active demand management, as well as having a bidirectional energy system [100]. ▪ Chile takes a consumer ownership model, where there are no subsidies provided by the government for rooftop solar systems [101]. PMG and PMGD projects benefit from an ability to sell energy at stabilised prices and are not exposed to the same price risks as projects with regulated power purchase agreements (PPAs) or merchant risk [102]. ▪ Chile has a NEM regulation which is applicable to residential and C&I consumers with RE generation technologies and cogeneration technologies with installed capacity less than 100kW [103]. There are TOU tariffs for residential and C&I customers. There is no FiT in Chile. ▪ The Ministry of Energy, in collaboration with various stakeholders, runs public awareness campaigns and educational programs such as the 'Energy Community' initiative which attracts community participation in local energy generation projects [104]. ▪ The National Energy Commission (CNE) has developed technical standards for the connection and operations of PMGDs, which include CER such as solar [105]. ▪ Chile has a carbon tax that was implemented in 2017 and is priced at US$5/t$CO_2$e today [106].
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Chile, the estimated daily flexibility needs are estimated to be 3.47GW, which gives a system flexibility need of (3.47/11.54) = 30%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	Presence of unbundled power industry and/or retail competition.	Chile has an unbundled electricity system with selective retail competition. The main generation companies include Enel Generación Chile, Colbún, AES Andes, and Engie Energía Chile. These companies operate in a competitive market, with numerous other IPPs. The national transmission system is operated by Coordinador Eléctrico Nacional (CEN), an independent entity responsible for coordinating the operation of the grid. The distribution market is dominated by companies such as Enel Distribución, CGE, and Chilquinta. They operate regional monopolies within their designated areas. Retail competition exists for large consumers who can choose their electricity provider. End consumers below 2MW have regulated prices and are exclusively served by local distribution companies [107].

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	Access to energy, capacity and/or ancillary services markets.	Chile has a well-established wholesale energy market where electricity prices are determined by supply and demand. The market includes spot prices and long-term contracts. There is a capacity payment mechanism in place to ensure sufficient generation capacity is available to meet peak demand. CNE regulates the capacity payments. Chile also has an ancillary services market to ensure grid stability, with services such as frequency regulation and voltage control [108]. CERs currently have limited access to wholesale markets (e.g., spot market, ancillary services market) [109]. In 2024, regulations have been passed for generation with storage and standalone storage to participate in the capacity markets.
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications).	Chile is still in the early stages of developing VPP capabilities. There are no VPP policies, regulations, financial support, public reports or standards and codes in Chile. Chilquinta Energia, has trialed a VPP that leverages energy storage to provide resilience and backup power to C&I customers.
7 **Presence of data protection and privacy considerations**	Presence of data protection and privacy laws or guidelines.	Chile has a Personal Data Protection Law, 2017 and is regulated by the Agency for the Protection of Personal Data. There are no energy specific data protection laws. There are no energy-specific clauses within the Personal Data Protection Law [110].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	Distribution system operators (DSO) such as CGE, have dedicated teams managing PMGD connections and integration and NEM [111]. CNE has a detailed register of all PMGD, including CER such as solar, but it has yet to develop visibility over assets <500kW [112].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	In 2018, Chile developed a smart meter rollout plan to install 6.5 million smart meters by 2025. As of 2023, there have been 400,000 smart meters installed putting the smart meter penetration at 5.8% [113].

India | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
1,428.63 million	**US$3,550 billion**	**US$2,485**

	Criteria	**Score**
1	Amount of CER capacity (as % of peak demand)	4
2	Coverage of pro-CER Regulations, policies, and incentives	8
3	System flexibility needs (as % of peak demand)	6
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	7
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	6
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	0
7	Presence of data protection and privacy considerations	6
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	6
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	2
	Total	**50%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** The number of available EVs in India between 2018 – 2023 is 2,338,730, which puts the total EV capacity at an estimated 17.77GW [114]. ▪ **BTM solar** According to the Ministry of New and Renewable Energy (MNRE), there is 11GWp of rooftop solar as of 2023 [115]. ▪ **Space and water heating** There is little to no space heating in most of India due to climate. As there are no public reports on the total number of water heaters in India, we take an approximation using the total water heating capacity in Brazil and the ratio of the population between Brazil and India. Brazil's population is 215 million and India's population is 1428.62 million. Taking a ratio gives a water heating capacity of (34.5GW * (1428.63/215)) = 229.24GW. Considering the ratio between the GDP per capita of both countries ($10,044 vs $2,485), we estimate the water heating capacity of India to be 56.7GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in India in 2023 stands at 10.2 million units [116]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 10.2GW. With a national peak demand of 223GW in 2023 [117], the flexible CER capacity as a percentage of peak demand for India is (17.77+11+10.2+56.7)/223 = 43%.
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ As per the National Electricity Plan (NEP) 2022-23, India has promised to source half of its electricity from renewable sources by 2030, with a target of 450GW of renewable energy, including 300GW of solar by 2030 [118]. The MNRE also has the Grid Connected Rooftop Solar Programme (GCRTS), with a 40GW target by 2026 [119]. India has the EV30@30 initiative, aiming for 30% of new vehicle sales to be electric by 2030 [120]. There are no targets for other forms of CER. ▪ As part of the GCRTS programme, residential electricity consumers receive a subsidy of between USD87 – 173 /kW for rooftop solar sizes <10kW, and a USD1,130 fixed subsidy for systems >10kW [121]. The National Portal for Rooftop Solar, launched by the MNRE, has a Financial Options section for solar rooftop loan products offered by leading banks [122]. Commercial and industrial customers can leverage Accelerated Depreciation (AD) benefits on solar projects, allowing them to write off 40% of the project cost in the first year [123]. ▪ All states in India have a NEM program for rooftop solar. TOU tariffs are applicable for commercial and industrial consumers and vary from state to state [124]. ▪ The National Portal is consumer-friendly and serves to raise consumer awareness about rooftop solar schemes and benefits [122]. ▪ The Central Electricity Authority (CEA) has introduced technical standards for grid connectivity of DERs (e.g., rooftop solar), and EV charging infrastructure, ensuring that these systems are safe and reliable for grid operations [125]. CEA also proposed battery standardisation and interoperability measures to promote the integration of EVs with the grid through reverse charging [126]. ▪ There are no carbon tax or carbon pricing mechanisms in India as of 2024.

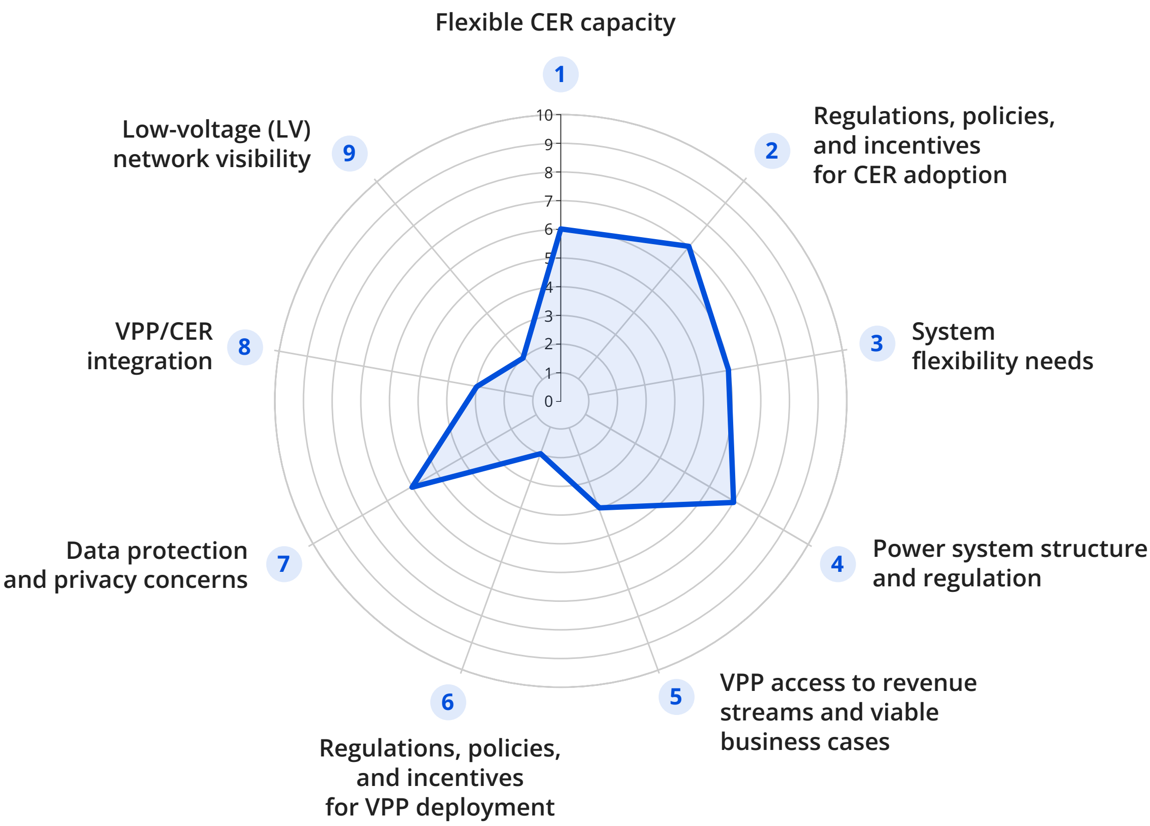
Criteria	KPI (assess current state)	Rationale
3 **System flexibility needs (as % of peak demand)**	**System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.**	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In India, the estimated daily flexibility needs are estimated to be 44.6GW, which gives a system flexibility need of (44.6/223) = 20%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	**Presence of unbundled power industry and/or retail competition.**	India's power system is unbundled, with generation, transmission and distribution owned and operated by separate entities. The power system can be described in two levels: central-level and state-level. At the central-level, the system is regulated by the Central Electricity Regulatory Commission (CERC) and the grid operated by the Power System Operation Corporation (POSOCO). There are multiple generators, including the National Thermal Power Corporation (NTPC) which is central government-owned, large private generators such as Tata Power and Reliance Power, and renewable energy generators. Interstate transmission is managed by the Power Grid Corporation of India Limited (PGCIL). At the state-level, the system is regulated by the State Electricity Regulatory Commission (SERC) with intrastate grid managed by State Load Dispatch Centers (SLDCs). Generation is managed by state generation companies (GENCOs). State Transmission Utilities (STU) manage interstate transmission and State Distribution Companies (DISCOMs) handle electricity distribution at the state level, with some electricity distribution handled by private distribution companies. Retail is currently managed by the DISCOMs, except in key cities such as Mumbai, Delhi and Kolkata [118].
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	**Access to energy, capacity and/or ancillary services markets.**	India has a wholesale energy market, no capacity market and a developing Secondary Reserve Ancillary Services (SRAS) and Tertiary Reserve Ancillary Services (TRAS) market for frequency control ancillary services and reserves [127]. As of 2023, only 7% of India's electricity generation is traded through three power exchanges (Indian Energy Exchange Ltd (IEX), Power Exchange of India Ltd (PXIL), and Hindustan Power Exchange Ltd), with the majority of energy and capacity needs met through long-term PPAs with power generators [128]. Qualified CERs, such as energy storage and demand response can participate in providing SRAS and TRAS. CEA has also suggested that aggregators of CERs such as EVs, be allowed to participate in the ancillary services market [126].

Criteria	KPI (assess current state)	Rationale
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications).	There are no VPP policies, regulations, financial support, public reports or standards and codes in India.
7 **Presence of data protection and privacy considerations**	Presence of data protection and privacy laws or guidelines.	India has Digital Personal Data Protection Act, 2023 (DPDP) and is enforced by the Data Protection Board. There are no energy-specific clauses within the DPDP [129].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	The Ministry of Power launched the National Smart Grid Mission, which is a dedicated team to plan and monitor implementation of the policies and programs related to Smart Grids in India [130]. The MNRE has dedicated sections of its website to solar, energy storage systems and other renewable energy technologies, with a full library of policies, guidelines, standards, specifications and frameworks, as well as CER registers [131]. There are no VPP specific capabilities today.
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	India's smart meter national program (SMNP) aims to replace 250 million conventional meters to smart meters by 2026 [132]. As of September 2024, there are 13.57 million cumulative smart meters installed, putting the smart meter penetration at 5.4% [133].

Brazil | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
216.42 million	**US$2,174 billion**	**US$10,044**

	Criteria	**Score**
1	Amount of CER capacity (as % of peak demand)	6
2	Coverage of pro-CER Regulations, policies, and incentives	7
3	System flexibility needs (as % of peak demand)	6
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	7
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	4
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	2
7	Presence of data protection and privacy considerations	6
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	3
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	2
	Total	**48%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** According to the Brazil EV Association, the number of available EVs in Brazil between 2018 – 2023 is 213,735, which puts the total EV capacity at an estimated 1.62GW [134]. ▪ **BTM solar** From the Brazil Energy Balance 2024, published by the Energy Research Office (EPE), there is a total installed capacity of 26.4GWp of Micro and Mini Distributed Generation (MMDG), of which solar PV represents 96.3% of generation. MMDGs are decentralised energy generation systems owned by consumers and small businesses and include renewable energy sources such as solar and biomass. This states the BTM solar capacity is 25.4GWp [135]. ▪ **Space and water heating** There is little to no space heating in Brazil due to its tropical climate. In the in-depth assessment of water efficiency opportunities in Brazil report published by CLASP, an appliance efficiency organisation, it is estimated that there are 23 million units of electric water heaters in Brazil. Assuming the average domestic electric water heater has a capacity of 1.5kW, the water heating capacity in Brazil is ~34.5GW [136]. ▪ **Aircon capacity** The number of stationary air-conditioning units in Brazil in 2023 stands at 4.1 million units [137]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 4.1GW. With a national peak demand of 101GW in 2023 [138], the flexible CER capacity as a percentage of peak demand for Brazil is (1.62+25.4+34.5+4.1)/101 = 65%.

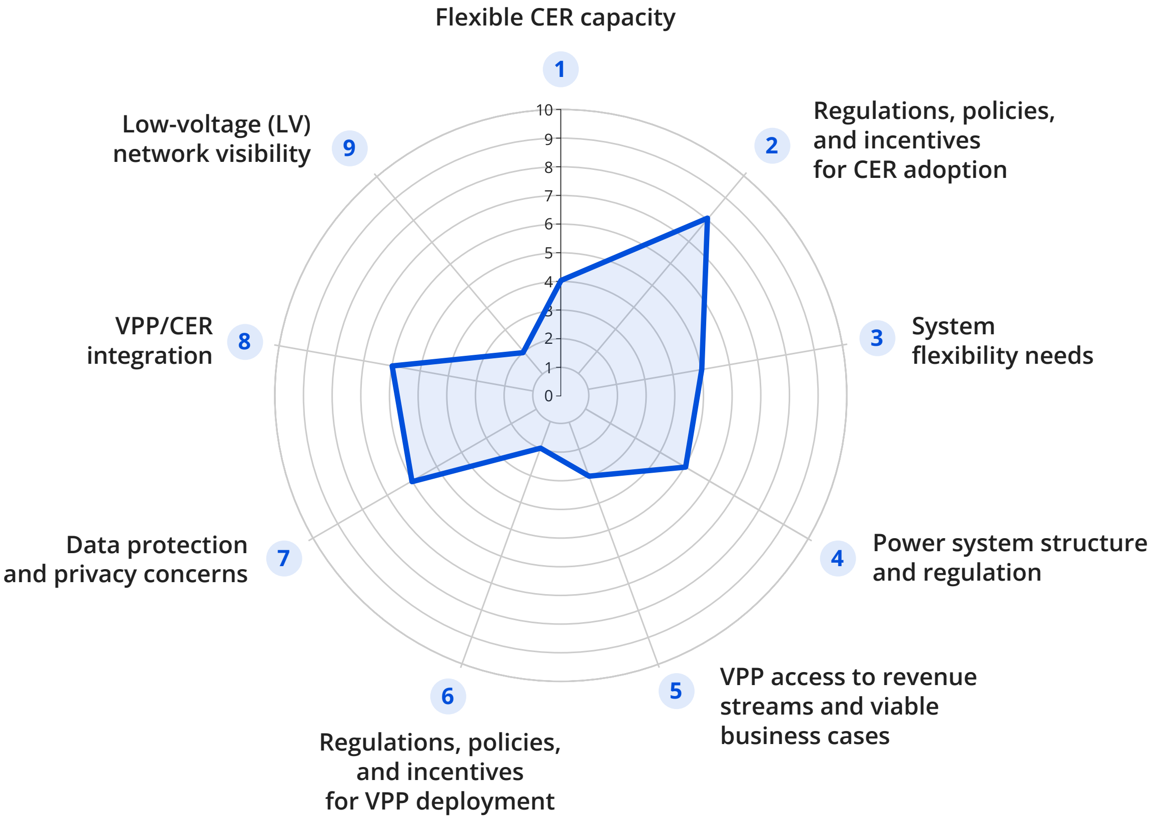
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ In the National Energy Plan 2050, published in Dec 2020, the report calls attention to CER and decentralised solar PV. It also emphasizes the need to build a roadmap that allows market participants to prepare for the influx of CER, as well as for transmission and distribution system operators to proactively manage the integration. However, there is no implementation plan that supports this ambition [139]. ▪ The Brazilian Ministry of Mines and Energy (MME) has published a new ordinance on incentives for distributed energy mini-generation projects, which includes tax suspensions on the acquisition, leasing and importation of goods and services related to distributed energy generation for five years [140]. ▪ Brazil has a net metering scheme, which was established in 2012, as well as time-of-use tariffs for residential and industrial customers [141]. There is no FiT for CERs [142]. ▪ The energy regulator, ANEEL, and the Brazilian government has a dedicated section on the website on MMDG and the benefits of distributed generation. ▪ In 2022, the National Institute of Metrology, Standardization, and Industrial Quality (INMETRO) published an ordinance establishing the criteria for the Conformity Assessment Requirements for Equipment for Generation, Conditioning and Storage of Electric Energy in PV systems [143]. There is a grid connection review procedure conducted by Brazilian power distributors, and ANEEL has recently approved exemptions to the grid connection review for solar PV <7.5kW and self-consumption MMDGs [144]. ▪ There is no carbon tax or other carbon pricing mechanisms in Brazil as of 2024.
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Brazil, the estimated daily flexibility needs are estimated to be 19.7GW, which gives a system flexibility need of (19.7/101) = 20%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	Presence of unbundled power industry and/or retail competition.	Brazil's National Interconnected System (SIN), the primary electricity system, is unbundled with selective retail competition, with separate entities managing generation (Petrobras, Engie, Enel, AES Brasil), transmission (Eletronorte, CTEEP) and distribution, which is coordinated by 102 power distribution companies.The retail market is liberalising, where consumers with contracted demand larger than 500 kW (mostly commercial and industrial customers) are entitled to operate in the Free Contracting Environment, where they can select their electricity retailers. Residential consumers only have the option of buying energy at government-regulated tariffs.

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	Access to energy, capacity and/or ancillary services markets.	All markets are contracted bilaterally. There is both an open energy market (Free Contracting Environment) and a regulated energy market (Regulated Contracting Environment). The open market is currently open to consumers with demand larger than 500kW [145]. Both markets contract energy bilaterally through PPAs; in the regulated market, consumers contract with distribution companies while in the open market, consumers can contract with any supplier [146]. Brazil held its first Capacity Reserve Auction in 2021, with 15-year bilateral contracts starting in 2026, kickstarting the Capacity Market [147]. Ancillary services are bilaterally contracted by the National Grid Operator (ONS) via an Ancillary Service Provision Contract (CPSA). CERs and VPPs are not able to participate in the Capacity Reserve Auction and the CPSA today [148].
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications).	There have been VPP pilots by private players, namely AES Brasil, and supported by ANEEL [149]. AES Brasil is developing Phase 2 of its VPP pilot, which will include demand response and BESS [150]. There are no VPP policies, regulations, financial support, public reports or standards and codes in Brazil.
7 **Presence of data protection and privacy considerations**	Presence of data protection and privacy laws or guidelines.	The General Data Protection Law (LGPD) is a legal framework to regulate the collection and use of personal data in Brazil. It came into effect on August 16, 2020 and is enforced by the National Data Protection Authority (ANPD). There are no energy-specific clauses within the LGPD [151].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	There are no CER/VPP specific capabilities or teams amongst utilities. However, there is a dedicated team within ANEEL that focuses on Micro and Mini Distributed Generation (MMDG), which primarily comprises rooftop solar PV [152].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	Smart meter rollout in Brazil has been progressing slowly, with a smart meter penetration of 5.7% as of 2022 [153].

South Africa | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
60.41 million	**US$378 billion**	**US$6,253**

	Criteria	**Score**
1	Amount of CER capacity (as % of peak demand)	4
2	Coverage of pro-CER Regulations, policies, and incentives	8
3	System flexibility needs (as % of peak demand)	5
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	5
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	3
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	2
7	Presence of data protection and privacy considerations	6
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	6
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	2
	Total	**46%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** There is a cumulative stock of 2,110 EVs in South Africa between 2018 – 2023, which puts the total EV capacity at an estimated 0.015GW [154]. ▪ **BTM solar** From the Centre for Renewable & Sustainable Energy Studies report [155], leveraging data from Eskom, there is a total installed capacity of 5.204GWp of embedded solar PV (which excludes utility-scale solar PV) in South Africa. ▪ **Space and water heating** According to Stellenbosch University, there were 5.4 million electric water heaters in South Africa in 2020, giving a water heating capacity of 8.1GW [156]. According to estimates from the National Renewable Energy Laboratory, electric space heating energy demand in South Africa in 2021 was 0.8-1.35GW. Taking a conservative stance, the space heating capacity in South Africa is 0.8GW [157]. ▪ **Aircon capacity** The number of stationary air-conditioning units in South Africa in 2023 stands at 165,000 units [158]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 0.165GW. With a national peak demand of 33.9GW in 2023 [155], the flexible CER capacity as a percentage of peak demand for South Africa is (0.015+5.204+8.1+0.8)/33.9 = 42%.

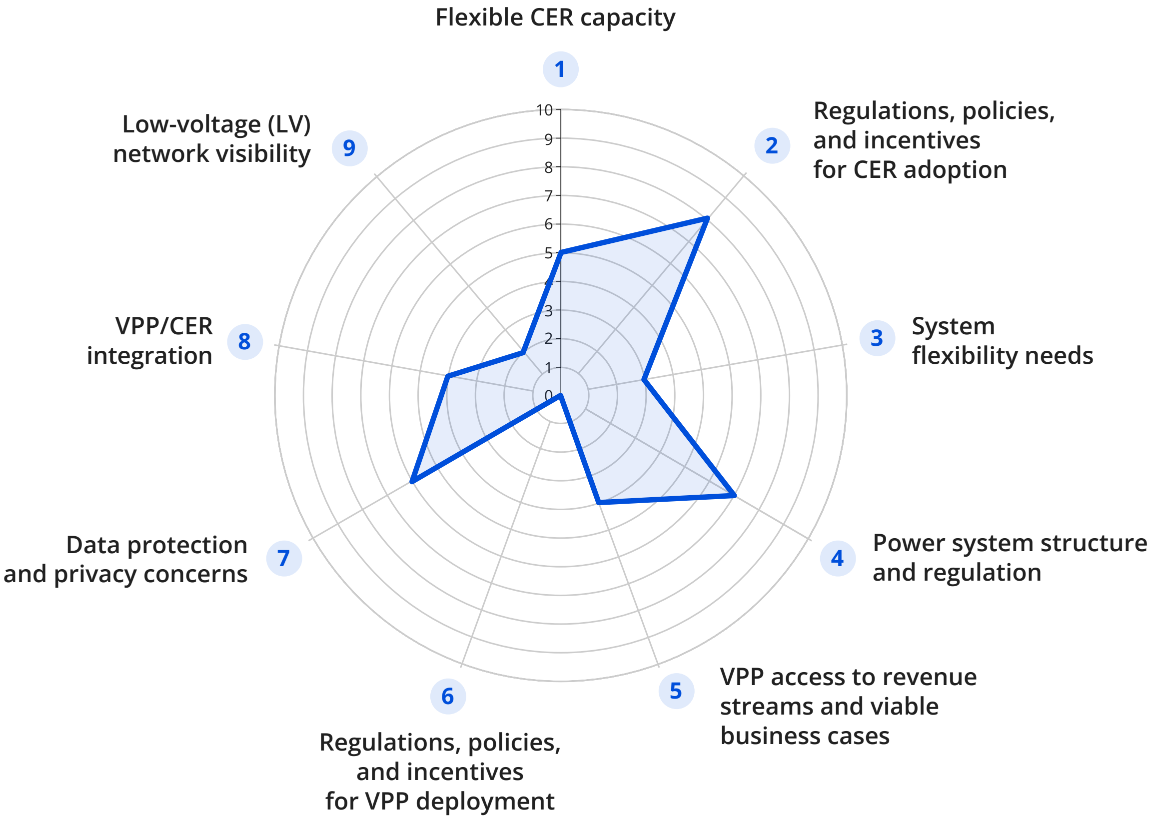
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ South Africa's Integrated Resource Plan (IRP) 2019 includes provisions for renewable energy, distributed generation, and battery storage, signalling support for CER integration (25GW renewable energy capacity and 3GW energy storage targets by 2030) [159]. ▪ The government has established in 2024 a solar panel tax rebate of 25% of the upfront investment cost up to a maximum of R 15,000 (~USD 837), targeted at residential consumers [160]. ▪ NEM and FiT programmes are available for residential and C&I customers in selected regions in South Africa e.g. in Cape Town via the Cash for Power Program [161]. There are TOU tariffs for residential and C&I customers [162]. ▪ Eskom has dedicated data portals on its website for renewable energy. The National Energy Regulator of South Africa (NERSA) conducts stakeholder workshops and events, including for renewable energy [163]. However, there has not been an event organised for CER. ▪ The South African Bureau of Standards (SABS) has published multiple standards for solar PV systems, including design, construction, testing and installation of PV systems [164]. ▪ South Africa has a Carbon Tax Act that was enacted in 2019 and rolled-out in phases, starting with Phase 1 from 2019-2022, and Phase 2 between 2023-2030. Carbon tax today is R190 (USD10.60) / tCO_2e. South Africa also has a carbon fuel levy on petrol and diesel [165].
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In South Africa, the estimated daily flexibility needs are estimated to be 5.5GW, which gives a system flexibility need of (5.5/33.9) = 16%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	Presence of unbundled power industry and/or retail competition.	South Africa has a partially unbundled market with some aspects of competition, and is historically dominated by Eskom, the state-owned utility. Eskom generates over 90% of the country's electricity, with the remainder coming from independent power producers that participate mainly in renewable energy generation, facilitated by the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). Since 2019, Eskom is in the process of unbundling from a verticaly integrated utility into three divisions: generation, transmission and distribution. As of 2024, the National Transmission Company South Africa (NTCSA) is the new entity of the former Eskom transmission division, managing transmission and system planning and operations. The unbundling process of the generation and distribution divisions are in progress [166].

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	Access to energy, capacity and/or ancillary services markets.	South Africa does not have a fully competitive wholesale energy market, though plans are in place to establish one. Eskom plays a central role in power procurement. There is no formal capacity market, and capacity procurement is managed through long-term power purchase agreements (PPAs) under programs like REIPPPP. Ancillary services are currently managed by Eskom. The electricity market is currently undergoing liberalisation, with the setup of the South African Wholesale Electricity Market (SAWEM) [167]. CERs and VPPs are not able to access the wholesale energy, capacity or ancillary services markets today.
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications).	There are no VPP policies, regulations, financial support, public reports or standards and codes in South Africa. However, there is the potential for CER aggregation, including from private players like Wetility, a solar, battery and demand response leasor [168].
7 **Presence of data protection and privacy considerations**	Presence of data protection and privacy laws or guidelines.	Data protection and privacy in South Africa is governed under the Protection of Personal Information Act, 2013 [169]. There are no energy-specific clauses within the POPIA.
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	There are no VPP specific capabilities or teams amongst regulators or utilities. Eskom distribution has a dedicated team focused on rolling out batteries and a team dedicated to managing integration of BTM solar PV [170].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	Eskom distribution division announced a smart meter rollout plan in 2023, and has installed 400,000 meters out of the planned 6.9 million meters. This puts South Africa's smart meter penetration rate at (0.4/6.9) = 6% [171].

Colombia | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
52.09 million	**US$364 billion**	**US$6,980**

	Criteria	Score
1	Amount of CER capacity (as % of peak demand)	5
2	Coverage of pro-CER Regulations, policies, and incentives	8
3	System flexibility needs (as % of peak demand)	3
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	7
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	4
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	0
7	Presence of data protection and privacy considerations	6
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	4
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	2
	Total	**43%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** The number of available EVs in Colombia between 2018 – 2023 is 15,080, which puts the total EV capacity at an estimated 0.115GW [172]. ▪ **BTM solar** From industry estimates, there are 1,500 small-scale self-generation solar projects that generate a net capacity of 457 MWp [173]. ▪ **Space and water heating** There is little to no space heating in Colombia due to climate. As there are no public reports on the total number of water heaters in Colombia, we take an approximation using the total water heating capacity in Brazil and the ratio of the population between Brazil and Colombia. Brazil's population is 216.42 million and Colombia's population is 52.09 million. Taking a ratio gives a water heating capacity of (34.5GW * (52.09/216.42)) = 8.30GW. Considering the ratio between the GDP per capita of both countries ($10,044 vs $6,980), we estimate the water heating capacity of India to be 5.77GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in Colombia in 2023 stands at 400,000 units [174]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 0.40GW. As there are no accessible figures for peak demand in 2023, we interpolate between the existing peak demand in 2017 and projected peak demand of 15GW in 2030 by system and market operator, XM [175]. This gives 2023 peak demand of 12.3GW. The flexible CER capacity as a percentage of peak demand for Colombia is (0.115+0.457+0.4+5.77)/12.3 = 55%.

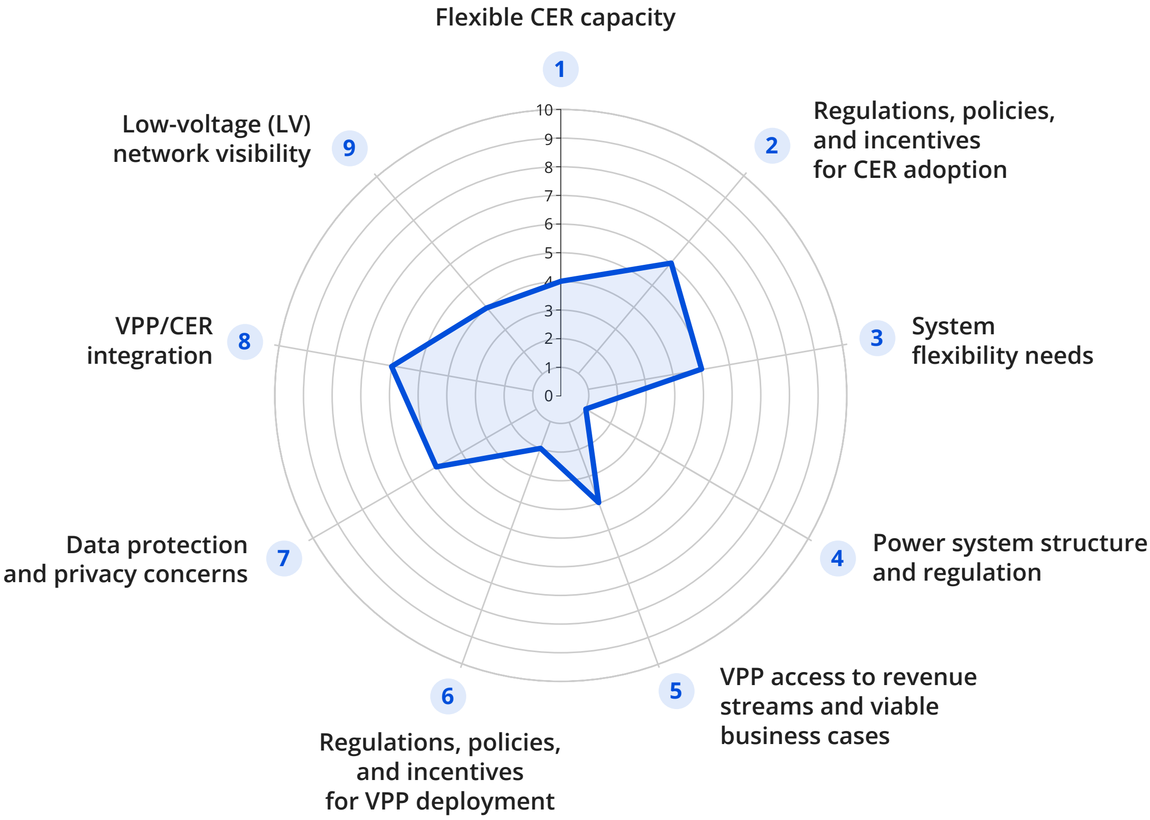
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ According to the 2050 National Energy Plan published in 2016, Colombia targets 25% of the energy matrix to come from Non-Conventional Renewable Energy (NCRE) by 2030, but there are no specific CER roadmaps or targets [176]. ▪ Colombia aims to promote NCRE, providing VAT exemptions on equipment and a 50% income tax deduction on the income from the sale of electricity from renewables such as solar, wind, biomass, among others, for 15 years [177]. ▪ Colombia has a NEM programme, allowing solar PV owners up to 5MW to sell excess electricity to the network, but does not have FiT and TOU tariffs [178]. ▪ The Colombian energy sector regulator, CREG, has dedicated sections on small-scale self-generation and distributed generation and AMI, including citizen participation activities [179]. ▪ The CREG recently published a resolution (101011 of 2022) outlining guidelines for the connection of small-scale wind and solar plants to the national grid [180]. The Ministry of Mines and Energy (UPME) also has a regulation governing small-scale self-generation and distributed generation with capacity equal or less than 1MW, allowing them to connect to the public network and export surplus energy [181]. ▪ Colombia established a carbon tax in 2017 and has a price of USD4.53/tCO_2e today [182].
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Colombia, the estimated daily flexibility needs are estimated to be 1.42GW, which gives a system flexibility need of (1.42/12.3) = 12%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	Presence of unbundled power industry and/or retail competition.	Colombia has an unbundled electricity system with selective retail competition. Major generation companies include Empresas Públicas de Medellín (EPM), Emgesa (a subsidiary of Enel), Isagen, and Celsia. The generation market is competitive, with a mix of public and private entities. The transmission network is operated by the National Interconnected System (SIN) and is managed by the company XM, a subsidiary of the state-owned company ISA (Interconexión Eléctrica S.A.). XM also oversees the system and market operations. Distribution is handled by regional companies, with EPM, Codensa (a subsidiary of Enel), and Electricaribe being some of the key players. The retail market is competitive for consumers with energy demand >2MW, who can freely select their providers. Consumers <2MW are subject to regulated rates by the CREG [183].

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	**Access to energy, capacity and/or ancillary services markets.**	Colombia has a well-developed wholesale electricity market (MEM), where energy is traded through bilateral contracts and on the spot market. Colombia has a capacity payment mechanism known as the Reliability Charge, which ensures that enough generation capacity is available to meet peak demand and maintain system reliability. The Reliability Charge is a bilateral contract between generators and CREG. The country has an ancillary services market, which includes services like frequency regulation and automatic generation control, which are procured via bilateral contracts with generators [183]. CERs and VPPs are not able to access these markets today [184].
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ **VPP roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications).**	Colombia is still in the early stages of developing VPP capabilities. There are no VPP policies, regulations, financial support, public reports or standards and codes in Colombia.
7 **Presence of data protection and privacy considerations**	**Presence of data protection and privacy laws or guidelines.**	Colombia has a Personal Data Protection Law, 2012, which is regulated by the Superintendency of Industry and Commerce. There are no energy specific data protection laws and no energy-specific clauses within the Personal Data Protection Law [185].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	**Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).**	The UPME has published the Smart Grid Vision 2030 plan which detailed the roadmap for a smart grid rollout. However, there are no dedicated teams on CER/VPP across regulators, generators and distribution companies, nor specific CER registers [186].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	**Smart meter penetration in %.**	A report by the Inter-American Development Bank estimates the smart meter penetration in Colombia to be 4% [187].

Malaysia | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
34.31 million	**US$400 billion**	**US$11,649**

	Criteria	Score
1	Amount of CER capacity (as % of peak demand)	4
2	Coverage of pro-CER Regulations, policies, and incentives	6
3	System flexibility needs (as % of peak demand)	5
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	1
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	4
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	2
7	Presence of data protection and privacy considerations	5
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	6
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	4
	Total	**41%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** According to the Road Transport Department of Malaysia, there is a cumulative stock of 16,599 EVs in Malaysia between 2018 – 2023, which puts the total EV capacity at an estimated 0.13GW [188]. ▪ **BTM solar** According to the TNB DN, there is a total installed capacity of 2.29GWp of BTM solar in Malaysia across the various solar programmes (feed-in-tariff programme, large-scale solar, net energy metering, self-consumption) [189]. ▪ **Space and water heating** There is little to no space heating in Malaysia due to its tropical climate. As there are no public reports on the total number of water heaters in Malaysia, we take an approximation using the total water heating capacity in Brazil and the ratio of the population between Brazil and Malaysia. Brazil's population is 215 million and Malaysia's population is 34.31 million. Taking a ratio gives a water heating capacity of (34.5GW * (34.31/215)) = 5.5GW. Considering the ratio between the GDP per capita of both countries ($10,044 vs $11,649), we estimate the water heating capacity of India to be 6.38GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in Malaysia in 2023 stands at 900,000 units [190]. Assuming a power capacity range of 1kW for a domestic air-conditioning unit, the total capacity is 0.9GW. The national peak demand in 2023 is estimated at 19.63GW by taking a linear interpolation of the national peak demand of 19.183GW in 2022 and 20.066GW in 2024 [191] [192]; the flexible CER capacity as a percentage of peak demand for Malaysia is (0.13+2.29+6.38+0.9)/19.63 = 49%.

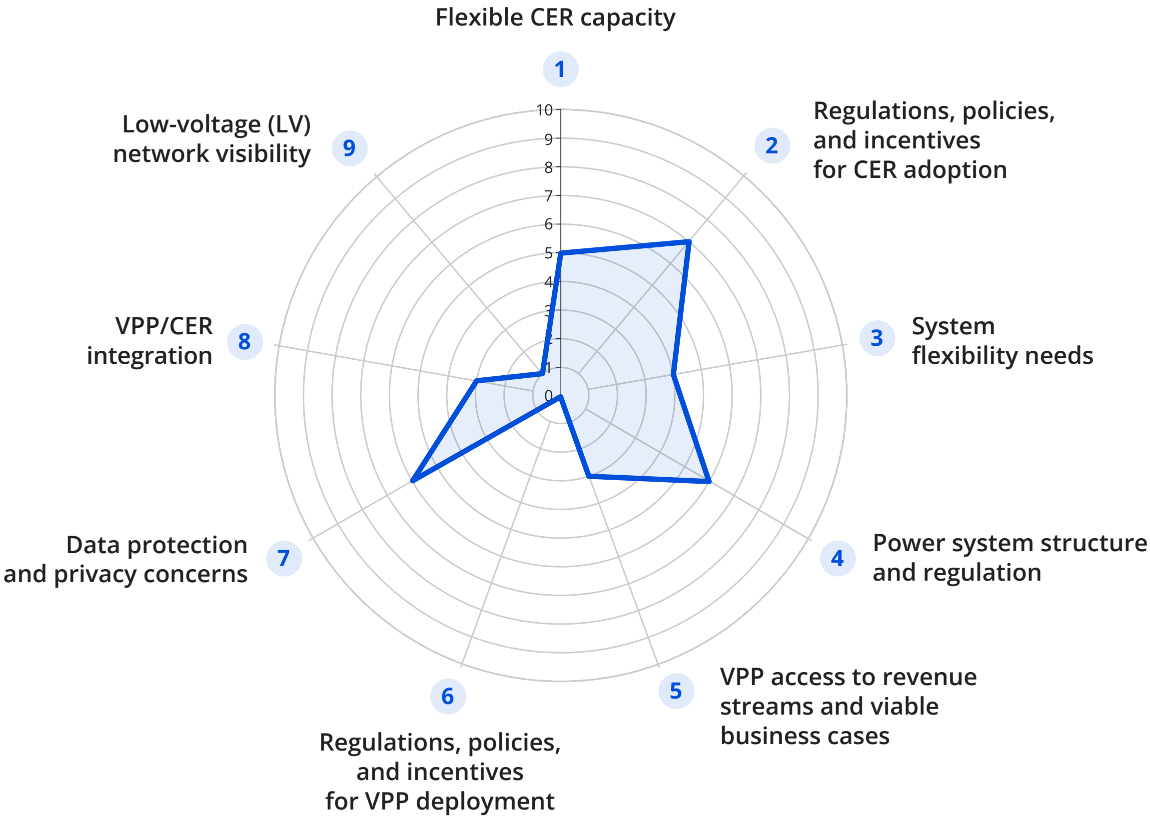
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ **CER roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Price mechanisms (net metering, TOU, FiT);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications);** ▪ **Obligations and penalties (carbon pricing, portfolio standards, energy levies).**	▪ Malaysia published its Renewable Energy Roadmap (MyRER), which targets 4.7GWp and 7.2GWp of solar capacity by 2025 and 2035 respectively. There is also an initiative to increase system flexibility by exploring a feasible framework for demand-side management, and smart grids including battery energy storage system integration to improve grid management. The aim is to allow third parties to participate in grid balancing markets [193]. However, there has yet to be an implementation plan for this initiative. ▪ Malaysia has the Green Investment Tax Allowance (GITA) that provides tax reduction on the upfront investment cost for solar and is applicable to businesses [194]. ▪ Malaysia has a net metering programme, currently in its third iteration. There is a FiT programme, but since 2017, is no longer applicable to solar PV. Malaysia has TOU tariffs for C&I customers, but not for residential customers [195] [196] [197]. ▪ There are public reports available, but there are no active consumer outreach or engagement programs from regulators or utilities on the topic of CER. ▪ There is a Malaysian Standard for solar PV grid-connected systems, but not for other CER. TNB Distribution, the main distribution system operator, has established a smart grid initiative, which includes connection procedures for CER [198]. ▪ There is no carbon pricing in Malaysia.
3 **System flexibility needs (as % of peak demand)**	**System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.**	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Malaysia, the estimated daily flexibility needs are estimated to be 3.1GW, which gives a system flexibility need of (3.1/19.6) = 16%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	**Presence of unbundled power industry and/or retail competition.**	In Peninsular Malaysia, the Malaysia Electricity Supply Industry (MESI) operates via a single buyer market model, where power generation is centrally procured by Single Buyer, a ring-fenced entity of state-owned power utility Tenaga Nasional Berhad (TNB). Current power generators include TNB and independent power producers. Power generation is undergoing further liberalisation with the introduction of Third Party Access to the grid, but transmission, distribution and retail are fully integrated and owned by TNB [199]. In East Malaysia, generation, transmission, distribution and retail are fully integrated and owned by the national utilities, Sarawak Energy and Sabah Electric for the state of Sarawak and Sabah respectively [200] [201]. The industry is regulated by the Energy Commission (ST).

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	**Access to energy, capacity and/or ancillary services markets.**	Malaysia has a wholesale energy market, with generators 100kW – 29.9MW participating as price takers, where they submit their planned generation schedules and are paid at the system marginal price. There is limited access to the capacity and ancillary services market – Single Buyer, a ring-fenced entity owned by TNB, manages procurement via bilateral Power Purchase Agreements with power generators [202]. CERs and VPPs are not able to participate in the wholesale energy, capacity or ancillary services markets today.
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ **VPP roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications).**	There have been VPP collaborations by TNB in partnership with South Korea in 2019 and China in 2022, but the results of the collborations or pilot VPPs have not been published. There are no VPP policies, regulations, financial support, public reports or standards and codes in Malaysia [203].
7 **Presence of data protection and privacy considerations**	**Presence of data protection and privacy laws or guidelines.**	Data privacy and protection is governed by the Personal Data Protection Act (PDPA). The PDPA purports to safeguard personal data by requiring data users to comply with certain obligations and conferring certain rights to the data subject in relation to their personal data [204]. There are no energy sector specific data protection or privacy frameworks.
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	**Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).**	ST publishes all the electricity statistics on a dedicated web portal, including a register of all DER <1MW. Malaysia's integrated utility, TNB, has a smart grid initiative, which includes CER integration strategies, guidelines and connection procedures. There are no VPP specific capabilities at the moment [198].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	**Smart meter penetration in %.**	As of 2022, TNB has installed 2.3 million smart meters across Malaysia, with a target to install 9.1 million smart meters by 2026 as part of their target to rollout smart meters across the entire nation. This puts Malaysia's smart meter penetration rate at (2.3/9.1) = 25% [205].

Kenya | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
55.10 million	**US$107 billion**	**US$1,950**

	Criteria	Score
1	Amount of CER capacity (as % of peak demand)	5
2	Coverage of pro-CER Regulations, policies, and incentives	7
3	System flexibility needs (as % of peak demand)	4
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	6
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	3
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	0
7	Presence of data protection and privacy considerations	6
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	3
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	1
	Total	**39%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** According to the Bi-annual Energy and Petroleum Statistics Report, published by the Energy and Petroleum Regulatory Authority (EPRA), there is a cumulative stock of 3,753 EVs in Kenya between 2019-2023, which puts the total EV capacity at an estimated 0.028GW [206]. ▪ **BTM solar** From the Bi-annual Energy and Petroleum Statistics Report, published by the Energy and Petroleum Regulatory Authority (EPRA), there is a total installed capacity of 0.196GWp of captive solar PV capacity in Kenya [206]. ▪ **Space and water heating** There is little to no space heating in Kenya due to climate. As there are no public reports on the total number of water heaters in Kenya, we take an approximation using the total water heating capacity in South Africa and the population ratio between South Africa and Kenya. South Africa's population is 59.9 million and Kenya's population is 52.4 million. Taking a ratio gives a water heating capacity of (8.1GW * (52.4/59.9)) = 7.09GW. Considering the ratio between the GDP per capita of both countries ($6,234 vs $1,950), we estimate the water heating capacity of Kenya to be 2.2GW. Given the strong growth of solar water heating systems (SWSH) with 52% and 44% of passive and active SWHs installed in domestic buildings [207]. We estimate domestic electric water heating capacity in Kenya to be (2.2 * 48%) = 1.06GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in Kenya in 2023 stands at 46,300 units [208]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 0.046GW. With a national peak demand of 2.17GW in 2023 [206], the flexible CER capacity as a percentage of peak demand for Kenya is (0.028+0.196+0.046+1.06)/2.17 = 61%.

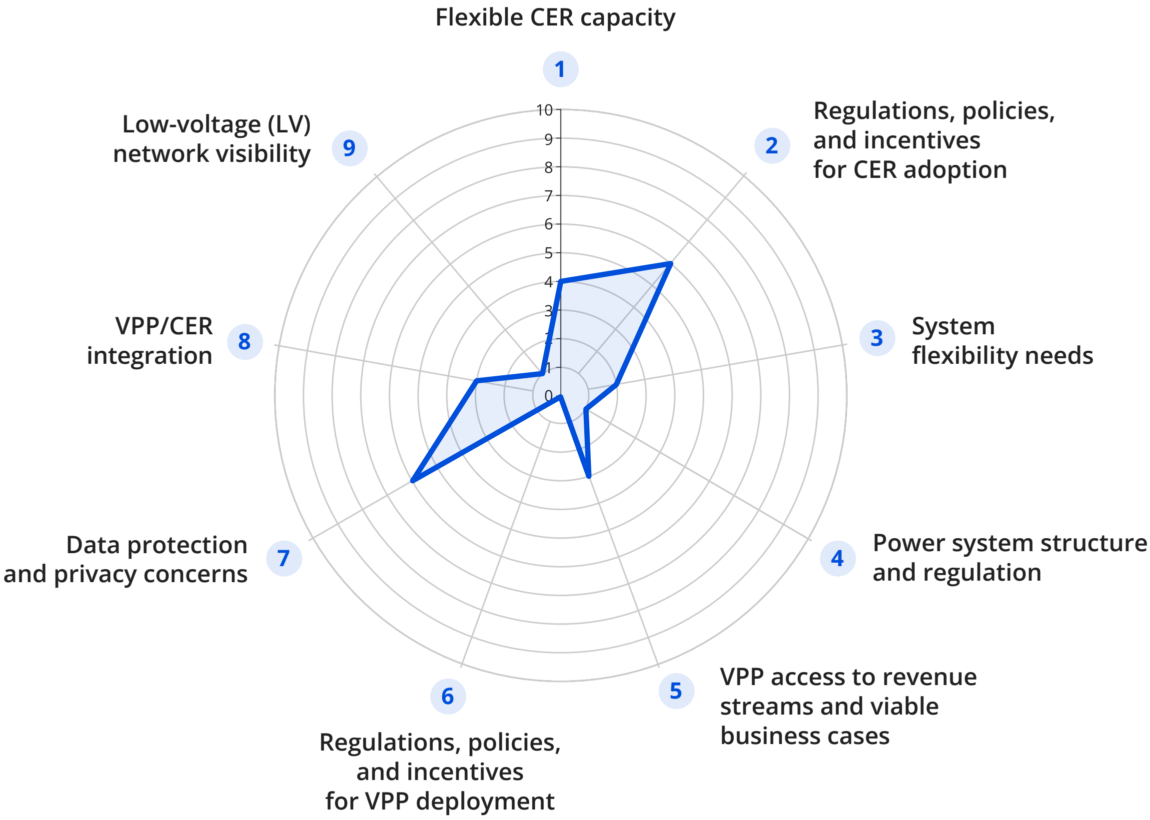
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ **CER roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Price mechanisms (net metering, TOU, FiT);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications);** ▪ **Obligations and penalties (carbon pricing, portfolio standards, energy levies).**	▪ The Kenya Energy Transition & Investment Plan (ETIP), published by the State Department for Energy in 2023 has detailed a net zero pathway with the key action of continuing to decarbonise electricity through renewables (geothermal, hydro, solar, wind) and flexibility (batteries and demand response) [209]. ▪ Kenya has a VAT exemption for solar and wind energy equipment, as well as on batteries. The Kenya Income Tax Act has a 100% deduction applicable to businesses for the cost of installing solar panels. Through the Kenya Rural Electrification Authority (REA), loans and grants on solar home systems have also been afforded to households [210]. ▪ Kenya has implemented a FiT as of 2012, but in 2022, the FiT has been adapted to exclude 'mature' clean energy sources, including solar, wind and geothermal [211]. Kenya has recently developed a NEM regulation in 2024, which are applicable to renewable technologies with installed capacity less than 1MW. There are TOU tariffs for commercial and industrial consumers, as well as for EVs, but not for residential consumers [212]. ▪ The EPRA has dedicated renewable energy portal containing resources related to all forms of renewable energy, including solar PV [213]. There have yet to be public studies done on CER. ▪ Kenya is drafting a Solar PhotoVoltaic Systems regulation, which standardises the requirements for solar PV installations, including requirements on licensed practitioners, importation and manufacture of solar PV equipment and specifications around design, installation and maintenance of solar PV systems [214]. ▪ There is no carbon pricing in Kenya.
3 **System flexibility needs (as % of peak demand)**	**System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.**	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Kenya, the estimated daily flexibility needs are estimated to be 0.31GW, which gives a system flexibility need of (0.31/2.17) = 14%.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	**Presence of unbundled power industry and/or retail competition.**	Kenya operates an unbundled electricity market with no retail competition. The generation, transmission, and distribution segments are separate, but significant state involvement remains. Power generation is led by Kenya Electricity Generating Company (KenGen), with the presence of several independent power producers. Kenya Electricity Transmission Company (KETRACO) and Kenya Power and Lighting Company (KPLC) both manage transmission and KPLC is the main electricity distributor and retailer. The Energy (Electricity Market, Bulk Supply and Open Access) regulations 2024 provides open access to the transmission and distribution systems for private distributors at a fee which is expected to increase competition, efficiency and reliability and improve the quality of service within the electricity market [215].

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	Access to energy, capacity and/or ancillary services markets.	Kenya lacks a competitive wholesale energy market. Electricity prices are set by the Energy and Petroleum Regulatory Authority (EPRA). No formal capacity market exists. Ancillary services are managed primarily by KenGen, with support from KPLC, but there is no separate ancillary services market [216] . CERs and VPPs are not able to participate in the wholesale energy, capacity or ancillary services markets today.
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ VPP roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications).	Kenya is still in the early stages of developing VPP capabilities. There are no VPP policies, regulations, financial support, public reports or standards and codes in Kenya.
7 **Presence of data protection and privacy considerations**	Presence of data protection and privacy laws or guidelines.	Data protection and privacy in Kenya is governed under the Data Protection act, 2019 and is regulated by the Office of Data Protection Commissioner (ODPC). There are no energy-specific clauses within the Data Protection Act [217].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	There are no CER/VPP specific capabilities currently present in the EPRA or KPLC. EPRA has a dedicated section of its website for renewable energy, as well as a renewable energy portal containing regulations and licenses, as well as a register of licensed electricians and technicians [218].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	KPLC, the main electricity distributor and retailer, has successfully installed 67,000 smart meters targeting small and medium enterprises as of Feb 2024. There has not been a roll-out of smart meters for residential customers. There are an estimated 7.4 million meters currently managed by KPLC, putting the smart meter penetration at 1% [219] [220].

Indonesia | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
277.53 million	**US$1,371 billion**	**US$4,941**

	Criteria	Score
1	Amount of CER capacity (as % of peak demand)	4
2	Coverage of pro-CER Regulations, policies, and incentives	6
3	System flexibility needs (as % of peak demand)	2
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	1
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	3
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	0
7	Presence of data protection and privacy considerations	6
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	3
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	1
	Total	**29%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** There is a cumulative stock of 74,657 EVs in Indonesia between 2018 – 2023 [221]. Based on the lower end spectrum of a Level 2 AC charger of 7kW we estimate the total EV capacity to be 0.522GW [222]. ▪ **BTM solar** As reported by the Ministry of Energy and Mineral Resources (MEMR), there are ~0.141GW of BTM solar as of 2023 [223]. ▪ **Space and water heating** There is little to no space heating in Indonesia due to climate. As there are no public reports on the total number of water heaters in Indonesia, we take an approximation using the total water heating capacity in Brazil and the ratio of the population between Brazil and Indonesia. Brazil's population is 215 million and Indonesia's population is 277.53 million. Taking a ratio gives a water heating capacity of (34.5GW * (277.53/215)) = 44.5GW. Considering the ratio between the GDP per capita of both countries ($10,044 vs $4,941), we estimate the water heating capacity of Indonesia to be 21.9GW. ▪ **Aircon capacity** The number of stationary air-conditioning units in Indonesia in 2023 stands at 3,400,000 units [224]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 3.4GW. With a national peak demand of 58.3GW in 2023 [225], the flexible CER capacity as a percentage of peak demand for Indonesia is (0.522+0.141+3.4+21.9)/58.3 = 45%.

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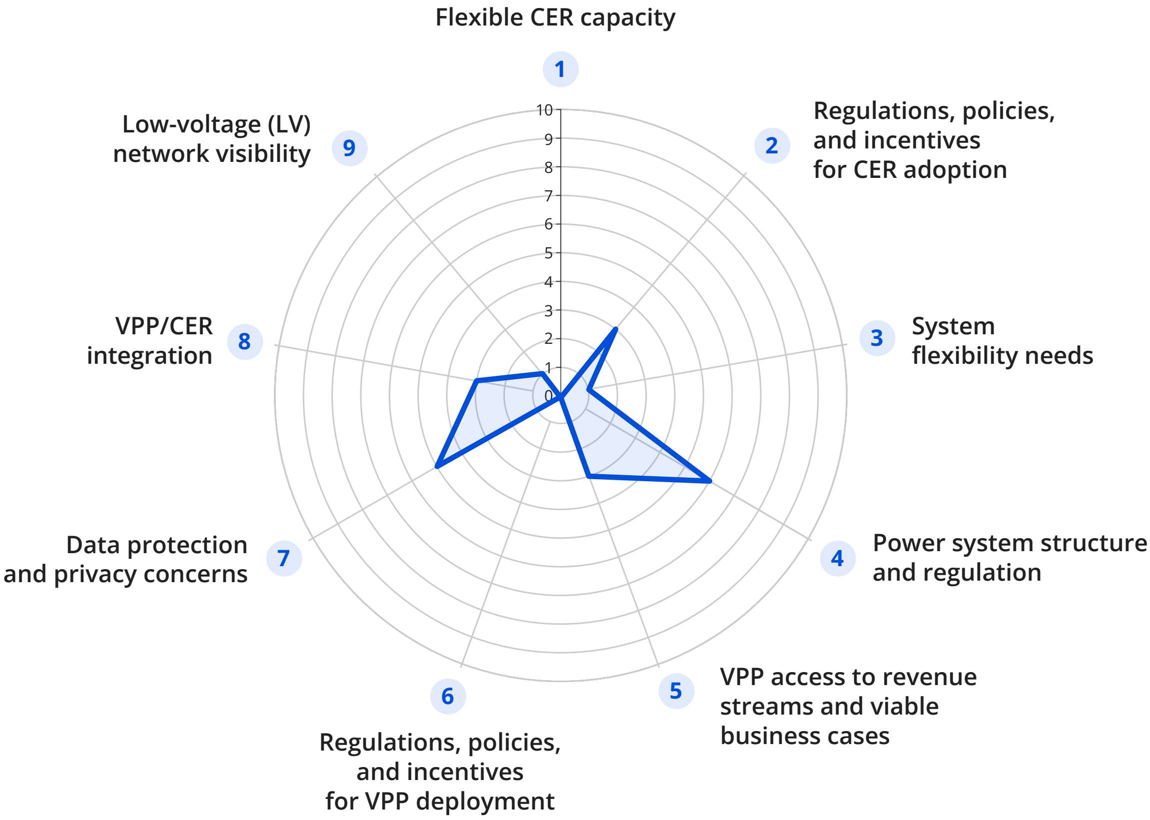
Criteria	KPI (assess current state)	Rationale
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ As part of the National Energy Policy (KEN), Indonesia has set a renewable energy target of at least 23% as part of the generation mix by 2025 and at least 31% by 2050. There are no CER specific roadmaps or targets [226]. ▪ Financial support is primarily targeted at solar PV. The MEMR and the United Nations Development Program (UNDP) Indonesia launched an incentive program in 2022 for rooftop solar systems under a Sustainable Energy Fund (SEF) grant. The incentive is aimed to encourage people to install rooftop solar systems, including households, businesses and small and medium enterprises (SMEs), and social category (schools/educational buildings, hospitals, houses of worship) [227]. 1. Indonesia introduced a net metering scheme in 2018 but has since ended in 2024, where solar PV owners can no longer benefit from exporting excess energy to PLN [223]. Indonesia has previously implemented FiT in 2016, but there are no new FiT launches [228]. TOU tariffs are applicable to selected industrial customers. 2. There is limited CER-targeted consumer education. 3. There is a standard solar PV installation approval procedure regulated by the MEMR, but not for other forms of CER [223]. 4. There is no carbon pricing in Indonesia today. Indonesia has developed plans for a carbon tax, priced at ~USD2/ton of CO_2e, which is set to be introduced in 2025. Concurrently, there is a carbon emissions trading scheme that is targeted at coal-fired power plants >25MW [229].
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Indonesia, the estimated daily flexibility needs are estimated to be 5.3GW, which gives a system flexibility need of (5.3/58.3) = 9% Although not considered in the index, it should be noted that Indonesia has five separate non-interconnected grids, each with their own flexibility needs.
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	Presence of unbundled power industry and/or retail competition.	Indonesia's power market is largely integrated, with state-owned utility Perusahaan Listrik Negara (PLN) having a monopoly over transmission and distribution, and holding a significant share of generation capacity. PLN controls a significant share of Indonesia's generation assets and generates 50-60% of Indonesia's electricty. It generates electricity from a variety of sources, including coal, natural gas, hydro, and geothermal. Private sector involvement is growing, with Independent Power Producers (IPPs) generating electricity and selling it to PLN under long-term Power Purchase Agreements (PPAs). PLN also monopolises transmission and distribution, managing the national grid and ensuring electricity delivery across the country's vast archipelago. PLN is the sole retailer of electricity, distributing power directly to consumers, including residential, commercial, and industrial users [230].

Criteria	KPI (assess current state)	Rationale
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	**Access to energy, capacity and/or ancillary services markets.**	Indonesia does not have a wholesale energy market, capacity or ancillary services market. PLN is responsible for generation and purchasing electricity from IPPs and directly selling it to consumers. PLN manages generation capacity through long-term PPAs with IPPs. Ancillary services (e.g., frequency regulation, voltage control) are managed by PLN as part of its integrated operations, but there is no separate ancillary services market open to competition [231]. CERs and VPPs are not able to participate in the wholesale energy, capacity or ancillary services markets today.
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ **VPP roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications).**	There are no VPP policies, regulations, financial support, public reports or standards and codes in Indonesia.
7 **Presence of data protection and privacy considerations**	**Presence of data protection and privacy laws or guidelines.**	Indonesia has a Personal Data Protection Law, 2022 and is enforced by the Ministry of Communication and Information. However, there are no specific energy or electricity sector data protection or privacy frameworks [232].
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	**Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).**	PLN has a 'Digital Moonshots' program that aims to implement smart grid initiatives at both transmission and distribution level, but there has yet to be a roadmap or implementation plan. PLN has an online service dedicated to new, and upgrading connections [233]. There are no VPP specific capabilities.
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	**Smart meter penetration in %.**	PLN has established a smart meter rollout plan to 79 million meters across Indonesia [234]. As of 2023, there have been 1.15 million smart meters installed putting the smart meter penetration at 1.5% [235].

Nigeria | Country overview

Population (2023):	GDP (2023):	GDP per capita (2023):
223.8 million	**US$364 billion**	**US$1,621**

	Criteria	Score
1	Amount of CER capacity (as % of peak demand)	0
2	Coverage of pro-CER Regulations, policies, and incentives	3
3	System flexibility needs (as % of peak demand)	1
4	Power system structure and regulation: presence of unbundled power industry and/or retail competition	6
5	VPP access to revenue streams and viable business cases: access to energy, capacity and/or ancillary services markets	3
6	Regulations, policies, and incentives for VPP deployment: coverage of VPP-friendly regulations, policies, and incentives	0
7	Presence of data protection and privacy considerations	5
8	Presence of VPP/CER capabilities with utilities/regulators (dedicated teams, CER registers, open data sets, etc.)	3
9	Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications	1
	Total	**24%**



Criteria	KPI (assess current state)	Rationale
1 **Amount of CER capacity (as % of peak demand)**	Sum of generation (BTM solar), storage (EV), and flexible load (electric space cooling/ heating, water heating for residential and buildings) in GW as a percentage of peak demand in GW.	▪ **EVs** There are ~200 EVs in Nigeria in 2023 [236]. There is negligible contribution to flexible CER capacity at this stage. ▪ **BTM solar** From the Rooftop solar solutions Nigeria market assessment published by the International Finance Corporation (IFC), there is a total installed capacity of 0.5-1.5GWp of rooftop solar in Nigeria [237]. Taking a conservative stance, the BTM solar capacity is 0.5GWp. ▪ **Space and water heating** Space and water electric heating are not widespread, due to climate reasons as well, and choice of fuel, fuelwood being the primary choice for space and water heating. ▪ **Aircon capacity** The number of stationary air-conditioning units in Nigeria in 2023 stands at 500,000 units [238]. Assuming a power capacity range 1kW for a domestic air-conditioning unit, the total capacity is 0.5GW. With a national peak demand of 19.8GW in 2023 [239], the flexible CER capacity as a percentage of peak demand for Nigeria is (0.5+0.5)/19.80 = 5%.
2 **Coverage of pro-CER Regulations, policies, and incentives**	▪ CER roadmaps and targets; ▪ Financial support (subsidies and tax exemptions, loans and grants); ▪ Price mechanisms (net metering, TOU, FiT); ▪ Consumer education (public consultation, workshops, public websites); ▪ Better governance (e.g., streamlined processes codes, standards, certifications); ▪ Obligations and penalties (carbon pricing, portfolio standards, energy levies).	▪ Nigeria, through its Electricity Vision 30:30:30 plan, aims to achieve 30GW of electricity generation capacity by the year 2030, with 30% of this capacity derived from renewable energy sources [240]. It does not specify the contribution of CERs. ▪ There is some financial support for solar panels via the Standalone Solar Home System for households and MSMEs [241]. ▪ Feed-in-tariffs and time-of-use tariffs are present in Nigeria, but only apply to utility-scale renewable energy projects and commercial and industrial customers respectively. There are no CER roadmaps, targets, public reports, standards and codes or penalties such as carbon pricing.
3 **System flexibility needs (as % of peak demand)**	System flexibility needs (VRE such as solar and wind) in GW as a percentage of peak demand in GW.	The system flexibility needs in GW are estimated by dividing the daily flexibility needs with national peak demand in 2023. In Nigeria, the estimated daily flexibility needs are estimated to be 0.6GW, which gives a system flexibility need of (0.6/19.8) = 3%.

Criteria	KPI (assess current state)	Rationale
4 **Power system structure and regulation:** presence of unbundled power industry and/or retail competition	**Presence of unbundled power industry and/or retail competition.**	The Nigeria Electricity Supply Industry (NESI) has unbundled generation, transmission and distribution, with several independent power producers that are publicly and privately owned, a state-owed transmission company, the Transmission Company of Nigeria (TCN) and 11 distribution companies (DisCos), that manage distribution and retail of electricity [242]. There is no retail competition as customers have to purchase electricity from the DisCo in the designated area. The recently signed Electricity Act, 2023 aims to liberalise electricity retail in Nigeria, by separating distribution from retail [243].
5 **VPP access to revenue streams and viable business cases:** access to energy, capacity and/or ancillary services markets	**Access to energy, capacity and/or ancillary services markets.**	Nigeria operates a Single-buyer model, where the Nigerian Bulk Electricity Trading (NBET) company purchases electricity from all power producers and sells it to DisCos. Energy, capacity and ancillary services are bilaterally contracted [244]. CERs and VPPs are not able to participate in the wholesale energy, capacity or ancillary services markets today.
6 **Regulations, policies, and incentives for VPP deployment:** coverage of VPP-friendly regulations, policies, and incentives	▪ **VPP roadmaps and targets;** ▪ **Financial support (subsidies and tax exemptions, loans and grants);** ▪ **Consumer education (public consultation, workshops, public websites);** ▪ **Better governance (e.g., streamlined processes codes, standards, certifications).**	There are no VPP policies, regulations, financial support, public reports or standards and codes in Nigeria.
7 **Presence of data protection and privacy considerations**	**Presence of data protection and privacy laws or guidelines.**	Data protection and privacy is regulated through the Nigeria Data Protection Act, 2023. However, there are no specific energy or electricity sector data protection or privacy frameworks [245].

Criteria	KPI (assess current state)	Rationale
8 **Presence of VPP/CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.)**	Presence of VPP/ CER capabilities with utilities/ regulators (dedicated teams, CER registers, open data sets, etc.).	There are no CER/VPP specific capabilities or teams amongst utilities and regulators. There is a Mini-grid Regulation, 2023 that governs isolated and interconnected mini-grids between 0kW-1MW [246].
9 **Smart meter or Advanced Metering Infrastructure (AMI) penetration and specifications**	Smart meter penetration in %.	Only 44.4% of registered customers are metered as of Q4 2023 [247]. The presence of the Nigerian Electricity Smart Metering Regulation indicates plans by Nigeria to prepare for smart-meter roll-outs [248]. The Nigerian government has set up the Meter Acquistion Fund (MAF) to fund the roll-out of smart meters by DisCos. There is minimal smart meter penetration in Nigeria today.

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