REGULATORY ASSESSMENT OF BATTERY ENERGY STORAGE SYSTEMS IN SOUTH AFRICA

RES 4 AFRICA FOUNDATION



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About RES4Africa

RES4Africa Foundation's (Renewable Energy Solutions for Africa) mission is to create an enabling environment for scaling up investments to accelerate a just energy transition and transformation. It gathers a member network from across the clean energy value chain and supports the creation of an enabling environment for renewable energy investments and strategic partnerships. See more: www.res4africa.org

About the Sub-Saharan Programme

RES4Africa's Sub-Saharan Programme works to support the region maximise its huge renewable energy potential. Through research and study dissemination, capacity building programmes and stakeholder engagement, we strive to create an enabling environment for the implementation of renewable energy projects in the region and drive the just energy transformation of Sub-Saharan countries.

Within the Sub-Saharan Programme, special attention is given to South Africa, the largest electricity market of the continent accounting for half of Sub-Saharan Africa installed energy capacity. Now with a permanent office in Johannesburg, RES4Africa Foundation is committed to support the clean energy transition of the country that, despite the successful initiation of a renewable energy transition, still highly dependent on the extraction and export of coal.

Authors

Project management team: Antonio Passero, Marianna Petrosillo, Lorenzo Vilona (RES4Africa)
Authors: James Mackay, Jasmina Hodžić, Roelof van Huyssteen, Marta Marchesano (PwC)

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EXECUTIVE SUMMARY

South Africa is facing a deepening energy crisis. Households and businesses are facing rapidly escalating electricity costs, declining reliability and unpredictable power outages or controlled electricity shutdowns known as load-shedding. Increasing the share of renewables in South Africa's electricity grid and commensurate use of Battery Energy Storage Systems (BESS) will be an essential part of solving South Africa's electricity crisis and meeting the country's commitments to decarbonise the economy. The current national planning levels for procurement of both renewable energy and BESS are based on planning gazetted in 2019 which significantly understates the pace and scale required from new generation capacity.

South Africa's existing energy laws and regulatory measures were largely formulated to regulate and support a fossil fuel-based electricity industry, without explicitly considering or promoting renewable energy and BESS applications. This study assesses international regulatory benchmarks, using the United Kingdom, California, and Chile as case-studies in order to make well-informed policy and regulatory recommendations to accelerate the deployment of BESS as a critical part of the South African energy mix.

For each case-study, the market design, use case or application, procurement models, ownership models and remuneration models were assessed. It was found that the BESS use case applied in the respective countries (capacity services, ancillary services or investment deferral), indirectly determines the design of the procurement and remuneration models for that country. In California, it was found that BESS applications were primarily introduced for energy shifting or addressing the timing imbalances between peak demand and renewable energy profiles. The UK has an innovative and advanced ancillary services market whereby BESS applications can provide ultra-fast balancing services. Lastly, Chile's vast transmission grid and large share of renewables has resulted in localised transmission constraints and broader grid bottlenecks, where BESS has played a key role in investment deferral and is allowed to participate in the transmission development plan as a transmission asset. Considering the existing South African regulatory framework applicable to BESS deployment, the following key policy recommendations were made based on the international benchmarks identified:

Market design: The ideal market design for South Africa would be a hybrid model, whereby energy from BESS is sold in both a regulated market, as well as a wholesale market. Such a multi-market model would increase competitiveness to stimulate market growth whilst still supporting the financial sustainability of existing utilities.

BESS Use case: Given South Africa's electricity crisis, BESS applications based on energy shifting, especially from peak solar during the day to match morning and evening peak demand. Such peak shaving capacity provision is the most immediate and feasible option for South Africa.

Procurement mechanism: A use case built upon an energy shifting model, will require a technology-neutral auction model based on a time block system. In such a system, BESS generators will be able to participate in auctions based upon the demand forecasts for each time block.

Investment: The remuneration structure for BESS generators should be outlined in Regulations and reflect the ability of the technology to provide electricity to the grid at short notice, during peak demand periods. Additional investment incentives should be provided for in the form of tax incentives as set out in section 12 of the Income Tax Act.

In order to affect the aforementioned policy recommendations, key actions are highlighted in the BESS Implementation Roadmap based upon short-, medium-, and long-term development priorities for the BESS industry.

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1. Analysis of South Africa's BESS landscape

It is well accepted that South Africa's electricity supply is 4000MW to 6000MW short of what is required for unconstrained economic growth. Closing this supply gap can include some fossil fuel technologies such as gas-to-power but will be dominated by renewable energy from Wind and Solar. This supply gap has largely been created due to an ageing and failing coal fleet with a declining electricity availability factor (EAF). Historic EAF target levels of 78% were used in national planning, but with the actual performance being as low as 60% the available energy supply has significantly underperformed national planning targets. Closing this historic supply gap will require a significant escalation in the rate of wind and solar capacity as the dominant energy generation technology and lowest cost of new energy. When considering the capacity factor of variable wind and solar, this would indicate up to 20,000 MW of additional renewable energy will be required in the medium term to eliminate load shedding in South Africa. This should be in addition to the nationally planned procurement set out in the Integrated Resource Plan IRP 2019.

Such a significant acceleration of renewable energy deployment will necessitate a commensurate acceleration of BESS deployment in order to secure sustainable and reliable electricity services for the South African economy.

The variability of renewable energy generation (Solar PV and Wind), however, presents a growing risk to the stability of the energy system when compared to traditional fixed energy systems, especially in relation to serving the typical morning and evening peaks. The main problem with solar and wind energy is that electricity production is not programmable, as PV systems cannot produce by night, and both PV and wind systems produce according to the meteorological conditions; thus it is very unlikely that demand and supply will match. The mis-match between peak solar generation and demand typically results in the "duck curve" where the bulk of solar generation is at midday and outside of the peak demand times. This becomes more pronounced as the share of renewable generation, specifically solar power increases and hence emphasises the need for Energy Storage. Battery Energy Storage Systems (BESS) provide an opportunity to overcome the risks associated with renewable energy profiles, although uncertainty surrounding their regulatory compliance and cost competitiveness has limited their application at the utility scale. As in other countries, competitive, dispatchable and reliable renewable energy is important to South Africa's future energy mix and capacity expansion choices. While South Africa is well endowed with renewable energy resources that can be sustainable alternatives to fossil fuels, so far these have remained largely untapped and as such, BESS applications remain underdeveloped within the South African context.

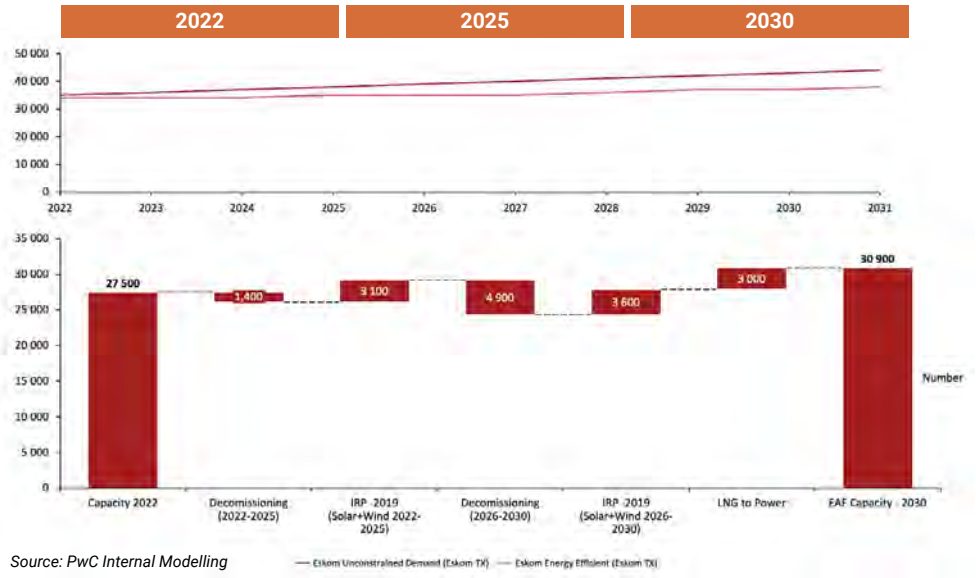
1.1 South Africa's existing BESS scenario

1.1.1 South Africa's energy landscape

During the last decade, South Africa has faced unplanned, unpredictable power outages. Additionally, businesses and households are forced to endure scheduled and controlled electricity shutdowns, known as load shedding, where power is rationed to relieve pressure on the system and prevent a collapse of the electricity grid. In 2021, the country had its worst load shedding yet, hitting an electricity outage duration of 1136 hours during the year, representing 2455 GWh of energy.[1] These electricity shortages are attributable to various factors including insufficient generating capacity, operational failures, and maintenance issues and breakdowns at ageing, poorly maintained power stations. For businesses, unreliable electricity results in increased running costs and reduced productivity and profitability. The power outages in South Africa will have caused many businesses in all kinds of sectors – from retail and service, to manufacturing and industry – to incur major financial losses. The Council for Scientific and Industrial Research (CSIR) calculated that the COUE (cost of unserved energy) at the end of 2021 was 87.50R/kWh.[2] This represents the cost of load shedding to the economy. Load shedding is forecast to continue over the next few years as Eskom struggles to meet demand.

The national planning for electricity capacity in South Africa is gazetted in Integrated Resource Plans published in terms of the National Energy Act. In terms of BESS, the most recent IRP (2019) makes provision for 513MW to be procured in 2022 and the remainder of 1575MW to be procured in 2029, meaning that in total, South Africa plans to procure approximately 2GW of BESS by 2030. In terms of renewable energy generation from solar and wind, the government plans to procure 14.4GW of wind and 6GW of solar energy from 2022 to 2030. However, even with the allocation of additional renewable energy capacity in the IRP, the country's electricity supply gap will continue to widen when compared to demand growth for an unconstrained and lower carbon economy, as indicated in the graph below.[3]

[1] CSIR, South Africa Load Shedding Statistics (30 November 2021), available at https://www.csir.co.za/sites/default/files/Documents/Loadshedding%20plot.pdf
[2] Ibid.
[3] Internal PwC research conducted in 2022.



Source: PwC Internal Modelling

Figure 1: Assessment of Eskom Generation Capacity – 2022 to 2030.

From the graph above, it is clear that national electricity procurement through wind and solar must significantly increase across behind-the-meter applications, embedded generation and national procurement under the Renewable Energy Independent Power Producer Procurement Programme (REIPPP). The system variability associated with the deployment of large capacities of wind and solar, will require a significant increase of BESS, which is typically seen as 25% - 30% of installed renewable capacity thus indicating that South Africa should consider BESS capacity of 5 – 6 times that contained in the IRP 2019. Although this study does not aim to outline or evaluate the technical design elements of the ideal BESS solution, the optimal sizing of battery energy storage is a crucial task at the design stage and will ultimately reduce total system cost and increase system reliability. Optimal BESS deployment should be designed based on modelling that secures sustainable electricity supply in a specific network and considers the renewable energy profile of the specific network.

In addition to load shedding, rapidly increasing tariffs by Eskom and municipalities have further improved the investment case for businesses to move towards renewable energy and energy-efficiency interventions. As such, there has been a growing trend of businesses looking at and investing in renewable energy technologies and BESS to not only improve energy security, but to decrease their exposure to escalating electricity prices.

The projected decline in prices of batteries, the continuing innovation in new battery technologies, as well as their benefits at times of peak demand and load shedding, are continuously strengthening the commercial case for increased BESS deployments. However, as BESS applications represent a new form of energy technology in South Africa, the country has yet to develop the regulatory regime that would promote the uptake of BESS. Despite this, the country has several BESS projects in various stages of development as will be outlined in the section below.

1.1.2 Analysis of existing BESS applications and planned projects

As part of South Africa's low carbon energy planning mix, the national Renewable Energy Independent Power Producer Procurement (REIPPP) Programme was launched in 2011. The REIPPP Programme awards government backed power purchase agreements (PPA's) to Independent Power Producers (IPPs) who submit competitive, priced bids to design, develop and operate large-scale renewable energy power plants in line with various bid windows as determined by the Minister of Mineral Resources and Energy. The most recent renewable energy auction under bid window 5 closed in October 2021. 102 bids totalling 9,6GW of RE were submitted. The Department of Mineral Resources and Energy announced 25 successful bids totalling 2,6GW, of which 4 are known to have included BESS technologies as part of their project plans.

As set out in their Integrated Report for 2020, Eskom has a distributed BESS project which aims to develop a 360MW storage system (1440 MWh with four hours storage). This project is planned to be implemented in two phases with phase 1 aiming to have a capacity of 800MWh and phase 2 a capacity of 640MWh. Phase 1 includes a BESS with a minimum of 80 MW/320 MWh at Skaapvlei Substation, in Vredendal, in the Western Cape; a 83 MW/332 MWh system across sites in the Eastern Cape and KwaZulu-Natal; and a 34.5 MW/175 MWh BESS for sites in the Western Cape. The IRP 2019 does mention that an additional 1575 MW worth of BESS will be introduced by 2029 which would bring total number of BESS to 5 GW.

In addition to the REIPPP Programme, the government also introduced the Risk Mitigation IPP Procurement Programme (RMIPPP). The RMIPPP is the first step in the government's plan to procure more than 13 800 MW of new energy over the next decade, as set out in the Integrated Resource Plan (IRP 2019). The RMIPPPP published its bid window in August 2020 detailing 11 Preferred Bidder projects, totalling 1 995.76 MW. Out of the 11 proposed projects under the RMIPPP Programme, 7 projects included BESS technologies as part of the projects.

Various energy intensive private companies have also begun introducing BESS projects into their business strategies to curtail the effects of load shedding whilst also contributing to their decarbonisation efforts. The table below shows a list of BESS projects and their respective capacities.

Table 1: List of BESS Projects

#	Programme	Name	Entity/Owner	Location	Capacity
1			Eskom	Western Cape, Eastern Cape, Northern Cape and KwaZulu Natal	360 MW
2	RMIPPPP	Oya Energy Hybrid Facility	Oya Energy (Pty) Ltd	Western Cape	40MW
3	RMIPPPP	Umoyilanga Energy	(not applicable - to be incorporated)	Eastern Cape, Northern Cape	75MW
4	RMIPPPP	ACWA Power Project DAO	Not established yet	Northern Cape	150MW
4	RMIPPPP	Mulilo Total Hydra Storage	Mulilo Total Storage	Northern Cape	150MW
6	RMIPPPP	Scatec Kenhardt 2	Scatec Solar SA 350 (Pty) Ltd (RF)	Northern Cape	1140MW
7	RMIPPPP	Scatec Kenhardt 1	Scatec Solar SA 330 (PTY) LTD.	Northern Cape	
8	RMIPPPP	Scatec Kenhardt 3	Scatec Solar 370 (Pty) Ltd	Northern Cape	
9	REIPPPP BW5	Grootfontein PV 1		Western Cape	Unknown
10	REIPPPP BW5	Grootfontein PV 2		Western Cape	Unknown
11	REIPPPP BW5	Grootfontein PV 3		Western Cape	Unknown
12	REIPPPP BW5	Beaufort West WEF		Western Cape	200 MWh
13	Private	EnergyPod® battery systems	Anglo American Platinum	Limpopo	0.2MW
14	Private	Implats Platinum Refinery Fuel Cell System	Impala Platinum Holdings		8MW
15	Private		Hive Hydrogen, Built Africa and Afrox subsidiary Linde		56 MW
16	Private	Abengoa	Abengoa	North West	1MW

2. International best practices

2.1 Diverse approaches to BESS development

The purpose of this chapter is to benchmark global best practices which can provide a reference and transferable lessons learned for regulating BESS in South Africa. The choice of markets to be benchmarked was driven by two considerations:

1. The volume of utility-scale BESS installed, as a neutral metric of successful BESS deployment
2. The diversity of their market contexts, where the objective of the benchmarking is to identify different experiences and draw conclusions on how they may apply to South Africa.

Based on these criteria, the markets chosen were California, the United Kingdom, and Chile. All three countries have large volumes of utility-scale BESS, but distinctly different market structures and enabling factors which led to the growth in BESS. The differences in their starting positions suggests that there isn't a one-size fits-all, and given an appropriate regulatory environment and economic enablers, BESS can thrive in diverse market contexts. Table 1 provides an overview of key features of the three selected markets.

Table 2: Key features of selected markets

Country	RES capacity (GW)	RES share in the power mix	BESS capacity target	Installed BESS capacity (MW)[4]	BESS capacity (MWh)	Average BESS duration (h)
California	25	33%	9.8 GW by 2030	536	930	4
United Kingdom	47	43%	13 GW by 2030	1300	No information	0.5 - 4
Chile	12	51%	363 MW, 1563 MWh by 2023[5]	175	623	5

[4] In the U.S., utility-scale batteries have a nameplate power capacity of 1 MW or greater, while behind-the-meter batteries range in size from 3 kW to 1 MW.
[5] The energy ministry has said Chile needs to add 2,000MW of energy storage capacity every 10 years between now and 2050, including battery storage, but this has not been made into a formal target. Source: BN Americas. Available here: https://www.bnamericas.com/en/analysis/spotlight-chiles-energy-storage-pipeline-as-renewables-advance

This chapter provides a benchmark of the three markets along the following dimensions:

- Key macro-deployment **drivers** which led to the growth of BESS. This dimension identifies the policy, regulatory, fiscal or market factor which provided the initial impetus to BESS development.
- **Market Conditions**. This serves to illustrate the diversity of market contexts in which BESS emerged
- **Use cases** for BESS (we identify 3 use cases), which can also be understood as a business model in which the BESS technology is applied in a given market context.
    - For each use case, we provide an insight into
        - procurement mechanisms, i.e., how did BESS enter the market.
        - ownership structures, which serves to understand how ownership risk is allocated.
        - remuneration models, which provides a view of how the economics of each use case are sustained.

Procurement, ownership and remuneration are inherently tied to the use case in which BESS is being applied, which is the reason why they are treated separately for each use case. It is worth noting that several use cases, procurement and remuneration models can coexist in one market, as will be seen in the sections that follow.

2.2 Key drivers of BESS in the UK, California and Chile

2.2.1 California: Command-and-Control policies supported by tax incentives

California's high share of variable RES (primarily solar PV) has historically created important challenges for the system operator to balance supply and demand on the grid. The problem of timing imbalance between peak demand and RES generation has been dubbed the challenge of the "duck curve". This challenge has been compounded by the fact that much of the conventional generation providing peak capacity, mostly installed in the 1960s, are aging and need to be decommissioned. To flatten the duck curve, the system operator CAISO placed on utilities a series of obligations to boost flexibility and ramping requirements.[6] One such command-and-control measure is the Assembly Bill 2514 from 2013, which introduced a requirement for investor-owned utilities (IOUs) to procure 1,325 MW of large-scale energy storage and have the energy storage operational by 2024.[7]

[6] Ten Years of Analyzing the Duck Chart. NREL, 2018. Available at: https://www.nrel.gov/news/program/2018/10-years-duck-curve.html
[7] The landmark rule regarding the integration of storage into the U.S. market is Order 841 issued by the Federal Regulatory Energy Commission (FERC) in 2018, namely "Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators".

Another enabler of BESS in California has been a fiscal measure, the Federal Energy Regulatory Commission (FERC) set up an Investment Tax Credit (ITC) which deducts a certain percentage of investment from taxes, proportional to the charging time associated with renewable sources. The incentive provides a 26% credit for systems installed by 2022 in order to reduce upfront costs, raised by uncertainties of the project's multiple revenue streams.

2.2.2 UK: Pivotal role of BESS in boosting system flexibility

Similarly, to California, the UK's high share of renewables in the electricity mix has given rise to issues of system adequacy. The 2017 Smart Systems and Flexibility Plan formally defined the role of energy storage in the evolving UK electricity market.[8] BESS are currently eligible to participate in Capacity Market auctions to cope with times of stress on the network, whereby generators are paid – via a long-term contract – to ensure they're available to deliver energy in case they are called to do so by the system operator. More than 15 battery storage projects have secured a contract in the year-ahead auction in 2018[9] and 158 MW in the four-years-ahead auction for 2021/2022.[10]

Another impetus to BESS deployment in the UK has been the introduction, on the ancillary services market, of Dynamic Containment (DC), an ultra-fast balancing service requiring sub-1 second activation. It represents an innovation in fast-acting frequency response services to provide frequency response within one per cent of 50Hz. Any technology type can take part in the dedicated 4-hour blocks auctions, but BESS is particularly suited to provide the service given its rapid response times.

2.2.3 Chile: Electricity design auctions as an implicit incentive to BESS

Chile has been a trailblazer in RES installations given its richness in solar power potential, and technology-neutral electricity auctions have been the key driver of BESS installations. The specific structure of the auction (time supply blocks) proved to be an indirect incentive for bidders to present integrated RES+BESS bids as a manner of lowering bid costs (for more info, see Box 1).

Additionally to address the geography-imposed burden on the country's grid infrastructure, Chile introduced a mechanism which allowed BESS to participate in the transmission development plan. Chile's specific geography stretching over vast north-south distances

[8] Upgrading Our Energy System Smart Systems and Flexibility Plan, OFGEM, 2017. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/633442/upgrading-our-energy-system-july-2017.pdf
[9] UK: Recent regulatory and market updates on energy storage. Bird & Bird, 2018. Available at: https://www.twobirds.com/en/news/articles/2018/uk/energy-storage-recent-regulatory-and-market-updates-in-the-uk
[10] Final Auction Results: T-4 Capacity Market Auction for 2021/22. National Grid, 2018. Available at: https://www.emrdeliverybody.com/Capacity%20Markets%20Document%20Library/Final%20T-4%20Results%20(Delivery%20Year%2021-22)%2020.02.2018.pdf

means its transmission grid is subject to major bottlenecks and locational constraints.[11] The high share of RES (over 50 %) has also caused negative power prices and curtailment in some regions: in 2018, some 7% of total wind and solar generation went curtailed and unconsumed. The exposure of generators to negative prices provided another implicit economic incentive to the installation of BESS.

The 2020 Flexibility Strategy[12] has the potential to provide an additional boost to BESS as it encourages investment in technologies that provide flexibility, foresees a clearer regulatory framework for storage, and promotes an increase in the role of BESS in the transmission planning.

While the Strategy still needs to be translated into concrete laws and regulatory measures, its publication is providing investment certainty which drives further BESS development.

Table 3: Main drivers of BESS deployment

Country	Background information	Regulatory driver	Description
California	• Legal mandate to procure 100% RES by 2045 • Over and under- generation of solar energy (Duck curve) • Goal to decrease reliance on gas plants • High local capacity required by the Resource Adequacy program (see Box 3)	Assembly Bill 2514[13] & Assembly Bill 2868[14]	State law requiring IOUs to install a certain number of batteries on their systems
		Investment tax credit[15]	Fiscal incentive benefiting storage deployments tied to solar
United Kingdom	• High installed capacity of RES • RES curtailment & negative price issue • Phase out coal by 2025 • Cutting-edge regulation for storage • Need for greater grid flexibility and ramping requirements	Capacity market auctions[16]	Yearly auctions to secure electricity supply for 1 or 15 years and safeguard against blackouts
		Dynamic Containment	Sub-second, ultra-fast response ancillary service
Chile	• Increases in electricity demand (mining industry as main driver) • RES curtailment & negative price issue • High climate targets & fossil fuels imports • Geographical constraints for the transmission system	Electricity auctions based on time-variant supply blocks	Auction scheme based on hourly or quarterly time blocks.

[11] The Chilean grid used to be separated between 2 system operators (northern SING and central SIC) until 2017, when an interconnector was built between the two zones.
[12] Estrategia de flexibilidad para el sistema eléctrico nacional. Ministerio de Energía, 2020. Available at: https://www.energia.gob.cl/sites/default/files/estrategia_de_flexibilidad_0.pdf
[13] Assembly Bill (AB) 2514 (Skinner, Chapter 469, Statutes of 2010), amended by Assembly Bill 2227 (Bradford, Chapter 606, Statutes of 2012). Available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100AB2514
[14] Assembly Bill (AB) 2868 (Gatto, Chapter 681, Statutes of 2016). Available at: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB2868
[15] Homeowner's Guide to the Federal Tax Credit for Solar Photovoltaics. U.S. Department of Energy, 2021. Available at: https://www.energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics
[16] Consolidated version of the Capacity Market Rules. Ofgem, 2021. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904364/Informal_consolidation_of_capacity_market_rules_july_2019.pdf

2.3 Market conditions overview

Vertical integration and degree of unbundling. The three markets analysed have different degrees of unbundling. The UK and Chile are fully liberalized markets where private operators are present in generation, distribution, and retail segments. Chile is considered a trailblazer in opening its electricity sector to private sector participation already since the 1990s, and have numerous IPPs operating in the market.[17] California, on the other hand, is a partially liberalized market which features an independent transmission system operator, the CAISO, while the generation and distribution segments are run by vertically integrated localized monopolies called the IOUs (Investor Owned Utilities).[18] While IOUs are default suppliers, customers can opt out and get served by CACs (Community Choice Aggregators).

The degree of unbundling of the market has a strong influence over ownership models for BESS, as will be seen later in the chapter. Ownership structures tend to reflect the general market structure: in the UK and Chile BESS is mostly owned by IPPs, while in California IOUs and CACs dominate the market.

Wholesale market. The existence of a wholesale market in which BESS can participate in trading their energy in a transparent and predictable manner is an important enabler for BESS, as it provides a revenue stream. BESS are particularly suitable to markets which have more granular trading sessions, as the closer the trading sessions are to real time, the higher are the prices and the profits that BESS can tap into. Both California and the United Kingdom have a highly liquid wholesale market composed of a day-ahead and an intra-day market. They also have very granular trading sessions which are highly suited for BESS: the UK allowed 30-minute products to be traded in continuous intraday markets without recourse to auctions. Similarly, California transitioned from hourly products to quarter-hourly products, in line with FERC Order 764 and with the need of optimizing the ramping capability.[19] Chile has a very simple spot market which is only open to generators, who use it to settle imbalances between their contract commitments and their actual production.

Ancillary services market. The existence of an ancillary services market open to BESS participation is another essential enabler to BESS, because it offers an additional – and potentially highly remunerated - revenue stream. The ability of BESS to rapidly charge and discharge large volumes of energy with short or no start-up time makes them uniquely positioned to provide ancillary services to the system operator. But not all markets have an ancillary services market.

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[17] The most important IPPs operating in the generation segment includes AES Gener (a subsidiary of US-based AES Corporation), Colbún S.A, Engie Energía Chile, Enel Generación Chile and Enel Green Power Chile, Mainstream Renewable Power (a subsidiary of Ireland-based company) and Acciona (subsidiary of Madrid-based company).
[18] The main IOUs are SDG&E (San Diego Gas & Electric), PG&E (Pacific Gas and Electric Company), SCE (Southern California Edison).
[19] Increasing time granularity in electricity markets. IRENA, 2019. Available here: https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Increasing_time_granularity_2019.pdf

In the UK, the system operator (ESO) allows BESS to provide two types of ancillary services: Firm Frequency Response (procured in monthly & quarterly tenders or weekly auctions) and Dynamic Containment (procured in the day-ahead ancillary services market).[20] Similarly, in California, four types of services are traded in the ancillary services market (spinning reserves, non-spinning reserves, regulation up, and regulation down).[21] To allow participation of energy storage resources in all ancillary services products offered, CAISO introduced the non-generator resource (NGR)[22] model to establish the initial basis for participation of storage in regulated markets. Chile, on the other hand, only recently started to procure ancillary services via market mechanisms. Until 2019 ancillary services used to be centrally allocated among existing generators; in 2020 secondary and tertiary reserves started to be competitively auctioned and Article 76 of Decree 113 explicitly states that BESS, among other technologies, is eligible to present a bid under an ancillary services auction.[23] But the Chilean Ancillary Services Market remains in its early stages and has likely not played a large role for the development of BESS.

This market design overview provides an important context to assessing the transferability of best practices from the UK, California and Chile. South Africa has a vertically integrated market model and there is no wholesale and ancillary services market; this means that only selected BESS use cases will be applicable locally. We look into use cases later in this chapter.

2.4 Uses and applications of BESS

In any given market, BESS can provide different types of services which vary depending on the market design and specific needs of the electricity sector in which they develop. Within the three benchmarked markets, we identify three broad use cases of BESS:

1. **Energy and capacity services**. This can include:
    a. arbitrage and smoothing RES generation via wholesale market trading, i.e. purchasing and BESS charging when RE supply is high and prices are low, and selling and discharging at peak demand times when prices are high, typically in wholesale markets to cash in on price volatility.
    b. capacity provision, i.e. providing energy capacity to meet peak demand, reduce price spikes associated with ramping shortfall, and maintain reliability of the system

[20] What is Dynamic Containment and what does it mean for battery energy storage in the UK? A. Done, Energy Storage News, 2020. Available here: https://www.energy-storage.news/what-is-dynamic-containment-and-what-does-it-mean-for-battery-energy-storage-in-the-uk/?utm_source=rss-feeds&utm_medium=rss&utm_campaign=general
[21] Annual Report on Market Issues and Performances. CAISO, 2020. Available here: http://www.caiso.com/Documents/2020-Annual-Report-on-Market-Issues-and-Performance.pdf
[22] Non-generator resource (NGR) and regulation energy management (REM) overview phase. CAISO, 2016. Available here: www.caiso.com
[23] DECREE 113 APPROVES THE REGULATION OF COMPLEMENTARY SERVICES REFERRED TO IN ARTICLE 72°-7 OF THE GENERAL LAW OF ELECTRICAL SERVICES.
MINISTRY OF ENERGY, 2020. Available at: https://www-bcn-cl.translate.goog/leychile/navegar?idNorma=1129970&idParte=10010150&_x_tr_sl=auto&_x_tr_tl=en&_x_tr_hl=it

2. **Provision of ancillary services**. These are necessary for the balanced and stable operations of a transmission or distribution system and are typically procured by transmission system operators (TSOs). They can be clustered into two main categories:
    a. Frequency ancillary services, including frequency containment reserve, which are very fast-response services used to balance momentary unpredictable variations between electricity demand and supply; frequency restoration reserve, used to respond to short-term changes in demand and generation provided by automatic generation control (up to 5 minutes, also called secondary reserves) or manually by generating units at the regional level (5 to 15 minutes, also called tertiary reserves) to restore primary frequency capacity; replacement reserve, used to restore the required level of reserves to be prepared for a system imbalance.
    b. Non-frequency ancillary services, including voltage control, related to the injection of reactive power to maintain system voltage within a prescribed range; and black-start, referring to the service of getting the system back online in case of a large-scale shutdown.

3. **Grid investment deferral**. This is where BESS is used as a transmission asset to defer grid reinforcements investments. BESS can be deployed at different points in the distribution and transmission network, avoiding transmission constraints and congestion costs.

Table 4: BESS revenue model overview

BESS use cases	Use 1: Energy arbitrage	Use 2: Ancillary services	Use 3: Capacity provision	Use 4: Investment deferral
Procurement	Wholesale traded	Ancillary service market	Capacity Market (Centralized capacity auction, UK, Chile)	Tenders (Chile, California)
Ownership	TSOs or IPPs	IPPs	IPPs	TSOs or IPPs
Remuneration model	Asset owned by TSOs - Not allowed Asset owned by generators - Remunerated by the energy market	Paid through contracts - Paid-as-clear (UK), hybrid regulated price (Chile) Paid for capacity & energy through wholesale market (California)	Paid through contracts - paid-as-clear (United Kingdom) or paid-as-bid (Chile)	Paid as regulated network tariff

Each of these three use cases use a different timescale of BESS response time, and they require different procurement, ownership structure, and remuneration models. In the sections that follow we analyse the experience of California, UK, and Chile for each use case with respect to procurement, ownership structure and remuneration. Table 5 provides an overview of the application timescale of each use case.

Table 5: Battery storage applications and timescales

Category	Application	Description	Service duration
Energy and capacity services	Energy arbitrage	Batteries charge low-cost off-peak energy and discharge it during periods of high prices.	Hours
	Peaking capacity	Provide reliable capacity to meet peak system demand.	2+hours
Ancillary services	Frequency Containment Reserve	Very fast response to balance momentary unpredictable variations between electricity demand and supply within the transmission grid.	Seconds
	Frequency Restoration Reserve	Fast response to short-term changes in demand and generation provided by automatic generation control (aFRR) or manually by generating units at the regional level (mFRR) to restore primary frequency capacity.	5-15 minutes (>15 for mFRR)
	Replacement Reserve	Used to restore the required level of reserves to be prepared for a system imbalance (generator failure, transmission line, circuit breaker, switch etc.)	15 minutes to hours
	Voltage support	The injection of reactive power to maintain system voltage within a prescribed range.	Seconds
	Black-Start	Units brought online to start the system after a system-wide failure (blackout).	Hours
Grid Investment deferral	Transmission and Distribution Replacement and Deferral	Reduce loading on transmissions and distribution systems during peak times.	Hours

2.4.1 Use 1: Energy and capacity services

Under this use case, BESS are used to store surplus energy generated by RES and discharge it at a later point in time. The reason to do so can include some or all of the following:

- A desire to maximize revenue through price arbitrage, whereby BESS is charged when market prices are low i.e. off-peak or under curtailment conditions and discharged when prices are high i.e. peak demand hours. A key driver of this type of arbitrage is curtailment risk (e.g., California and Chile), and the existence of a highly liquid wholesale markets where large price volatility provides opportunities for revenue (e.g., UK and California)
- A desire to reduce losses, related to the prospect of negative prices in the wholesale market. The current market design in some countries allows for the occurrence of negative prices, when the increasing deployment of VRES hits low demand. RES producers can participate in the market bidding negative prices, i.e. receive payments to withdraw electricity from the system.[24]
- A need to meet peak demand in a least-cost manner, reducing the strain on the system operator and avoiding the risk of demand shedding.

The use of BESS for energy and capacity services is present in all three benchmarked markets, although in slightly different forms.

Procurement

Procurement of BESS for energy and capacity services can be done via three mechanisms: RES auctions coupled with BESS, capacity market auctions, and centrally allocated capacity provision obligations.

Chile has had major successes in procuring BESS via technology-neutral electricity auctions based on a time block system. The blocks are clustered in unequal hourly and seasonal blocks, whereby contracts are awarded to bidders presenting the lowest price per MWh in each time block. Selected projects enter into a PPA contract to deliver a certain volume of electricity for individual hours of the day.[25] Bidders can propose various time combinations.[26] [27] This system of time-differentiated supply blocks provides an implicit incentive for bidders to present combined RES + BESS bids, as storage capacity allows RES plants to offer competitive prices even in those time slots where the RES asset does not generate electricity (e.g. at night or in certain seasons of the year). Box 1 provides additional information on Chile's auction system.

[24] Negative Electricity Prices: Causes and Effects. Agora Energiewende, 2014. Available at: https://www.agora-energiewende.de/fileadmin/Projekte/2013/Agora_Negative_Electricity_Prices_Web.pdf
[25] Aprueba Bases Preliminares de Licitación Pública Nacional e Internacional para el Suministro de Energía y Potencia Eléctrica para Abastecer los Consumos de Clientes Sometidos a Regulación de Precios, Licitación Suministro 2022/01. Comisión Nacional de Energía, 2021. Available at: https://www.cne.cl/wp-content/uploads/2021/12/Res-CNE-N%C2%B0-590_Aprueba-Bases-Preliminares-Licitacio%CC%81n-2022_01.pdf
[26] The Chilean electricity market and its implications. IOP Conference Series: Earth and Environmental Science, 617(1). Wang, H., Xie, Z., Le, Q., Wang, K., Li, H., Tao, J. and Liu, D., 2020. Available at: https://iopscience.iop.org/article/10.1088/1755-1315/617/1/012035/pdf
[27] In the case of projects that combine different sources of primary energy or incorporate systems of storage, it must comply with the conditions established by the tender. For further information see: Renewable Energy Auctions – A Guide to Design. IRENA and CEM, 2015. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/Jun/IRENA_Renewable_Energy_Auctions_A_Guide_to_Design_2015.pdf

BOX 1. Chile: time-differentiated supply blocks auctions

The supply block system was introduced in 2014 with the aim of securing energy supply and reducing investment risks. Generators bid for specific time blocks, different quantities and prices of energy supply, on the basis of a specific demand quantity. Blocks are clustered according to the following two schemes:

- three unequal hourly blocks, covering 24 hours - to meet the demand at certain times of the day
- four three-month blocks, covering one year and bidders can make various combinations - to provide generation of base load.

Generally speaking, continuous supply blocks are highly exposed to the variability of the spot market, as suppliers participate in the wholesale market in order to compensate for moments of shortage, e.g. in night hours. On the other hand, hourly supply blocks are a safer mechanism, because generators can decide to manage their output in the most efficient way, limiting the need to access the spot market.

The qualification requirements are very flexible, technology-neutral and make no distinction between national or international companies. The average price of the contracts awarded in pay-as-bid auctions with differences between the contracted quantity and the plant's generation must be settled at the electricity spot price.

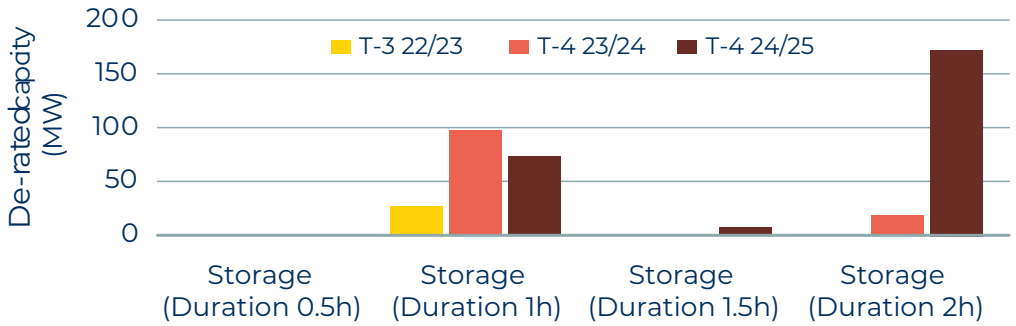
BESS for energy and capacity services can also be procured via **capacity market auctions** such as in the UK. The Capacity Market is part of the government's Electricity Market Reform package[28] to ensure system adequacy in the context of a growing RES share in the electricity mix. Capacity is procured through technology-neutral auctions, meaning that BESS can also participate. To be eligible to participate, assets need to have a capacity higher than 2 MW and they must not receive support from other policy measures, as may be the case with RES. Two types of auctions are present:

- The main auction is the T-4, which procures the capacity needed for delivery in four years' time. In this auction, newly built generators and BESS can secure 15-year agreements.

[28] Information retrieved from GOV.UK, Appendix 5: Electricity Market Reform (EMR). Available at: https://www.gov.uk/government/publications/2010-to-2015-government-policy-uk-energy-security/2010-to-2015-government-policy-uk-energy-security#appendix-5-electricity-market-reform-emr

- The second capacity auction is the T-1, in which smaller sites can participate ahead of each delivery year.[29]

BESS has increasingly been able to secure contracts under the capacity mechanism: in the latest T-4 auction concluded in March 2021, out of the 40.8GW of aggregate de-rated capacity procured, awarded new build battery storage capacity more than doubled to 252MW (see Figure 1).[30]



Source: Frontier Economics. https://www.frontier-economics.com/media/4691/cm-2021-briefing.pdf

Figure 2: UK Capacity Market Auction, Awarded Battery Storage Capacity

Lastly, BESS for energy and capacity services can be procured via **centrally allocated capacity provision obligations** such as in California. The CAISO does not operate a formal capacity market; instead, the Public Utilities Commission (CPUC), the regulatory agency, requires each Investor-Owned Utility (IOUs) and Community Choice Aggregator (CCAs) to meet a Resource Adequacy requirement, which IOUs and CCAs can choose to meet with BESS capacity (see Box 3).[31] In addition to the Resource Adequacy, IOUs are also obliged to meet an explicit energy storage procurement target totalling 1.3 GW of storage by 2020, as per assembly bill 2514 from 2013. In order to meet their obligations, IOUs and CCAs have tended to procure BESS via PPAs, contracting the delivery of energy and battery dispatch rights, although some IOUs have also opted for direct ownership.[32]

[29] Capacity Market: an EMR Primer. Clifford Chance, 2015. Available at: https://www.cliffordchance.com/content/dam/cliffordchance/briefings/2015/11/capacity-market-an-emr-primer.pdf
[30] Source: Frontier Economics. https://www.frontier-economics.com/media/4691/cm-2021-briefing.pdf
[31] In December 2020, a a group of Community Choice Aggregators launched a joint Request for Offers to procure up to 500 megawatts (MWs) of long-duration storage. For further information see: https://cal-cca.org/california-community-choice-aggregators-issue-request-for-long-duration-storage/
[32] For example, in April 2020, Clean Power Alliance (a community-choice aggregator) signed a PPA with IPP sPower, contracting 100 MW battery project to support the grid near Los Angeles. For further information see: https://www.greentechmedia.com/articles/read/clean-power-alliance-contracts-for-100mw-battery-biggest-so-far-among-community-choice-aggregators.

BOX 2. California: Resource Adequacy Requirements

One of our biggest challenges in California's transition to 100% clean electricity is to maintain reliability of the system. The Resource Adequacy (RA) program establishes monthly and annual electricity capacity standards for utilities and supports them in meeting targets set by AB 2514 and 2686.

Since 2006 the California Public Utilities Commission (CPUC) Resource Adequacy program requires suppliers and load-serving entities to contribute to reliability reserves, via three types of Resource Adequacy requirements:

- System Capacity (peak load hours) - meet the 1-in-2 peak demand forecast, plus an additional planning reserve margin with an effective rate of 17.5%.
- Local capacity - Load-serving entities have the capacity needed to meet demand in the event a local transmission grid emergency occurs.
- Flexible capacity - procured enough capacity to meet demand in the crucial early evening hours when solar resources are no longer available, as a way of addressing the duck curve requirement over a 3-hour ramp window.[33]

In the 2018 decision D.18-06-030, the CPUC allowed combined storage and demand response projects to be eligible to participate in the RA program, which provided a key impetus for IOUs and CACs to meet their Resource Adequacy requirement via battery storage.

Ownership structure

The ownership structure of BESS used for energy and capacity services tends to reflect the pre-existing ownership structures which are prevalent in each host market.

In fully liberalized markets such as the UK and Chile, network operators are excluded from arbitrage trading, and only IPPs, utilities or developers, are allowed to make returns on wholesale markets. In that sense, BESS used for energy shifting and arbitrage tends to be owned by IPPs. This type of ownership is in line with the ownership model of RES procurement auctions more broadly, whereby developers or IPPs maintain ownership of the asset while the contracting authority receives, on the basis of a PPA, a stream of electricity volumes over a given period of time.

[33] Resource Adequacy Factsheet. CAISO, 2021. Available at: http://www.caiso.com/Documents/Resource-Adequacy-Fact-Sheet.pdf

Also, in the case of competitively procured capacity volumes like in the UK, the principles of a liberalized market apply whereby asset owners need to be independent operators such as IPPs, developers, or integrated technology providers. It may be interesting to note that the last UK capacity market auction saw a number of joint ventures composed of technology providers teaming up to jointly build and manage a BESS asset.[34]

In California, the hybrid market structure of vertically-integrated local monopolies coexisting with IPPs is reflected also in the BESS market. In order to meet their storage target obligations and the Resource Adequacy obligations, IOUs have opted for a mixed approach. Most tend to procure BESS via Request for Offers open to IPPs and developers, whereby IPPs maintain ownership of the asset while the IOU receives energy and the right to dispose of the asset at its own will. In addition to this approach, some IOUs also opted to maintain ownership of their BESS project. This is the case, for example, with PG&E's Moss Landing project, touted as possibly the world's largest BESS project, which will be jointly designed, constructed, and maintained by Tesla and PG&E, with PG&E retaining ownership.[35]

Remuneration model

The remuneration model for Use Case 1, Energy and capacity services, can vary depending on how BESS was procured but also on the underlying market design.

In cases where BESS is procured via technology-neutral auctions, such as in Chile, BESS is not remunerated explicitly as a separate asset. Instead, Chilean auction bidders receive a revenue stream via a PPA for time-scaled energy blocks, awarding lowest bid for power per time block ($/MWh). In order to settle imbalances between contract commitments and actual production, bidders trade on the spot market, where negative electricity prices can occur.[36] BESS is **remunerated implicitly**, as the ability to charge in times of overgeneration and discharge in times of low generation reduces the bidder's need to resort to the spot market, and therefore reduces exposure to spot market price volatility and potentially to negative prices.

In the rare cases where BESS is used purely for arbitrage trading, the remuneration model is fully **market-based, traded in the wholesale market**. Arbitrage, as uncontracted revenue, is typically paid by the energy market, and in highly liquid and highly active energy markets such as in the UK and California, generators can cash in on high volatility and high price

[34] For example, 100 MW being constructed by Japanese engineering firm Nippon Koei, and procured by a JV led by Toshiba Mitsubishi Electric Industrial Systems Corporation. Source: https://www.solarpowerportal.co.uk/news/nippon_koeis_100mw_of_uk_battery_storage_to_enter_construction
[35] Source: https://www.forbes.com/sites/arielcohen/2020/08/13/tesla-begins-construction-of-worlds-largest-energy-storage-facility/?sh=-4c2ae4684fde
[36] The system operator i.e. Coordinador Eléctrico Nacional, coordinates the dispatch in the spot market, which balances the differences between energy produced and energy sold through supply contracts of regulated customers.

differentials in the real-time market. Therefore, an essential enabling factor to remunerating BESS via arbitrage or via technology-neutral auctions is the existence of a wholesale market where RES generators are exposed to price variability. The possibility of curtailment and of negative prices on the wholesale market serves as an additional incentive for BESS deployment.

In cases where BESS is procured via competitive capacity market auctions such as in the UK, the remuneration is composed of **a fixed (£/kW-yr) and a variable (£/kWh) component**, with the variable component subject to a price cap. Winning bidders are awarded a long-term fixed revenue contract of 15 years for their availability to provide capacity to the market, whether this capacity is actually used or not. On top of the fixed revenue, they receive a market-rate return on the volumes sold on the wholesale market up until the price cap; in case the wholesale market price exceeds the cap, the extra revenue must be returned.

In California where the procurement of BESS capacity is mandated on utilities (whether IOUs or CCAs) to meet the Resource Adequacy or the storage target obligations, utilities who own their BESS are only remunerated with a fixed ($/MW) component and are not allowed to receive market-based returns from wholesale trading. This is related to the way IOUs and CCAs are remunerated in general: they can earn a return only on their rate-base but are not able to earn profit on energy sales.[37] On the other hand, if the BESS owner is a 3rd party, that 3rd party is indeed allowed to combine the fixed ($/MW) revenue with a variable energy revenue ($/MWh) generated from participation in wholesale market. This ability to stack multiple revenue streams is a key enabler of BESS and makes 3rd party ownership more economically viable than direct ownership by a utility.[38]

2.4.2 Use 2: Ancillary services

To maintain reliable power system operations, the electricity system operator must ensure that generation exactly matches electricity demand and therefore that frequency, voltage, and power load remain within certain pre-defined limits. This does not happen automatically, but through continuous corrections: namely, ancillary services. There are various categories of ancillary services which function on different timescales, from sub-seconds to several hours. Traditionally the system operator used to centrally allocate ancillary services obligations on generators, and the demand volume for ancillary services used to be low.

[37] Information retrieved from CAISO's website. www.caiso.com
[38] Role of Policy in Development of Business Models for Battery Storage Deployment. A. Kumar, G. Shrimali, Stanford Sustainable Finance Initiative, Precourt Institute for Energy, 2020. Available at: energy.stanford.edu/sites/g/files/sbiybj9971/f/role_of_policy_in_development_of_business_models_for_battery_storage_deployment_-_the_california_case_study_working_paper_0.pdf

But the need to integrate a growing share of RES in the power mix tends to increase the volume of ancillary services needed. As a response to this increase in requirements and the need to procure ancillary services at the lowest cost, system operators in highly developed electricity markets started to procure ancillary services through competitive market mechanisms. This is the case in the UK and California, which operate an intra-day Ancillary Services Market (ASM). Chile is still in the early phases of opening its ASM.

Due to the ability to rapidly charge or discharge in a fraction of a second, BESS is uniquely suited to compete on the ASM and provide system operators with the services needed. In this context, important technical characteristics of BESS for this use case are:

- Rated power capacity, i.e. the total possible instantaneous discharge capability (in MW) or the maximum rate of discharge that the BESS can achieve, starting from a fully charged state.
- Energy capacity, i.e., the maximum amount of stored energy (in MWh)
- Storage duration, i.e., the amount of time storage can discharge at its power capacity before depleting its energy capacity. For example, a battery with 1 MW of power capacity and 4 MWh of usable energy capacity will have a storage duration of four hours.[39]

The ancillary services use case mostly concerns BESS with a high power and energy capacity and short storage duration, as the grid operator mostly needs short reaction times.

Procurement

Under this use case, there is no explicit procurement of BESS capacity. Instead, BESS capacity emerges in the free market as a response to the existence of potentially lucrative revenue streams which are open to a variety of technologies, including to BESS. Out of the three markets benchmarked here, the UK BESS market is most oriented to the ancillary services use case.

In the UK the ancillary services market, generators connected to the transmission and distribution networks or energy storage providers can offer:

- Firm Frequency Response (FFR) services, to balance fluctuations in grid frequency;
- Dynamic Containment frequency response (DC) service, which aims at delivering sub-second, post-fault response service.

[39] NREL, Grid-Scale Battery Storage - Frequently Asked Questions.

Firm Frequency Response services can be tendered on a defined frequency deviation agreed (non-dynamic frequency response) or can be continuously provided to manage the normal second-by-second changes on the system (dynamic frequency response) providing the response within 10 or 30 seconds of an event, and sustaining it for 20 seconds, 30 minutes or indefinitely.[40] The service is procured through a monthly or weekly tender process, once providers succeed in the pre-qualification assessment.

This process is slowly giving way to an innovative new service introduced in 2020, the Dynamic Containment, which is an ultra-fast balancing service procured in the day-ahead market requiring sub 1 second activation. The introduction of this service has been a key driver for an increase in BESS installations, as the revenue streams are attractive and the technical ability of BESS to response in short timeframes makes it able to withstand competition on this market.

Ownership structure

In a liberalized market context where ancillary services are procured via competitive market procedures, only independent parties are eligible to participate in market exchanges. This means that the ownership of BESS which provides the ancillary service must be in the hands of an IPP, a developer, a technology provider, and ESCO etc. The system operator is excluded from owning BESS or earning revenue on the provision of ancillary services.

Remuneration model

In fully functioning ASMs, remuneration for BESS providing ancillary services is purely market based. This means that BESS receive the revenues they are able to capture on the free market, with little to no long-term certainty.

In the specific example of the UK, the FFR service is procured in monthly & quarterly tenders or weekly auctions, where availability is remunerated on a pay-as-bid and while utilisation is on a pay-as-cleared basis. Dynamic Containment auctions follow a different mechanism: the framework includes 4-hour blocks, instead of 24-hours, with pay-as clear pricing. This has resulted in an increase in market opportunities for BESS, but at the same time it brought an increase in the volatility of service prices. Generally speaking, high volatility represents an earnings opportunity for BESS and especially in ancillary services markets, where prices can significantly exceed those on the wholesale market. But the prevalent market view is that this use case is unsustainable over the long term, as high profit levels lead to rapid market growth, and new entrants begins to cannibalise each other. There is some evidence that advanced markets are already starting to see a gradual

[40] Information retrieved from National Grid Electricity System Operator's website. Available here: https://www.nationalgrideso.com/industry-information/balancing-services/frequency-response-services/firm-frequency-response-ffr

loss of revenue from battery-related ancillary services.[41] Therefore, this use case is viable over the short and medium term, where early-moving BESS can capture considerable revenues but with a likely decline trend as new entrants join the market.

For the South African market which does not need a high volume of ancillary services, where the grid code does not add value for fast responding technologies, and where procuring such services via competitive mechanisms is likely to lead to suboptimal economic allocation due to low competition, this use case has limited applicability for the time being. A more suitable solution may be to explore this use case via pilot projects, which are capable to access also additional revenue streams to as to provide competitive pricing, as is being applied in Italy. The key difference of the Italian experience vs. the UK is the remuneration model: in order to provide an additional economic incentive to BESS, contracted units are remunerated via a fixed (MW) component via long-term contact, as well as a variable component received on the free market.

BOX 3. Italy: pilot projects in the ancillary service market

As a way of opening the Ancillary Services Market to new players, the regulator ARERA introduced (with Decree 300/2017/R/eel)[42] [43] a number of pilot projects designed to introduce new sources of dispatch capacity as below.

Pilot project UVAM (Virtually Aggregated Mixed Units), launched in November 2018, allows distributed resources (consumption and production units) as well as storage systems of as small as 1MW to participate, in an aggregated form, in ancillary services markets. The economic regulation of UVAM differs from that of large plants because it involves not only ordinary remuneration linked to energy activated (€/MWh), but also remuneration for resource availability (€/MW).

In another pilot project, in December 2020 Terna held an auction of fast reserve frequency response (response time under 1 second). Five-year contracts were awarded to around 250MW of BESS to provide fast reserve services, at an average weighted price of €29,500 / MW / year. Projects will be called on by Terna to provide the Fast Reserve frequency regulation for 1,000 hours per year from 2023-2027, but BESS assets will also be able to stack revenues from other available market opportunities such as reserves or wholesale markets.[44]

[41] Evaluación de las subastas de los servicios complementarios de reserva. BdE Spa, 2021. Available here: https://gpm-ag.cl/wp-content/uploads/2021/05/Estudio-SSCC-BdE-vf-002.pdf
[42] Arera, Deliberazione 5 Maggio 2017, 300/2017/R/EEL. Available here: https://www.arera.it/allegati/docs/17/300-17.pdf
[43] Information retrieved from Terna's website. Available here: https://www.terna.it/it/sistema-elettrico/progetti-pilota-delibera-arera-300-2017-reel/progetto-pilota-upi
[44] Batteries awarded five-year grid services contracts in Italy through low-price auction. A. Colthorpe, Energy Storage News, 2020. Available here: https://www.energy-storage.news/batteries-awarded-five-year-grid-services-contracts-in-italy-through-low-price-auction/

2.4.3 Use 3: Investment deferral

The electricity grid typically needs to be strengthened and upgraded to meet peak demand and / or integrate RES peak generation volumes. Meeting these needs can require sizable investments, even though peak demand and peak generation may only occur over a few hours of the year. BESS can help facilitate the integration of RES generation into the grid and reduce network congestion by acting as a source of demand to defer or avoid the need for costly network build. Thanks to its adaptability, BESS can be deployed at different points in the network to store excess power and meet load requirements during peak hours, reducing network congestion. Connecting BESS to the high voltage grid or in proximity of transformation stations also mitigates permitting / social acceptance issues, and the BESS asset can also be moved in case new network congestions need addressing. In cases where the BESS is located strategically, it would be capable of providing services for all 3 of our use cases.

This use case of BESS has seen particular prominence in Chile, where the high share of RES has already been causing negative prices and curtailment. The specific geography of the country aggravates this issue, as localized transmission constraints and broader grid bottlenecks are frequent. Partly in response to this grid issue, the 2017 regulation by CNE which defined the legitimate uses of BESS included its use as a transmission asset.[45] This was further formalized in the 2019 Supreme Decree 125 with a mechanism to incorporate BESS into the National Transmission Plan, aimed at reinforcing the high voltage network and expanding the zonal transmission system.[46]

To a certain extent this use case is also present in California, as the RA selection requirements (see Box 3) includes the need to procure local BESS capacity as a way to compensate for insufficient transmission capacity. The hypothesis of storage to be regulated as a transmission asset is undergoing a stakeholder consultation in CAISO and will be included in an updated version of the Energy Storage and Distributed Energy Resources and Resource Adequacy Enhancements work.[47]

Procurement

The Chilean energy commission (CNE) each year defines a network expansion plan and conducts public invitations to tender for the construction, operation and maintenance of the new transmission infrastructure required in the country, both in terms of national and zonal transmission. Project developers and private sector operators are free to propose projects, including BESS projects, to be included in the transmission plan.

[45] CNE 2017, Reglamentos de Coordinación y Operación - Sistemas de Almacenamiento. https://www.cne.cl/wp-content/uploads/2017/08/Mesa-N%C2%B0-2-Reglamento-Cy-O-Sistemas-de-Almacenamiento-1.pdf
[46] See Article 90 and 91 of Decreto 125 as Decreto 37 Aprueba Reglamento De Los Sistemas De Transmisión Y De La Planificación De La Transmisión. https://www.bcn.cl/leychile/navegar?idNorma=1160108
[47] Source: CAISO https://stakeholdercenter.caiso.com/StakeholderInitiatives/Storage-as-a-transmission-asset

In 2020, the IPP AES Gener submitted to CNE a proposal for two 200 MW BESS projects to be included in the National Transmission Expansion Plan, in a specific location where 700 MW of RES generation is set to come online on an already constrained transmission corridor. As of 2022, the Transmission Plan does not include any BESS projects, but there is no formal barrier to that being the case in the future.[48] If and when such an inclusion of a BESS project in the Transmission Plan occurs, the procurement process would include a standard tendering procedure for infrastructure assets.

Ownership structure

In Chile's liberalized market context, transmission assets of any type – including BESS – are owned by private entities. There are some limits to vertical integration, whereby the participation of generators and distributors in the national transmission segment cannot exceed 8% of the total value of the country's transmission assets (or 40% if more companies own together more assets).[49] At any rate, the system operator is an independent actor and is therefore not allowed to own and / or earn market revenues on transmission assets, including BESS.

In other markets such as California and Italy (see Box 4), the system operator may own BESS assets but they are remunerated on a cost-of-service basis, and may not earn market revenue (e.g. from arbitrage trading).

Remuneration model

In the use case where BESS is used as a transmission asset to defer grid investments, its remuneration is based on the regulated asset model. Remuneration is set by the National Energy Commission every four years according to a methodology designed to ensure that owners of the transmission asset recover the costs of capital, operation, maintenance, and administration, plus a profit level which the commission deems to be a fair value – currently set at between 7% and 10% after taxes.[50] An alternative remuneration mechanism for projects providing network support services are capacity payments. A key feature of this use case is that BESS owners receive long-term certainty over their asset's future revenue stream, which is fixed and not subject to spot market volatility.

[48] The latest Transmission Expansion plan was published in January 2022. https://www.coordinador.cl/wp-content/uploads/2022/01/Informe-PET-enero-2022.pdf
[49] Energy Projection and Opportunities in Chile. InvestChile, bnamericas, 2021. Available here: https://investchile.gob.cl/wp-content/uploads/2021/04/03ebook-energia-eng-.pdf
[50] Thomson Reuters, Practical Law. https://uk.practicallaw.thomsonreuters.com/w-019-3060?transitionType=Default&contextData=(sc.Default)&firstPage=true

BOX 4. Italy: innovative grid upgrade deferral projects

The rapid growth of variable RES in Italy left insufficient time to strengthen and expand the transmission and distribution network, and the country has seen a high degree of localized grid congestion. To address the issue, the 2011 Grid Development Plan of Terna, Italy's TSO, introduced the **Large-Scale Energy Storage projects** which use BESS connected to the high-voltage grid to reduce VRE curtailment and solve grid congestion.[51]

In a competitive auction won by NGK of Japan, Terna awarded the construction of three grid-scale sodium sulphur (NaS) batteries with a total capacity of 34.8 MW/250 MWh in the south of the country. The batteries are characterized as "energy intensive", i.e. high storage capacity and a duration of 8 hours which is optimized for long periods of congestion. The aim was for the batteries to store wind energy that would otherwise have been curtailed due to transmission congestion. The stored energy was then transported to northern parts of the country whenever transmission lines were not congested.[52]

Terna remains a 100% owner of the assets. The remuneration of the assets was regulated by a special regulatory act (Delibera ARERA 288/12/R/EEL), whereby any pilot project included in the transmission development plan (and subsequently approved by an Expert Commission) can stack two remuneration streams. The first is the standard remuneration of a CAPEX investment in a RAB / WACC mechanism, while the second is an additional incentive of a 2% return on top of the CAPEX invested over the 12 years of the asset lifetime. The additional return is made conditional upon the reaching of at least 50% of the forecasted RES curtailment reduction target which had been set by Terna at the onset of the project.[53]

[51] Source: Terna https://www.terna.it/en/electric-system/system-innovation/pilot-storage-projects
[52] Virtual power lines, International Renewable Energy Agency, Abu Dhabi. IRENA, 2020. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Virtual_power_lines_2020.pdf?la=en&hash=C58043124D596D1CF75395066817C38B55AC1983
[53] Delibera 288/12/R/EEL https://www.arera.it/allegati/docs/12/288-12.pdf

2.5 Other considerations for BESS: Environmental requirements

Environmental requirements for utility-scale BESS may concern the identification of suitable locations for the project deployment, safety requirements for hazards avoidance (e.g. fire, thermal runway, explosive, chemical and toxic leaks etc.) and asset end-of-life (e.g. circularity, reuse, repurpose and storage of used batteries). Existing regulation for BESS in the benchmarked markets (Chile, UK, California) are not at the level of maturity needed to be considered as best practices. For this reason, we expanded the scope of our research to the analysis of international guidelines for BESS. Table 6 provides an overview of main international guidelines concerning BESS environmental standards and requirements.

Table 6: International standards on BESS environmental requirement

Guideline	Description	Country/countries considering the standard/regulation
ANSI/CAN/UL 1974	Evaluation for repurposing batteries	Under standardisation evaluation within EU legislation, approved by ANSI and SCC
IEC 62619:2017	Safety requirements for secondary lithium cells and batteries, for use in industrial applications.	Under standardisation evaluation within EU legislation
SAE J2950, SAE J2997	Standards for Battery Secondary Use	Under standardisation evaluation within EU legislation
EN 50272-3:2002	Safety requirements for secondary batteries installations.	Under standardisation evaluation within EU legislation
IEC 62933	Safety requirements for grid-integrated EES systems (including BESS)	Under standardisation evaluation within EU legislation
IEC 62485	Safety requirements for secondary batteries and battery installations	Under standardisation evaluation within EU legislation
AUS/NZ 5139	Installation and safety requirements for BESS	Australia and New Zealand
NFPA 855	Minimum requirements for mitigating hazards associated with the Stationary energy storage system (including BESS)	US States (es. New York State, Michigan State)

2.5.1 Identification of BESS suitable locations

The identification of a BESS suitable location is affected by different factors including the presence of inhabitants in the area, system components, natural environment, properties and structures, and other external influences (see IEC 62933 Part 5.1 § 6.2.4; AUS/NZ 5139 § 4.2.2). The surrounding environment represents both a factor of risks and an element to be safeguarded in BESS project planning and development. In particular, the natural environment poses a variety of risks that should be taken into account when considering the location of a BESS projects, including extreme weather conditions (e.g., ambient temperature and humidity, frost, wind, snow, fog), landslides, earthquakes, lightning and flooding (see IEC 62933 Part 5.1 § 6.2.6; AUS/NZ 5139 § 4.2.2.1). Under NFPA 885, BESS location requirements shall comply with minimum distance requirements of ten feet from lot lines, public ways, buildings, stored combustible materials, hazardous materials, high-piled storage, and other exposure hazards.

Additionally, NFPA 855 classifies BESS projects by either:

a. "remote locations" (i.e., more than 100 feet (30.5m) away from buildings and other hazards not associated with electrical grid infrastructure); or
b. "locations near exposures" (i.e., less than 100 feet (30.5m) away from buildings and other hazards not associated with electrical grid infrastructure).

2.5.2 Guidelines for BESS end-of-life

NFPA 855 and IEC 62933 (Part 5-2 § 7.13.4) provide general guidance for the dismantling of BESS equipment and the end of its service life, including specific BESS end-of-life provisions regarding qualifications for entities engaged in repurposing used battery equipment, and the reconditioning and testing of such materials, equipment and devices (NFPA 885 § 4.2.10). Chapter 14 of NFPA 855 provides explicit requirements for the storage of used or off-specification batteries, including the areas where they may be stored, collection locations, storage methods, and special requirements for indoor versus outdoor locations.

More detailed decommissioning requirements are also set forth in NFPA 855 Section 8.1 which covers the removal of the system from service and from the facility in which it is located and information on disposal of materials associated with each ESS, including requirements for decommissioning plans, decommissioning processes, and decommissioning reports.

2.5.3 BESS Best practices: key messages for South Africa

Each of the markets selected for this benchmarking manifests similar outcomes in terms of high volumes of BESS installation. Yet they have vastly different starting points in terms of market design and drivers, which contributed to the rise of BESS and approach to BESS use cases.

A key lesson learned on **market design** is that full unbundling of the electricity system is not a precondition to ensure the success of BESS deployment: California's hybrid market model where IPPs coexist with vertically integrated local monopolies has been positive for BESS development. However, having in place transparent market price mechanisms – e.g. a wholesale electricity market, including where negative prices are allowed to occur provides a vital price signal and economic incentive for the installation of BESS. Having an ancillary services market also provides an important additional revenue stream for BESS.

Out of the three **use cases** examined here, ***Use Case 1 – Energy and capacity services*** is considered most attractive for the South African context, especially the use of BESS for arbitrage. A key success factor for this use case is to have appropriate electricity price signals and a market where electricity can be traded. While achieving a deep and highly liquid wholesale market may take years, Chile provides a good example of a wholesale market which, without high degrees of financial sophistication, and which provides required price signals (including negative prices) and BESS incentives. ***Use Case 3 – Investment Deferral*** could have some application in localized grid congestion nodes. ***Use Case 2 – Ancillary Services*** could be a long-term option for South Africa but is not applicable in the current market context.

The most transferable **procurement model** for South Africa is Chile's approach to electricity auctions, which in theory are technology neutral in their design, but in practice provides an implicit incentive for bidders to present a RES + BESS offer. Their key design element is supply block pricing, whereby winning bidders are awarded a PPA for specific delivery volume for each hour block, and any difference between generated and contracted volumes must be settled on the spot market. The ability to store excess generation and then deploy it in hours of under-generation helps bidders mitigate the price risk associated with exposure to the spot market. California's command-and-control approach to BESS procurement provides an additional, if different, best practice on procurement. In the context where the system operator's aim was to increase system adequacy, imposing an explicit mandate on utilities to procure a given volume of BESS capacity served to meet that policy goal.

It is difficult to speak of best practices on **ownership models**, as ownership of BESS tends to reflect pre-existing ownership structures and market design which are prevalent in each host market. In fully liberalized markets such as the UK and Chile, network operators are not allowed to engage in market activities and only IPPs, utilities or developers, are allowed to make returns on wholesale markets. California presents an interesting hybrid model which may be applicable to South Africa: in order to meet their Resource Adequacy obligation, utilities have been seen to lease BESS from IPPs or 3rd parties in exchange for a fixed capacity charge, while the IPP maintains ownership. This allows the IPP to stack revenues from Resource Adequacy with those from arbitrage and ancillary services trading; this practice of revenue stacking would not be allowed if the owner of the BESS asset were to be the regulated utility.

Remuneration models can differ vastly depending on the use case. An ideal remuneration structure is seen in the UK capacity market and Italy's ancillary services pilot projects, whereby BESS receive a fixed (€/ MW) long-term payment able to reduce investment risk and stimulate bankability, in combination with a variable (€ /MWh) payment able to make the economic case of investing more attractive. The economic case for BESS can also work with only the variable component and without having long-term certainty, but only in cases where the variable component is highly lucrative – as is the case with ancillary services market trading in the UK and California. Use case 3 – Investment deferral offers a different approach to remunerating BESS, based on regulated asset returns and without any exposure to market pricing mechanisms.

Another success factor for BESS is the ability to stack different revenue streams. For example, a battery providing capacity services is technically also able to provide energy arbitrage, transmission congestion relief and ancillary services, depending on which of these streams is more economically attractive in any given moment. The UK provides an interesting example as BESS capacity contracted in the capacity market can also participate in the ancillary services market, thus allowing it to maximise the value of their assets.

3. Overview of regulatory framework for BESS in South Africa

Renewable energy is still at low levels of market penetration in South Africa and well below the capacities needed to eliminate load shedding and address South Africa's widening electricity supply gap. It is proposed that this is largely not due to technology limitations or investment appetite but rather due to the exclusionary effect of historic and existing energy laws and regulations, which were developed to support a centralized and vertically integrated energy system. It is arguably a lesser challenge for renewables to overcome economic barriers, than it is for these renewable and BESS technologies to overcome legal and institutional obstacles that have little to do with the sustainability potential of renewables.

Moreover, the application of BESS technologies has also suffered as a result of ineffective renewable energy regulation. Direct legal regulatory intervention has become urgent in view of South Africa's electricity supply deficit. Climate change, security of supply concerns, corruption and Eskom's monopoly are all elements that justify the need for the opening of the electricity supply industry to the private sector beyond the scope of the REIPPP Programme. Policy and political pronouncements on opening the market, unbundling Eskom and a roadmap to rescue Eskom would need to be supported by effective targeted legal intervention to increase renewables and BESS applications in South Africa.

It is considered that existing legal frameworks and recent regulatory reforms provide significant latitude for BESS uptake, even though such support is largely implicit. The laws and policies in relation to BESS deployment are discussed below:

Although current regulations don't prevent BESS uptake, little to no guidance is provided as to "how" BESS applications will be supported. Leveraging the provisions of existing legislation, such as section 19(1) of the National Energy Act that allows the Minister of Mineral Resources and Energy to publish BESS specific Regulations can bring about tremendous development opportunities for BESS. Such a set of Regulations would in turn support BESS provisions currently set out in existing developmental policy such as the IRP and IEP. However, it is clear that the existing laws and policies also present BESS with regulatory barriers that would need to be overcome in order for BESS to truly become a commercially viable option for South Africa.

Law or Policy applicable to BESS	Relevance of law or policy to BESS
National Energy Act 34 of 2008	The National Energy Act is South Africa's overarching piece of legislation regulating the energy sector. Section 5 of the National Energy Act imposes a duty on the Minister of Energy to promote access to affordable, sustainable, and environmentally suitable energy and energy services to all people. The Act requires the Minister, in consultation with the Minister of Trade and Industry, the Minister of Labour and the Minister of Environmental Affairs, to "*adopt measures not contemplated in any other legislation, to minimise the negative safety, health and environmental impacts of energy carriers*." Section 19(1) of the National Energy Act provides a legal mechanism to introduce a set of regulations specifically aimed at promoting and regulating renewable energy, and by extension BESS applications: *"The Minister may, after consultation with those Cabinet Ministers whose areas of responsibility will be affected by the proposed regulations, without derogating from his or her general regulatory powers, by notice in the Gazette* ***make regulations*** *regarding…* *(d)* ***minimum contributions*** *to national energy supply* ***from renewable energy sources.*** - This provision allows the government to publish procurement capacities of renewables which would require the procurement of corresponding BESS capacity in order to stabilise the variability associated with the BESS. *(e) the* ***nature of the sources*** *that may be used for renewable energy contributions to the national energy supply.* - This provision enables the government to specify which renewable energy technologies they would procure electricity from. As done in the RMIPPPP bidding windows, this provision will also allow the government to procure BESS technologies as a technology pairing mechanism.

Law or Policy applicable to BESS	Relevance of law or policy to BESS
National Energy Act 34 of 2008	*(f)* ***measures and incentives*** *designed to promote the production, consumption, investment, research and development of renewable energy* - This provision allows the government to leverage renewable energy incentives to increase investment in BESS. *(h) steps and procedures necessary for the* ***application of energy efficiency technologies and procedures*** - This provision allows the government to introduce administrative procedures related to the implementation of BESS technologies. Such provisions will increase investor confidence in South Africa's ability to implement BESS technologies. *(m)* ***holding of strategic energy feedstocks*** *and carriers, including financing mechanisms for such stocks* - This provision will allow government to introduce provisions that will enable the grid to access strategic energy feedstocks stored at BESS applications and also introduce financing mechanisms specifically aimed at increasing the commercial feasibility of BESS. *(q) measures to* ***promote security of supply through access to common infrastructure by any party****, where not provided for under any other legislation* - This provision will allow government to introduce mechanisms whereby BESS owners will be able to access transmission and distribution infrastructure in order to supply electricity to consumers. Additionally, it allows BESS to participate and be classified as a transmission asset in the future. *(s) the safe, healthy and sustainable use of energy, standards and specifications not elsewhere legislated or regulated, for… (vi)* ***the storage and packaging of energy carriers*** - This provision relates to the introduction of standards and specifications directly linked to BESS applications and must be leveraged in order to introduce the necessary health, safety and environmental standards for BESS which are currently absent in the South African regulatory framework.

Law or Policy applicable to BESS	Relevance of law or policy to BESS
National Energy Act 34 of 2008	Considering the provisions above and the opportunities that BESS presents, the government should consider introducing a set of regulations specifically aimed at promoting BESS applications in South Africa. Such a set of regulations should specifically be focussed on 3 aspects: 1. BESS applications as a mechanism to reduce renewable energy variability; 2. Standards and procedures for the deployment, operations and decommissioning of BESS applications; and 3. Incentives to spur investment BESS applications.
Electricity Regulation Act 4 of 2006	Although the promotion of renewable energy and BESS is not explicitly mentioned in the objects of the Act, there are implicit references that can support the argument for increased renewables in the country's energy mix, which will inevitably require the deployment of commensurate BESS capacity. This is evident when considering the references to sustainability and the acknowledgement that the interests of future electricity customers must be considered. The Act aims to "promote the use of diverse energy sources and energy efficiency". A 2011 Amendment Bill proposed to amend this act to add expressly that this object would be to promote the use of "diverse sources of energy, renewable energy sources, and energy efficiency", but the Bill was never passed. Section 34 of the Act gives effect to the energy diversification objective of the Act and empowers the minister of Mineral Resources and Energy to issue determinations, in line with the capacity provisions set out in the IRP, to procure energy from different generation sources. This includes the procurement of renewable energy and BESS capacity provided for the IRP.

Law or Policy applicable to BESS	Relevance of law or policy to BESS
Electricity Regulation Act 4 of 2006	Section 46(1)(b) is one of the key enabling provisions underpinning the drafting and revisions of the IRP and provides that the Minister may determine which types of energy sources may be procured and the percentages of electricity that must be generated from such sources. This enables the Minister to make determinations specifically aimed at procurement of renewable energy and could be leveraged to also require renewable energy capacity to be paired with BESS capacity as part of the renewable procurement requirements. In October 2020, the Minister of Mineral Resources and Energy published an amendment to the Electricity Regulations on New Generation Capacity published under the Electricity Regulation Act. The amendment allows municipalities to apply to the Minister to procure or buy new generation capacity in accordance with the Integrated Resource Plan, subject to certain conditions.[54] This provision is a fundamental change in the existing municipal electricity procurement model and provides a regulatory platform for municipalities to not only procure renewable energy directly from IPPs, but to build BESS capacity requirements into energy procurement processes. However, a serious flaw in this legal regime is that it makes energy procurement entirely dependent on ministerial discretion in making determinations. It is doubtful if this was the intention of the law maker. This implies that private sector investors, other spheres of government (such as metropolitan municipalities) and large corporates wanting to generate electricity cannot do so unless there is a determination. A further flaw of section 34 of ERA is that the energy regulator's (NERSA) power to issue a generation licence is subject to ministerial consent. In other words, the minister, rather than the regulator, has de facto control over who can enter the electricity market and using what sources.

[54] See regulation 5(3) that provides that: "A municipality, as an organ of state, may apply to the Minister to procure or buy new generation capacity in accordance with the Integrated Resource Plan, and such municipality must-
(a) conduct and submit a feasibility study as contemplated in sub-regulation (2), where it intends to deliver the new generation capacity project through an internal mechanism as contemplated in section 76(a) of the Municipal Systems Act:
(b) submit proof that it has complied with the provisions of section 120 of the Municipal Finance Management Act and the Municipal Public-Private Partnership Regulations published by Government Notice No R. 309 in Government Gazette No. 27431 of 1 April 2005, where it intends to deliver the new generation capacity project through an external mechanism as contemplated in section 76 (b) of the Municipal Systems Act, and
(c) submit proof that the application is aligned with its Integrated Development Plan."

Law or Policy applicable to BESS	Relevance of law or policy to BESS
Electricity Regulation Amendment Bill of 2022	On 10 February 2022, The South African government published the proposed Electricity Regulation Amendment Bill. The proposed amendments broaden the national regulatory framework for the electricity supply industry. They aim to establish a wholesale electricity market in line with international best practice and provide for the establishment and functions of a Transmission System Operator. The proposed amendments form part of several steps the country is taking to reform the electricity sector towards achieving a stable and secure supply of energy. The Bill is yet to be finalised and promulgated, but its provisions will result in a significant paradigm shift for the country's energy sector. The following key amendments are relevant to the development of the BESS industry. • The Bill specifically makes provision for the procurement of ancillary services meaning,[55] "services necessary to support the continuous and secure operation of electric power system and necessary to maintain reliable operations of the interconnected power system, including, but not limited to, those services necessary for voltage and reactive power control, automatic generation control, frequency control and black start capabilities." This implicitly promotes the deployment of BESS to provide ancillary services, however it must be noted that Eskom's Ancillary Services Technical Requirements for 2022/23 – 2026/27 explicitly excludes BESS and renewable energy technologies as viable options to provide ancillary services. As such, for the proposed ancillary services provision provided for in the Bill to be effective in relation to BESS and renewables, Eskom would have to amend their Ancillary Services Technical Requirements to allow BESS and renewable energy technologies to be considered as ancillary services options.

[55] See section 31(4)(c) and (e).

Law or Policy applicable to BESS	Relevance of law or policy to BESS
Electricity Regulation Amendment Bill of 2022	• The Minister of Public Enterprises will establish a juristic person to be known as the Transmission System Operator SOC Ltd in order to provide for an open market that will allow for a non-discriminatory competitive electricity trading platform.[56] Market participants will trade energy based on regulated and bilateral agreements in the day ahead market. Furthermore. the Bill provides that "Market participants will supply reserves in the day ahead reserve market and Balance Responsible Parties will trade physicals after the day ahead market closing with one another to account for changing circumstances." – This provides an opportunity for BESS capacity to enter the market and for BESS owners to purchase surplus energy after-market closure at the end of each day. In such a case, energy arbitrage would be possible whereby BESS owners would be able to purchase surplus electricity at lower rates at closure of the market and sell the electricity back into the market at a later stage, for a higher tariff. • *Schedule 2 of the Bill exempts generation Facilities with energy storage to be registered or licenced with NERSA, only if such facilities are used to provide standby or back-up electricity in the event of, or for a duration no longer than, an electricity supply interruption.* – This provision therefore specifically aims to reduce the administrative burden in the events where BESS applications are adopted as a means to provide electricity during planned and unplanned electricity outages. • *Schedule 2 of the Bill exempts generation Facilities with energy storage to be licenced with NERSA where the facility has a capacity of no more than 100 MW with a Point of Connection on the transmission or distribution power system.* – This provision minimises the administrative burden for renewable energy project developers and enables them to build renewable energy plants paired with BESS without the risk of electricity curtailment.

[56] See section 30(1).

Law or Policy applicable to BESS	Relevance of law or policy to BESS
Integrated Energy Plan	The IEP aims to guide future energy infrastructure investments, identify, and recommend policy development to shape the future energy landscape of the country. It is an overarching plan that informs the development of future energy sector roadmaps, i.e., for security of supply (liquid fuels and electricity) and for diversity of supply (coal, gas and renewable energy. South Africa's IEP specifically promotes the opportunities related to BESS applications. The IEP states that: "Solar PV and CSP with storage present excellent opportunities to diversify the electricity mix, to produce distributed generation and to provide off-grid electricity. Solar technologies also present the greatest potential for job creation and localisation. Incentive programmes and special focused programmes to promote further development in the technology, as well as solar roll-out programmes, should be pursued."
Integrated Resources Plan of 2019	The IRP does promote the increased uptake of energy storage applications and provides that: "taking into account the longer gas infrastructure lead time, the power system selects more energy storage. This can be expected, given the extent of the wind and solar PV option in the IRP." The IRP has allocated a total of 2088MW of storage up to 2030 as part of South Africa's energy mix, with 513MW being allocated for operation by 2022 and the remainder of 1575MW to be operational in 2029. A significant change introduced by the Electricity Regulation Amendment Bill 2022 allows the Minister of Energy to publish a section 34 determination that deviates from the Integrated Resource Plan or Transmission Development Plan in an emergency or if it is necessary to do so in the national interest. This means that the capacity provisions outlined in the IRP can be ignored in the event of an emergency or if it is in the national interest and therefore allows BESS applications to be procured at far greater capacities to address the peak capacity constraints faced by the country.

Law or Policy applicable to BESS	Relevance of law or policy to BESS
Integrated Resources Plan of 2019	Furthermore, the IRP provides that: "Storage technologies including battery systems, compressed air energy storage, flywheel energy storage, hydrogen fuel cells etc. are developments which can address this issue (variability and intermittency), especially in the South African context where over 6 GW of renewable energy has been introduced, yet the power system does not have the requisite storage capacity or flexibility." It is clear from the provisions in the IRP that the government considered BESS applications to be an integral part of the energy transition, however, as explained above, the capacity limitations set out in the IRP restricts the BESS industry to grow and compete at the levels necessary to become a commercially viable option for South Africa.
White Paper on Renewable Energy of 2003	The White Paper does implicitly support the increased uptake of BESS technologies and provides that: ***"Research and Development into cost effective energy storage systems utilising renewable energy will be encouraged."*** Thus far, the government has not supported and funded the research required to encourage investment and deployment of BESS technologies at the scale required to address South Africa's electricity crisis.
Independent System and Market Operator Bill of 2012 (ISMO)	The aim of the Bill was to establish an Independent System and Market Operator (ISMO) as a state-owned entity to ensure the independent operation of the electricity sector and to ensure safe, secure, and efficient operation of the integrated power system, trading of electricity at wholesale level. Under the Bill, the ISMO would be a buyer of power from electricity generators in a transparent manner and promote efficiencies within the electricity value chain. As BESS is considered a generation asset in the South African context, the ISMO Bill would only support the uptake of BESS as far as storage is provided for in the IRP as it requires that it (ISMO) "buys electricity from a generator or external trader in line with Government policy."

Law or Policy applicable to BESS	Relevance of law or policy to BESS
Independent System and Market Operator Bill of 2012 (ISMO)	When considering the provisions of the Electricity Regulation Amendment Bill of 2022, it is clear that many of the provisions of the ISMO Bill were kept, or informed the design of the Amendment Bill. Key features of the ISMO Bill, such as the establishment of a wholesale electricity market and the role of the ISMO as the buyer of power from electricity generators, has been kept, and would benefit the development of the BESS industry.
Independent Electricity Management Operator Bill 2019 (IEMO)	The Independent Electricity Management Operator Bill (IEMO) builds on the foundation laid down by the ISMO Bill. The Bill was introduced to parliament in 2019, but never received the support needed to go beyond the initial parliamentary introduction. The Independent Electricity Management Operator relies on two crucial aspects: • **INDEPENDENCE** – where electricity generation and distribution are separated. • **ELECTRICITY MANAGEMENT FOCUS** – The Bill creates a separate entity governing the buying and selling of electricity that does not have a stake in production. Similar to the limitations of the ISMO Bill, the IEMO Bill would only support the uptake of BESS as far as storage is provided for in the IRP as it requires that the procurement of energy be "consistent with the Integrated Resource Plan and in terms of procurement processes contained in the Electricity Regulation Act".

4. Gap analysis between the current South African scenario and the "to-be" scenarios:

Based on South Africa's existing energy landscape as discussed above, the following section aims to identify disparities between South Africa's existing legal framework and the benchmark practices outlined in the case studies of chapter 2.

4.1 Market design overview

Eskom and its monopoly in the South African electricity sector has been the subject of debate in South Africa for over a decade. Although it is forecast to be reformed, Eskom currently still operates as a vertically integrated monopoly. This means that it performs the generation, transmission, distribution, and retail functions in relation to electricity. This differs fundamentally from the market designs in the benchmark countries and limits the ability of BESS to participate in the electricity market, as has been the case in the benchmark countries.

Country	BESS Best practice identified	Possible adoption in South Africa?	Gap in the South African context
CHILE	The deregulated energy market and the large amount of IPPs in Chile makes it possible for IPPs to generate sufficient electricity to be sold directly to utilities and large-end consumers. IPPs are therefore able to participate in the spot market without resorting to the long-term contracts that the system operator (Comisión Nacional de Energía -CNE) tenders out. This creates the ideal opportunity for BESS applications to be adopted as part of the IPP's generation offering	No	The current centralised regulated market in South Africa makes abundant IPP participation seen in Chile impossible. IPP participation is subject to ministerial determinations provided for in the Electricity Regulation Act and the generation capacity limits as set out in the Integrated Resource Plan. This makes the adoption of BESS subject to similar regulatory constraints faced by renewable energy generators. In the event that the Electricity Regulation Amendment Bill is passed, a similar model could be considered for South Africa, due to the enabling regulatory environment created by the Bill.
CALIFORNIA	The California Community Choice Association's (CCA) mission is to create a legislative and regulatory environment that supports the development and long-term sustainability of locally-run Community Choice Aggregation electricity providers in California. Through CCA, communities can purchase renewable electricity on behalf of residents and businesses and thereby enable them to meet local climate change goals and support the development of the renewable energy industry.	Yes, short term	California's community choice aggregators (CCAs) system provides an interesting model for South Africa to explore when considering the constitutional responsibility of municipalities to provide electricity reticulation services to their residents and the recent announcement by President Cyril Rhamaphosa that enables municipalities to procure new generation capacity directly from IPPs. A model similar to California's CCA, would allow municipal residents to provide input towards the type of electricity that they would want to consume, thereby providing a mechanism for residents to opt for renewable energy and BESS applications instead of fossil fuel-based generation. The provisions create a regulatory mechanism that has the potential to result in increased renewable energy deployment and would enable municipalities to require that BESS applications be paired with the renewable energy that they procure as a matter of municipal procurement policy.
UNITED KINGDOM	The UK's unbundled energy industry and wholesale market with 30-min interval intraday capabilities, makes the UK model an ideal platform to introduce BESS capacity into the electricity system at short notice.	No	South Africa does not have a wholesale energy market and is still reliant on PPAs as the most independent method of procuring electricity. This limits the ability of BESS technologies to be used to provide a quick response solution during circumstances where the electricity grid is severely constrained.

Governments across the world have come to the realisation that they do not need to be the provider of energy services. Unlike the reigning circumstances in South Africa, other governments realised that they can achieve their national targets by ensuring that services are delivered rather than providing the services themselves. From the analysis above, it is clear that the liberalised or semi-liberalised electricity markets have created the ideal circumstances for BESS applications to form a key component of electricity markets seeking to decarbonise. As such, the partial liberalisation of the South African electricity market will be required to create a more conducive market environment for BESS deployment. This will also enable the government to introduce incentives and regulations aimed at supporting BESS within a wholesale electricity market, as envisioned by the Electricity Regulation Amendment Bill.

KEY MESSAGE: In the markets where restructuring and liberalisation has taken place, it has provided BESS applications with a platform to participate in competitive wholesale electricity markets. As such, optimal uptake of BESS has been achieved in circumstances where semi-or- fully liberalized electricity markets exist.

4.2 BESS Use cases

As stated above, there are three broad use cases that have resulted in the most significant uptake of BESS applications in the benchmark countries. These use cases include capacity services (peak capacity), ancillary services and investment deferral. The benchmark practices, as well as their applicability and relevance to South Africa's energy circumstances are discussed below.

Use 1: Peak capacity (capacity provision)

South Africa has experienced contrasting energy demand scenarios in the past. For example, in April 2020, Eskom communicated their difficulty in managing up to 9GW of excess power due to a decrease in electricity demand as a result of the Covid-19 lockdown measures the country put in place. In an effort to manage grid stability, Independent Power Producers were issued with energy curtailment notices from Eskom that advised IPPs that, during certain times, the power they produced would not be utilised nor paid for by the utility, until the energy demand returned to normalised levels. Contrastingly, four months prior to the curtailment notices being issued, Eskom was expecting constrained supply capacity and announced Stage 6 load shedding measures to reduce demand pressure and to prevent the grid from collapsing. During the load shedding implementation windows and peak demand periods,

Eskom is often forced to make use of their Open Cycle Gas Turbines to supply electricity. The units are powered by Fuel oil (Diesel). They are intended to supply electricity into the National Grid during peak hours and emergency situations. Each open cycle gas turbine, which generates 150 megawatts of energy, costs Eskom R500,000 per hour and there are currently 20 turbines. The volatility of South Africa's energy supply scenario reinforces the need to increase the amount of renewable energy and BESS capacity in the system in order to address the electricity supply gap the country is currently facing.

Country	BESS Best practice identified	Possible adoption in South Africa?	Gap in the South African context
CHILE	Chile's block auction system aims to secure energy supply during high demand periods by allowing bidders to bid based on time-differentiated supply blocks. This provided an implicit incentive for bidders to present combined RES + BESS bids, as storage capacity allows RES plants to offer low prices even in those time slots where the RES asset does not generate electricity.	Yes, short term	As mentioned above, South Africa's REIPPP programme allowed Concentrated Solar Power bidders to submit a "base price" which was then adjusted upwards or downwards according to the time of day that the project's energy is delivered. During high demand scenarios, bidders could earn 270% of the base price. Therefore, similar provisions could be introduced for BESS in South Africa in order to incentivise project developers to meet peak demand "blocks" on the grid.
CALIFORNIA	California uses BESS largely for grid reliability purposes through the Resource Adequacy program (System Capacity during peak load hours and local capacity). In the 2018 decision D.18-06-030, the CPUC allowed combined storage and demand response projects to be eligible to participate in the Resource Adequacy program, which provided a key impetus for utilities (primarily Investor Owned Utilities and Community Choice Aggregators) to meet their Resource Adequacy requirement via battery storage.	Yes, short term	South Africa does not have any mechanism similar to the Resource Adequacy program nor entities similar to Investor Owned utilities. Currently, South Africa relies on gas peakers to provide sufficient electricity when the grid is constrained. The possibility exists to require municipalities to procure a certain amount of electricity from BESS applications, similar to the approach followed in California.
UNITED KINGDOM	BESS applications are currently eligible to participate in Capacity Market auctions to cope with times of stress on the network, whereby generators are paid – via a long-term contract – to ensure they are available to deliver energy in case they are called to do so by the system operator.	Yes, short term	Currently, South Africa does not have the necessary systems in place that would enable BESS to be a supplier of capacity when the grid is constrained. However, similar provisions to that of the UK in South Africa, and the introduction of reliable long-term offtake agreements would boost investor sentiment and encourage participation in the South African BESS sector.

Use 2: Ancillary services

In South Africa, ancillary services are largely performed or controlled by Eskom. Each reserve category forming part of South Africa's ancillary services has its own requirement and is exclusive, meaning that capacity reserved for one category cannot be used for another category. The utility defines and categorises ancillary services into the following categories:

- **Instantaneous Reserves**: Instantaneous reserve is generating capacity or demand side managed load that must be fully available within 10 seconds to arrest a frequency excursion outside the frequency dead-band. This reserve response must be sustained for at least 10 minutes. It is needed to arrest the frequency at an acceptable level following a contingency, such as a generator trip, or a sudden surge in load. Generators contracted for instantaneous reserve are also expected to respond to high frequencies (above 50.15 Hz) as stipulated in the South African Grid Code.
- **System restoration reserves**: System restoration services are those services that are required in the unlikely event of a failure of the multiple system defence barriers protecting the system from a blackout. These services (i.e., unit islanding and black-start) form part of the national system restoration plan. Currently, Eskom has decided that renewables and battery energy storage will not be considered for black-start until such time that the grid-forming inverter technology reaches maturity in a restoration context. Eskom has also confirmed that battery energy storage will not be considered for unit islanding certification.[57]
- **Reactive Power Supply and Voltage Control**: Renewable power plants are required to be equipped with reactive power control functions capable of controlling the reactive power supplied by the IPP at the point of connection as well as a voltage control function capable of controlling the voltage at the POC via orders using set points.
- **Constrained Generation**: The System Operator manages real-time system constraints within safe operating limits, using constrained generation as one of the ancillary services as required. In particular, it requires multiple outages of a credible nature to be studied to ensure that the operation of the system protects against cascading outages for such an event, wherever practical.

[57] Ancillary Services Technical Requirements for 2022/23 – 2026/27.

Country	BESS Best practice identified	Possible adoption in South Africa and associated timeframe?	Gap in the South African context
CHILE	In order to support the procurement of ancillary services, Chile's hybrid pricing model ensures an economically efficient manner of procuring ancillary services whereby uncompetitive market conditions would lead to the assignment of ancillary services directly from an electricity generator using an efficient cost-study remuneration model. Contrastingly, competitive conditions would lead to an auction for ancillary services.	Yes, medium term	South Africa's procurement of ancillary services is regulated and without adequate compensation, BESS projects lack the revenue opportunity to make BESS projects viable. In order to create a competitive ancillary services market for BESS similar to Chile's system would require Eskom to update its Ancillary Services Technical Requirements to allow for BESS to be considered for instantaneous reserves and system restoration services.
CALIFORNIA	California uses battery storage for reliability purposes, so large-scale battery storage installations tend to be energy-oriented with small power capacities and long durations to qualify as reliability resources. Ancillary services are procured by means of an established intra-day Ancillary Services Market (ASM).	No	South Africa's energy grid is a complex system and currently, Eskom has a team dedicated to the balancing of the system. No market structure currently exists whereby ancillary services can be procured in a competitive manner. Additionally, the introduction of such a system under the proposed ancillary services provisions of the Electricity Regulation Amendment Bill will be a time consuming process, only feasible in the medium-long term.
UNITED KINGDOM	The UK battery ancillary services market is one of the most advanced ancillary services market structures in the world. In the UK, the system operator (ESO) allows BESS to provide two types of ancillary services: Firm Frequency Response (procured in monthly & quarterly tenders or weekly auctions) and Dynamic Containment (procured in the day-ahead ancillary services market) providing the response within 10 or 30 seconds of an event, and sustaining it for 20 seconds, 30 minutes or indefinitely.[58]	No	Although the UK's seconds-based response mechanism is certainly a pioneering method to incentivise BESS applications and make use of the technology's short response times, such a system would not be realistic for South Africa to pursue given the advanced balancing services that are present in the UK.

[58] https://www.nationalgrideso.com/industry-information/balancing-services/frequency-response-services/firm-frequency-response-ffr

KEY MESSAGE: Based on BESS use cases benchmarking practices identified, it is clear that South Africa lacks the competitive renewable energy market to enable BESS to provide ancillary services. Ancillary services are also currently regulated and excludes BESS as a feasible option for ancillary services.

Given South Africa's current supply gap crisis and load shedding predicament, it is proposed that the most feasible use case for BESS would be to act as a capacity/peaking mechanism during peak demand cycles.

The feasibility of BESS from an ancillary services perspective should however be tested by means of introducing pilot projects where batteries are paired with renewable energy to a productive unit to provide greater flexibility in the release of the Primary Reserve service. The need for ancillary services will become increasingly important as renewable energy capacity increases and thermal coal power is phased out.

4.3 Procurement mechanisms and ownership

Currently, procurement of utility-scale BESS occurs in line with South Africa's Integrated Resources Plan (2019). In addition to the provisions of the IRP and requirements of the Electricity Regulation Act, NERSA also plays a significant role in the procurement of energy in South Africa. NERSA's Electricity, Infrastructure and Planning Department takes care of planning for the country's future electricity demand/needs. It also promotes alternative electricity generation technologies such as BESS applications and renewable energy options and promotes demand side management and energy efficiency initiatives.

However, the IRP is only applicable to utility scale BESS procurement. Behind-the-meter/customer-located storage is not subject to the provisions of the IRP and can be procured. In the short term, behind-the-meter/customer-located storage is best suited to provide a critical service for South Africa: backup power. In particular, behind-the-meter battery storage enables South Africans to adapt to load shedding and offset its costs based on security of supply.

When considering the procurement and licensing of BESS, it is important to consider who the owner of the energy storage assets should be. Should these be part of the grid network owner's regulated asset base, or owned independently? In emerging markets such as South Africa, where a vertically integrated parastatal entity owns the majority of generation plants, and has a monopoly on transmission, distribution and supply, the more relevant question is whether energy storage assets should increasingly be tendered on an independent power producer (IPP) basis or be directly procured and therefore form part of the state's transmission system.

Apart from certain requirements pertaining to Local Community Ownership[59] under the

[59] The REIPPPP aims to promote the direct development of previously marginalised and disadvantaged groups, and communities. Ownership is intended to provide a flow of economic benefits as well as provide identified parties with voting rights in some cases, which allows them to directly influence project Activities.

REIPPP Programme, the ownership of generating capacity provided for under the IRP and REIPPPP typically vests in the IPP.

Seeing as the procurement mechanism associated with BESS is dependent on the use case for which BESS must be procured, the table below considers the procurement of BESS for the use case that would be most suitable to South Africa's current circumstances, namely, peaking capacity.

Country	BESS Best practice identified	Possible adoption in South Africa and associated timeframe?	Gap in the South African context
CHILE	Chile introduced an innovative auction design, based on a time block system. The blocks are clustered in three unequal hourly blocks, covering 24 hours and four three months blocks, covering one year and bidders can make various combinations.	Yes, short term	For a system such as the time-differentiated supply blocks auctions to be viable for South Africa, a certain degree of deregulation of the electricity sector would be needed to at least introduce an electricity market. Within the context of the proposed Electricity Regulation Amendment Bill, the possibility exists for a similar time block based mechanism to be introduced as part of the electricity market, where BESS participants would participate in a daily auction and contract award algorithms would award bidders based on the pricing criteria.
CALIFORNIA	In California, capacity services are procured via centrally allocated capacity provision obligations. The Public Utilities Commission (CPUC), the regulatory agency, requires each IOU and CCA to meet a Resource Adequacy requirement. In addition to the Resource Adequacy, IOUs are also obliged to meet an explicit energy storage procurement target totalling 1.3 GW of storage by 2020, as per assembly bill 2514 from 2013.	Yes, short term	South Africa does not have a model whereby consumers can choose what type of electricity they consume/ purchase from Eskom.[60] Additionally, municipalities are not required to procure any capacity from renewable energy or BESS applications. Introducing a municipal model which enables municipalities to procure electricity on behalf of consumers would result in an increase in demand for renewable energy sources and also encourage the increased uptake of BESS applications in order to reduce variability concerns.
UNITED KINGDOM	Capacity services in the UK are procured by means of capacity market auctions and the auctions are technology neutral. The UK's Contracts for Difference (CfDs), enable long-term contracts to be entered into between electricity generators and the Low Carbon Contracts Company (LCCC), owned by the government that enables the generator to stabilise its revenues at a pre-agreed level.	Yes, medium term	Currently, South Africa's long-term contracts undergo a bid process under the REIPPP and RMIPPP programmes. The sixth round of the REIPPPP Bid Window, is the second bid window to be procured in response to the Second Ministerial Determination gazetted on 25th September 2020 in terms of Section 34 of the Electricity Regulation Act (ERA), and aligned to the Integrated Resource Plan of 2019 (IRP 2019).The auctions would should be technology neutral in order procure the levels of BESS needed to fill South Africa's supply gap.

[60] Eskom is currently running a Renewable Tariff Pilot Programme, where the customers can procure renewable energy from Eskom without having to procure energy through Power Purchase Agreements or installing own embedded generation. The Renewable Energy Tariff pilot will allow customers to be able to source up to 100% of electricity from Eskom's renewable sources that are considered "green".

KEY MESSAGE: The procurement of energy capacity services has typically happened by means of bid or auction processes. Although BESS is also procured in terms of South Africa's Integrated Resources Plan, the capacity procured from BESS is capped. Alternative measures to increase BESS capacity such as a minimum municipal BESS capacity target, similar to that of California, could be considered.

Tariff and remuneration structure

The classification of BESS technologies as either a generation or transmission asset is an important consideration when designing a remuneration structure. In the UK the classification of BESS as both a generation and transmission assets led to unintended consequences. Electricity storage facilities were subject to a double charge under the balancing and settlement code for both import and export of electricity. The stored power was also subject to double charging under levies applied to electricity consumption, as the charges were levied both upon supply to the battery and upon supply to the end user. A similar incident in South Africa would result in discouraging BESS investment. Recognition of the characteristics of an energy storage facility is therefore required in regulatory frameworks, to exempt storage from certain obligations or to adjust these to accommodate its unique characteristics. In South Africa, BESS is procured under the provisions of the IRP and section 34 of the Electricity Regulation Act, meaning that it is procured as a generation asset forming part of the country's electricity generation capacity. This differs from the classification of BESS as a transmission asset, as is the case in Chile and the UK where BESS are allowed to participate in the ancillary services markets.

The classification of BESS as a generation asset is important when considering the design of a tariff mechanism. In South Africa, Eskom applies to NERSA for tariff increases. Electricity to large users is typically charged at fixed rates plus a metered capacity and active energy charges. The active energy charge is typically done at set time of use (TOU) rates for specific times of the day, day of the week and time of the year. NERSA's Pricing and Tariffs Department takes care of the economic regulation of the electricity supply industry by setting tariff guidelines and structures, defining tariff methodologies (e.g., Rate of Return, Multi Year Price Determination), evaluating tariff applications from licensees and setting pricing frameworks. When considering the provisions of the Electricity Regulation Amendment Bill, NERSA would have to determine a tariff, a maximum tariff or a guideline tariff for BESS technologies. The design of a beneficial tariff structure will be essential to ensure the commercial viability of BESS as a large-scale generation asset in South Africa.

Country	BESS Best practice identified	Possible adoption in South Africa and associated timeframe?	Gap in the South African context
CHILE	The deregulated energy market and the large amount of IPPs in Chile makes it possible for IPPs to generate sufficient electricity to be sold directly to utilities and large-end consumers. IPPs are therefore able to participate in the spot market without resorting to the long-term contracts that the system operator (Comisión Nacional de Energía -CNE) tenders out. This creates the ideal opportunity for BESS applications to be adopted as part of the IPP's generation offering	Yes, short term	Under the current provisions of the Electricity Regulation Amendment Bill, a similar approach would be feasible for South Africa, where the proposed market structure would enable physical bilateral transactions to be entered into between IPPs and private sector consumers and regulated transactions between IPPs and the Central Purchasing Agency. The Central Purchasing Agency means the state-owned entity within the Transmission System Operator who will be the Single Buyer of electricity in the regulated market. The customised technology tariffs requirements in the Bill will also allow BESS to be remunerated in accordance with their ability to provide peaking capacity to both public as well as private sector customers.
CALIFORNIA	Projects contracted with a Resource Adequacy contract, whether procured by a utility or not, receive a fixed capacity revenue ($/kW-month) and variable revenue from the wholesale market participation to the asset owner. If the asset owner is a utility, variable energy revenue ($/kWh) received from participating in the wholesale market is subtracted from the total project cost to obtain net cost.	Yes, short term	Under the current provisions of the Electricity Regulation Amendment Bill, the South African government would be able to set a maximum tariff, in respect of the relevant technology pursuant to the relevant IPP procurement process. The provisions also allow tariff guidelines to be introduced. This could enable BESS applications to be remunerated at a set tariff, with additional remuneration being applicable during times of peak electricity demand. The tariff structure for BESS could build on the tariff structure applied to CSP technologies under the REIPPP programme which are considered to be storage technologies. Generators can earn up to 270% of the base price during peak hours. With the necessary amendments, such a mechanism could be rolled out in the form of the RMIPPP where Renewable Energy Sources + BESS solutions could be procured.
UNITED KINGDOM	In a peaking/capacity context, payments are made monthly based on the auction price and the capacity offered. The payment reflects system demand and will be higher in months when demand for electricity is higher, such as winter.	Yes, short term	

BESS incentives

Currently, no specific incentives or targets are in place in South Africa to encourage investment in BESS technologies. As proven in California, energy storage procurement targets for utilities are one of the quickest ways to develop energy storage. European countries are focusing extensively on the financial incentive options for industrial, commercial, and even residential customers to install and operate energy storage systems. In the USA, the U.S. Storage Act that would provide a 30% tax credit for installed energy storage was not enacted but is an excellent instrument as proven in the PV market.

Country	BESS Best practice identified	Possible adoption in South Africa and associated timeframe?	Gap in the South African context
CALIFORNIA	California: California's Investment Tax Credit (ITC) which deducts a certain percentage of investment from taxes, proportional to the charging time associated with renewable sources. The incentive provides a 26% credit for systems installed by 2022 in order to reduce upfront costs, raised by uncertainties of the project's multiple revenue streams.	Yes, short term	South Africa does not currently have incentive mechanisms similar to that of California. However, South Africa's Income Tax Act has historically been used to introduce a set of clean energy tax incentives. In terms of section 12I of the Act, Industrial policy projects that use improved energy efficiency and cleaner production technology, inter alia, are entitled to an allowance of 35% – 100% of the cost of new and unused manufacturing assets used in the project. A similar provision could be introduced to classify BESS as Industrial policy projects in order to receive the additional investment and training allowance set out in section 12I.
ITALY	Italy's Delibera ARERA 288/12/R/EEL Act introduced a curtailment mechanism for BESS projects to receive the standard remuneration of a CAPEX investment, while also receiving an additional incentive of a 2% return on top of the CAPEX invested over the 12 years of the asset lifetime. The additional return is made conditional upon the reaching of at least 50% of the forecasted RES curtailment reduction target which had been set by Terna at the onset of the project.	No	For such a model to be feasible for South Africa, the country would need a much larger scale of wind and solar with a real possibility of energy curtailment. However, BESS operators in South Africa would not be able to receive revenue based on curtailment, as currently no curtailment is taking place.

4.4 BESS environmental considerations

The relationship between energy production processes and resultant environmental problems requires integrated regulation, especially in respect of renewable electricity and the global and local problems that renewable energy is likely to solve. While regulation alone will not lead to the environmental reparation needed, it can at least ensure that we understand the extent to which the energy sector is affecting the environment and thereby the degree to which we can leverage energy resources to promote environmentally sustainable development that is just, in a distributive, procedural, restorative, and social equity sense.

As is the case in the benchmark countries, South Africa has yet to develop the necessary regulatory provisions to ensure that the environmental impact of BESS applications are managed appropriately. However, sections 24 and 44 of National Environmental Management Act make provision for the promulgation of regulations that identify activities which may not commence without an environmental authorisation (EA) issued by the competent

authority. In this context, the EIA Regulations that came into effect on 8 December 2014 and amended in April 2017, promulgated in terms of NEMA, govern the process, methodologies and requirements for undertaking environmental impact assessments in support of EA applications. Listing Notice 1 of the Regulations lists activities that require a Basic Assessment process, while Listing Notice 2 lists activities that require a Scoping & Environmental Impact Report (S&EIR). Listing Notice 3 lists activities in certain sensitive geographic areas that require a Basic Assessment.

Although the regulations do not explicitly require a Basic Assessment or Scoping & Environmental Impact Report to be done when planning a BESS development, the underlying activities related to the development of BESS can be considered to trigger certain activities that require assessment in terms of the regulations. For example, listing notice 1 requires that a Basic Assessment be done in cases where a project led to the following:

1. "The clearance of an area of 1 hectare or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for – (i) the undertaking of a linear activity" – in this case the development of a BESS project may require land to be cleared in preparation for the BESS application and could require a Basic Assessment do be done, dependant on the size of the BESS application.
2. "The development and related operation of facilities or infrastructure, for the storage, or for the storage and handling, of a dangerous good, where such storage occurs in containers with a combined capacity of 80 cubic metres or more but not exceeding 500 cubic metres." However, in March 2020, the Department of Forestry Fisheries and the Environment clarified the applicability of listed activities under the EIA Regulations, which relate to the development and operation of facilities or infrastructure, for the storage, or storage and handling of dangerous goods. The government found that battery energy storage is not considered a storage facility as defined in the regulations and that the purpose of BESS is not to store dangerous goods.

Although the EIA regulations can be used in order to assess the environmental impact of BESS applications, South Africa needs to introduce specific standards aimed at minimizing the environmental impacts of BESS applications. Such standards must outline all environmental considerations including environmental requirements linked to the end of life of large-scale batteries. This includes aspects such as decommissioning, waste management practices for hazardous waste from lithium-ion technologies and refurbishment and reuse standards that would apply to refurbished batteries.

5. Policy recommendations for South African energy storage

The successful adoption of BESS in South Africa will be highly dependent on the country establishing policies, regulations, tariff structures, and market conditions that provide a favourable and predictable investment environment to invest in, adopt, operate, and maintain BESS technologies. Based on the gaps identified above, the following key policy recommendations will be needed to increase the uptake of BESS in South Africa.

5.1 Market design overview

The publication and eventual implementation of the Electricity Regulation Amendment Bill will inevitably result in the increased introduction of variable renewable energy resources in the South African energy market. Within this context, the role of BESS in the energy market will become increasingly important in order to guarantee the reliable operation of the electricity grid. BESS companies will be able to enter the electricity market and act as a buffer between the wholesale market and consumers.

From the examples outlined in Chapter 1, it is clear that where the market has been liberalised, it has been easier for BESS technologies to penetrate the market, as the market is more active. This contrasts sharply with the situation in South Africa where the energy system is largely still in the hands of the state. Despite this, caution must always be exercised to ensure that developing countries like South Africa do not undertake reforms simply to accommodate pressures from developed countries.

Within the context above, the preferred market design for South Africa would be a hybrid model, whereby energy from BESS is sold in both a regulated market, as well as a wholesale market. Such a multi-market model would increase competitiveness to stimulate the market whilst still supporting the financial well-being of Eskom. As such the market design would be similar to that of California, where a partially liberalised electricity market exists which features an independent transmission system operator. In the hybrid market model, BESS would be able to buy and sell electricity in the regulated market by entering into Power Purchase Agreements with the Central Purchasing Agency, who will be the sole buyer of electricity for the public sector.

When it comes to the complexities of the market design, the UK and California have advanced energy trading platforms that function on a day-ahead and intra-day trading basis. They have

also introduced more granular trading sessions such as 30-minute electricity products in the intraday markets without recourse to auctions. For example: If a trader wants to purchase 20 MWh for the 15-minute interval from 4:00-4:15 in the afternoon and finds a seller willing to supply the required amount of power, the deal must be closed by 3:30 p.m. Similarly, California transitioned from hourly products to quarter-hourly products, which functions in a similar fashion to the 30-minute electricity products traded in the UK. Although this creates the ideal market circumstances for BESS to participate in due to the technology's short response time, such an intraday market requires significant technical development. Given South Africa's current vertically integrated market and electricity crisis, such a short-notice intraday market would not be a feasible option for South Africa in the short term. Therefore, South Africa's electricity market would need to function on a day-ahead basis.

In a day ahead market, market participants commit to buy or sell wholesale electricity one day before the operating day based on trading periods of 1 hour. Eskom, IPPs, municipalities, traders and buyers would need to exchange supply and demand capacities with the Market Operator having the responsibility to match suppliers with buyers. In the day-ahead market, BESS would be able to supply energy in the market for peak demand periods, thereby benefiting from increased peak hour tariffs. Considering this structure, the BESS supplier would need to submit the MWh quantity available at specific hours with a specific price per hour.

The development of a mature day ahead wholesale market structure will take time. However, South Africa's energy supply gap is an immediate concern and BESS can play a role in addressing the country's immediate needs. In order to hedge against uncertainties in the day-ahead market, market participants should also build BESS into mid- to-long term PPAs in order to guarantee set tariffs outside the day ahead market.

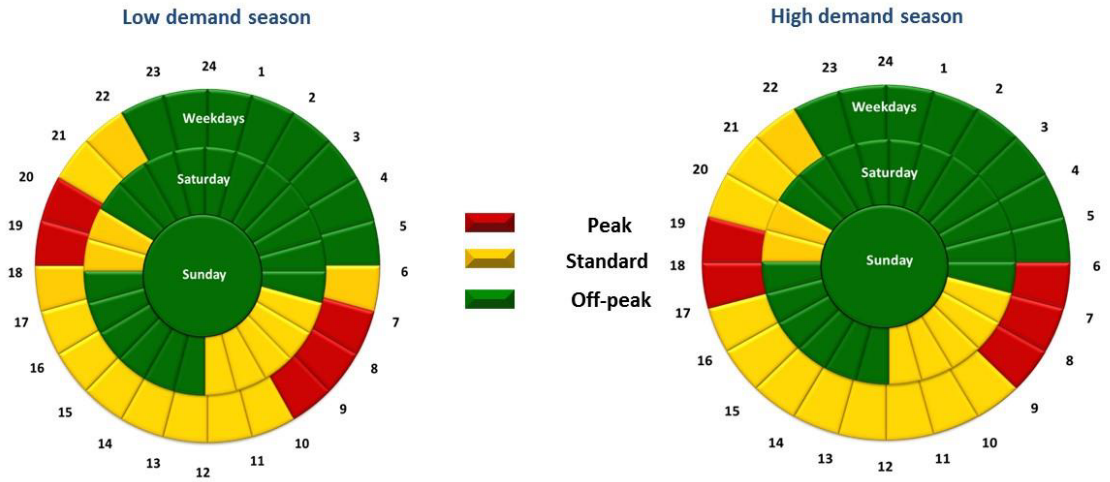
When the South Africa day ahead market structure is mature, the possibility exists to introduce an ancillary services market, also referred to as the balancing market, where BESS service providers may offer ancillary services to the system operator and be remunerated if the offer is accepted, and the services are correctly provided. However, introducing BESS as an ancillary services technology would require that Eskom amend their Ancillary Services Technical Requirements to allow for BESS to be considered for instantaneous reserves and system restoration services.

5.2 BESS use cases

In countries following a market-based approach and where renewable energy is an abundant source of energy, such as in Chile, energy arbitrage is a feasible option to increase BESS applications in the country. Although South Africa has in the past experienced significant

curtailment of renewable energy sources due to national lockdown restrictions, South Africa does not currently have sufficient energy surpluses to make energy arbitrage a commercially attractive option for the BESS industry. However, when compared to the other use cases, (ancillary services and investment deferral), energy arbitrage coupled with peak shaving capacity remains the most commercially feasible option for BESS applications in the short term and would serve to alleviate South Africa's electricity shortage.

To try and equalise the supply and demand curve for energy in South Africa, the state utility, Eskom, has a Time of Use (TOU) tariff structure for large users of electricity. In low demand seasons (summers), weekdays between 07:00 – 10:00am and 18:00-20:00pm are considered peak hours. In high demand seasons (winter) peak demand occurs from 06:00-09:00 am and 17:00-19:00 pm. This is reflected in the figure below:



During peak hours, South Africa has relied upon Eskom's OCGTs (Open Cycle Gas Turbines) to generate sufficient electricity to meet peak demand. However, the OCGT power stations are powered by liquid fuel (diesel) and are emission intensive energy solutions. Based on South Africa's international climate change commitments, we are required to reduce our emissions and BESS applications provide an opportunity to gradually phase out the emission intensive OCGTs and use BESS as a peak-shaving solution. BESS would also constitute a more commercially feasible option when compared to the costs associated with running the OCGTs.

In the longer term, and given the possibility to procure ancillary services as provided for the Electricity Regulation Amendment Act, South Africa could procure BESS as a means to provide ancillary services. The introduction and procurement of ancillary services from BESS could diversify and stack project revenue streams thereby increasing the value captured from the project and reducing costs to final customers.

5.3 Procurement mechanisms

The procurement of BESS for energy arbitrage / peak shaving capabilities can be done by means of RES auctions coupled with BESS, capacity market auctions, and centrally allocated capacity provision obligations. Given the fact the most feasible use case for BESS in South Africa is energy arbitrage and peak-shaving, South Africa's BESS procurement mechanism should be based on the need to secure energy supply and reduce investment risk.

In the short term it is proposed that South Africa introduce a technology-neutral, electricity auction based procurement mechanism based on a time block system. This would be similar to the mechanism used in Chile, with the exception that capacity from BESS would be procured as a generation asset, and not as a transmission asset as is the case in Chile. This will enable BESS developers to store energy from various generation technologies and sell electricity into the grid based on a competitive tariff mechanism centred around time blocks reflecting different demand periods such as peak time blocks and minimum demand time blocks.

In the long term, and within the context of the emended Electricity Regulations on New Generation Capacity which allows municipalities to procure energy directly from Independent Power Producers, a mandatory BESS capacity procurement target could be introduced. Such a system could be similar to the resource adequacy mechanism in California, where distributors and/or municipalities would be required to procure a certain percentage of their electricity from RE sources that are paired with BESS in order to reduce grid constraints during peak hours. Such a mechanism could ultimately also be linked to the requirement of municipalities to submit municipal change response implementation plans under the proposed Climate Change Bill, where renewables and BESS would provide a mechanism for municipalities to reach their municipal climate change mitigation targets.

5.4 Investment

The short-term benefits of grid-level BESS applications in South Africa will primarily be linked to energy arbitrage and peak-shaving capability. These benefits cannot be realised unless investments in energy storage can yield returns that are comparable with similar investments in the energy sector. Returns on investments related to BESS applications can be obtained only if an enabling regulatory framework related to remuneration, incentives and ownership are in place.

5.4.1 Remuneration

Sustainable development of BESS applications will not occur unless tariffs for the various services provided by energy storage are established, and the tariffs are sufficient for energy storage investors to recover cost and make an acceptable return on investment. South Africa's REIPPPP has provided a standard from which to build in order to remunerate BESS applications for peak-shaving services. The ability of CSP plants to procure 270% of the base rate during peak hours due to its storage capabilities, is a key provision that should also be introduced for BESS applications.

Within the context of the newly published Electricity Regulation Amendment Bill, it is essential that peaking tariff provisions related to BESS are clearly set out by NERSA. The Bill allows for specific tariffs, maximum tariffs, or guideline tariffs to be developed for a particular generation technology, such as BESS[61]. Given the proposed use case for BESS in South Africa, the key principle related to the design of a BESS tariff should be the fact that, like CSP technologies, BESS can contribute to peak-shaving and the alleviation of load shedding and should be compensated based on these characteristics.[62] However, given the aforementioned provision in the Bill, BESS would have to be classified as a generation asset and not as a transmission asset. Such a tariff design could also incorporate a capacity payment structure in the case where the procurement of BESS takes place separately from RE technologies. In such a case, storage would be provided as a service to electricity generators, incorporating a pass through costs associated with the charging cost and discharge of electricity.

When designing the tariffs for BESS peak-shaving generation assets, the following factors need to be considered:

- Tariffs for electricity hour-by-hour at peak time, amount of energy supplied to grid by energy storage hour-by-hour at peak time.
- Tariff for electricity hour-by-hour at off-peak time, amount of energy used for charging of energy storage hour-by-hour at off-peak time.

[61] See section 14A(1)(b) of the Bill that provides that: "The Minister may, either prior to or after the relevant section 34 determination and in order to facilitate the procurement of electricity or new generation capacity through an IPP procurement process, in writing request the Regulator, prior to the commencement of such process and within a reasonable time period specified by the Minister in the request, to determine a tariff, a maximum tariff or a guideline tariff for a particular
generation technology, that shall apply in respect of electricity generated by means of that technology pursuant to that IPP procurement process"
[62] The Bill does allow for specific tariffs, maximum tariffs or guideline tariffs to be developed for a particular generation technology, that shall apply in respect of electricity generated y means of that technology pursuant to that IPP procurement process.

5.4.2 Incentives

Based on the international benchmarks, it is clear that monetary incentives have been a key measure which have spurred investment in BESS. For example, in California the Federal Energy Regulatory Commission (FERC) set up an Investment Tax Credit (ITC) which deducts a certain percentage of investment from taxes, proportional to the charging time associated with renewable sources. The incentive provides a 26% credit for systems installed by 2022 in order to reduce upfront costs, raised by uncertainties of the project's multiple revenue streams. In South Africa, there have also been a range of incentives aimed at increasing the uptake of renewables. The introduction of clean energy tax incentives has historically been provided for in section 12 of the Income Tax Act and has resulted in increased renewable energy uptake and energy efficiency measures. Some of the measures set out in section 12 can however be interpreted to also cover BESS applications. Some of the incentive measures have been outlined below and could be applied to support the uptake of BESS in South Africa.

Table 7: Incentive measures

Description	Details	Section	Application to BESS
Accelerated depreciation allowance (RE)	In respect of assets brought into use for the first time and solely for the production of renewable electricity. The allowance is based on the cost of the assets and 50%, 30%, and 20% is granted in each of the first three years of use, respectively.	12B(1)(h)	The application of Section 12B should be extended to include BESS applications as generation assets.
Industrial policy project (IPP) allowance (Energy Efficiency)	Industrial policy projects that use improved energy efficiency and cleaner production technology, inter alia, are entitled to an allowance of 35% – 100% of the cost of new and unused manufacturing assets used in the project.	12I	BESS projects could be classified as Industrial policy projects in order to receive the additional investment and training allowance set out in section 12I
Research and Development allowance (Renewable Energy and Energy efficiency)	A 150% allowance in respect of expenditure incurred directly and solely on approved R&D activities undertaken in South Africa. The expenditure must be incurred in the production of income, in carrying on any trade. The allowance also extends to pre-trade expenditure incurred in respect of approved R&D activities.	11D; 11A	In order to encourage pilot projects, sections 11D and 11A could be extended to include BESS research and development projects.

Ownership

The ownership structure for BESS tends to reflect the pre-existing market structures which are prevalent in each host market. If this principle is applied in South Africa, the vertically integrated market would require that BESS applications are owned by Eskom. However, with the impending market reform provisions set out in the Electricity Regulation Amendment Bill and the proposed role of BESS as a peak shaving technology, Eskom would most likely be a purchaser of stored energy from BESS applications belonging to IPPs.

In the proposed regulatory market in South Africa, the Central Purchasing Agency (CPA) will conclude PPAs with each electricity generator (which should include BESS applications) to ensure sufficient supply to meet the demand. The CPA would then conclude Sales Agreements with Distributors, such as municipalities. As such, in both the regulated as well as the bilateral market, the ownership of the BESS would most likely vest with IPPs.

However, the possibility also exists to make use of Public-Private Partnerships (PPPs). PPPs have been used as a means of procuring public infrastructure, fulfilling government and parastatal service obligations, and generating energy in South Africa since the late 1990s. For the foreseeable future, the IPP sector will continue to be an area of PPP activity. Following a review of the Public-Private Partnerships framework, government announced in the recent 2022 South African budget speech by Minister Enoch Godongwana, that a PPP centre for excellence will be established to accelerate infrastructure investment. As such, there are opportunities for IPPs and the private sector players to take advantage of the PPP processes to develop the BESS sector for the benefit of both public as well as private sectors. PPP mechanisms specifically focussed on increasing BESS developments must therefore be introduced by government.

5.5 Amendment of existing laws

South Africa's current energy legislation and energy resource planning tools do not show the necessary urgency to increase the share of renewables in the market and to address South Africa's electricity crisis. A difficult, but necessary, "just transition" to a low-carbon economy requires laws to phase-out fossil fuels. Simply introducing policy recommendations focussed on increasing the application of BESS technologies will not have the desired effect. South Africa's underlying energy crisis must first be addressed by introducing additional renewable energy capacity to the extent where surplus energy is generated at sufficient volumes to be stored in BESS applications. Therefore, as a starting point certain fundamental changes must be made to address South Africa's chronic energy shortfall. The key policy recommendations to effect the fundamental changes necessary to increase BESS have been set out below.

5.5.1 Integrated Resources Plan

The IRP is an electricity infrastructure development plan arguably based on the least-cost electricity supply and demand balance, taking into account security of supply and the environment through the minimisation of GHGs and water use. The IRP 2019 supports a diverse energy mix and sets out nine policy decisions to ensure the security of South Africa's electricity supply. Across all scenarios, in order to meet increasingly ambitious power sector CO2 mitigation targets in South Africa, wind and solar PV technologies must play a dominant role and have repeatedly been calculated to represent the least cost energy development path for South Africa.

However, artificial and arbitrary constraints on renewable energy investment in the IRP raise costs associated with procuring renewable forms of energy and limits the sector's ability to meet South Africa's future energy requirements and its climate change mitigation goals. Within this context, the IRP 2019 does not consider the fact that renewable energy is a least-cost option, nor does it consider the global energy technology shifts taking place that will fundamentally alter the viability of South Africa's current coal fleet, either because of economics or global climate change policy.

In order for BESS to be commercially feasible, the IRP must be updated to at least triple the capacity provisions for wind, solar, and BESS in order to address South Africa's international climate change commitments and the country's energy crisis. It must be noted that the recently published Electricity Regulation Amendment Bill requires the IRP to be revised every three years in order to adjust its capacity provisions based on supply and demand projections. Furthermore, the Amendment Bill also allows the Minister of Mineral Resources and Energy to deviate from the IRP in an emergency or if it is necessary to do so in the national interest. Within this context, there is an opportunity to increase the current BESS capacity provided for in the IRP to provide emergency generation capacity desperately needed in the country.

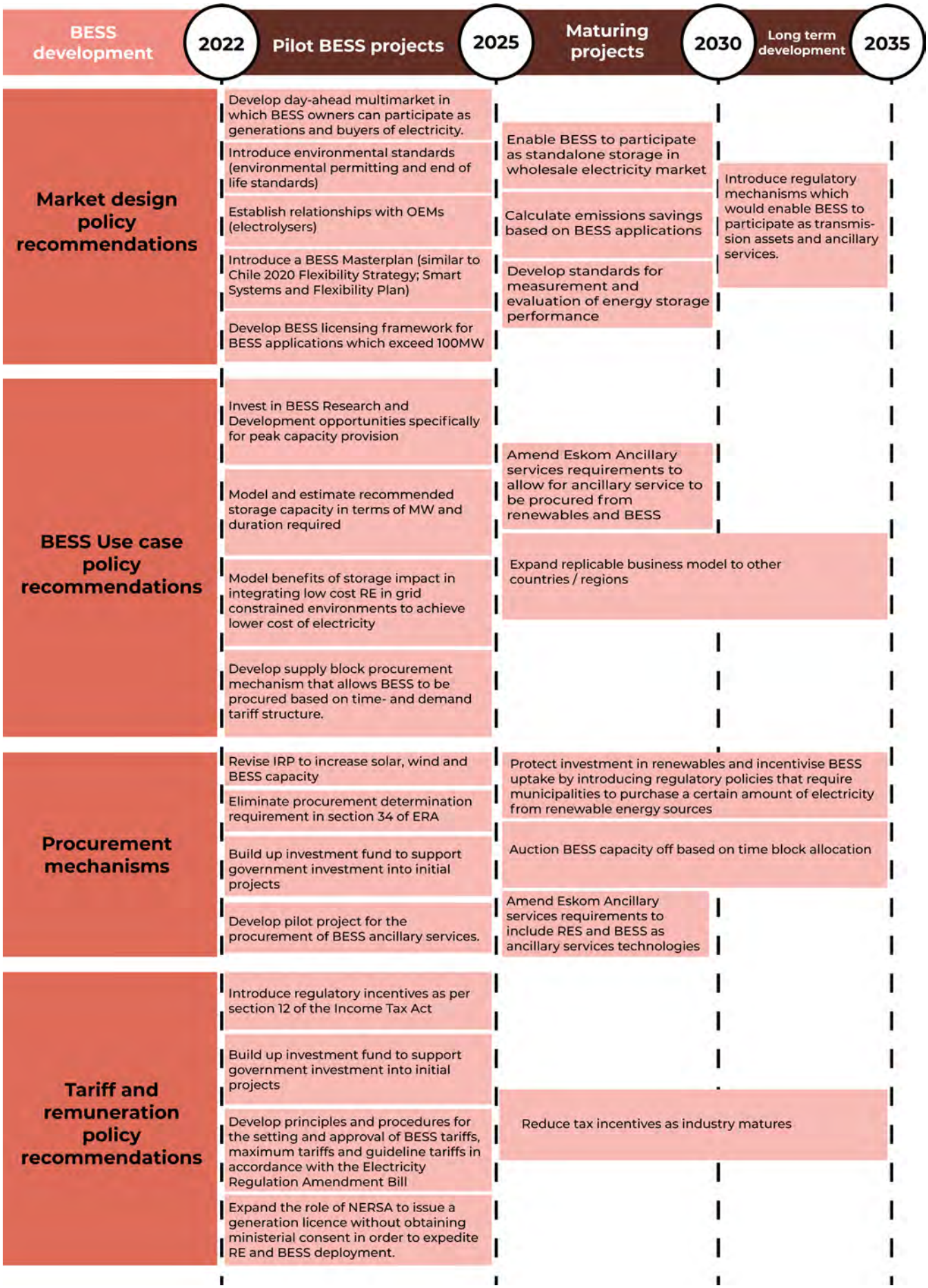
5.5.2 Electricity Regulation Act

The diversification of energy sources is enabled by section 34 of ERA, which empowers the Minister of Mineral Resources and Energy to increase generation capacity by making new generation capacity regulations. The determinations must be published in accordance with the energy mix set out in the IRP. Based on this plan, the Minister of Mineral Resources and Energy issues periodic determinations setting out how much new power generation is needed, and from which sources such power must be procured.

A flaw in the aforementioned legal regime is that it makes energy procurement entirely dependent on ministerial discretion in making determinations. This implies that private sector investors, other spheres of government (such as metropolitan municipalities) and large corporates wanting to generate electricity cannot do so unless there is a determination. This hampers not only renewable energy procurement, but also the procurement of BESS applications. If the aim of the ERA (and Regulations for New Generation Capacity made under it) is to grow South Africa's renewable energy sector, then the regulatory constraints as set out in section 34 must be amended. The requirement to obtain a ministerial determination prior to developing renewable energy and BESS projects must be removed from the Act in order to minimise the administrative burden associated with the development of renewable energy infrastructure.

6. South African energy storage roadmap

Given South Africa's energy crisis, urgent actions need to be taken in order to generate sufficient capacity for BESS applications to be a commercially viable energy solution. The proposed energy storage roadmap outlines the actions required over the short, medium, and long term to develop South Africa's BESS industry and create the enabling environment required to support the BESS industry.


BESS development
2022
Pilot BESS projects
2025
Maturing projects
2030
Long term development
2035
Market design policy recommendations
Develop day-ahead multimarket in which BESS owners can participate as generations and buyers of electricity.
Introduce environmental standards (environmental permitting and end of life standards)
Establish relationships with OEMs (electrolysers)
Introduce a BESS Masterplan (similar to Chile 2020 Flexibility Strategy; Smart Systems and Flexibility Plan)
Develop BESS licensing framework for BESS applications which exceed 100MW
Enable BESS to participate as standalone storage in wholesale electricity market
Calculate emissions savings based on BESS applications
Develop standards for measurement and evaluation of energy storage performance
Introduce regulatory mechanisms which would enable BESS to participate as transmission assets and ancillary services.
BESS Use case policy recommendations
Invest in BESS Research and Development opportunities specifically for peak capacity provision
Model and estimate recommended storage capacity in terms of MW and duration required
Model benefits of storage impact in integrating low cost RE in grid constrained environments to achieve lower cost of electricity
Develop supply block procurement mechanism that allows BESS to be procured based on time- and demand tariff structure.
Amend Eskom Ancillary services requirements to allow for ancillary service to be procured from renewables and BESS
Expand replicable business model to other countries / regions
Procurement mechanisms
Revise IRP to increase solar, wind and BESS capacity
Eliminate procurement determination requirement in section 34 of ERA
Build up investment fund to support government investment into initial projects
Develop pilot project for the procurement of BESS ancillary services.
Protect investment in renewables and incentivise BESS uptake by introducing regulatory policies that require municipalities to purchase a certain amount of electricity from renewable energy sources
Auction BESS capacity off based on time block allocation
Amend Eskom Ancillary services requirements to include RES and BESS as ancillary services technologies
Tariff and remuneration policy recommendations
Introduce regulatory incentives as per section 12 of the Income Tax Act
Build up investment fund to support government investment into initial projects
Develop principles and procedures for the setting and approval of BESS tariffs, maximum tariffs and guideline tariffs in accordance with the Electricity Regulation Amendment Bill
Expand the role of NERSA to issue a generation licence without obtaining ministerial consent in order to expedite RE and BESS deployment.
Reduce tax incentives as industry matures

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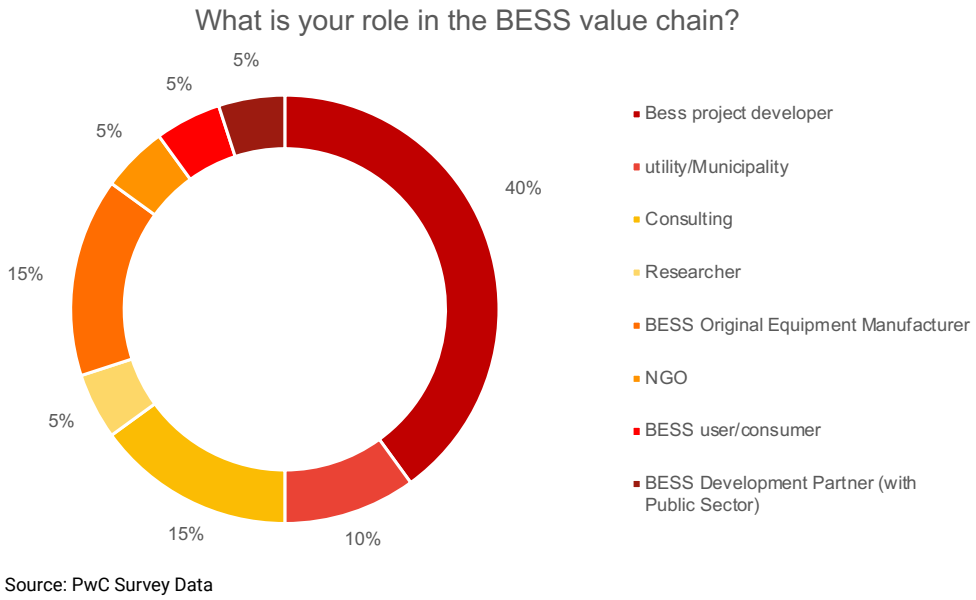
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Appendix

Contact with local stakeholders and experts

A stakeholder engagement process was concluded with the aim of gathering views and opinions relating to local condition and perceptions of the local BESS industry. Various stakeholders participated in the engagement process, as illustrated in the figure below.



Source: PwC Survey Data

Figure 3: What is your role in the BESS Value Chain?

The following list of questions and answers were analysed in order to inform and support the report recommendations:

***Question 1: Market design**: Most countries driving a successful BESS industry have liberalised or partially liberalised markets. In your opinion, would South Africa's electricity sector need to be liberalised before BESS applications become an economically feasible option for South Africa? Please explain your answer.*

The majority of the stakeholders surveyed responded that the nature of the South African energy market is partially liberalised and that further deregulation will allow for easier deployment of renewables and BESS projects. Some stakeholders also relayed that BESS applications can become feasible without fully liberalising the current energy sector. Some participants noted that the monetisation of BESS must be a priority and that liberalisation is not

critical. Furthermore, participants noted that BESS applications can work in both a regulated as well as a deregulated market. Some stakeholders relayed that further liberalisation of the energy market will help create more BESS opportunities but achieving this in South Africa is highly unlikely. They also relayed that a liberalised energy sector will enable arbitrage, private sector provisions of grid auxiliary services and other revenue streams.

An interesting response in this regard was the view that BESS applications have not taken off because the technology is treated as a discretionary facility and not a requirement for a just energy transition.

***Question 2: BESS Use Cases**: The services that BESS can provide, can be divided into different categories ranging from energy arbitrage, peaking capacity, ancillary services and grid investment deferral. Within the context of the current South African regulatory framework and given the energy crisis in the country, which BESS use case presents the greatest potential to increase BESS capacity in the country?*

Most of the stakeholders noted that the use case of peaking capacity would have the greatest potential to increase BESS in the country, with ancillary services as a secondary choice to increase BESS capacity. Stakeholders echoed the principle that additional BESS capacity would smoothen out the variability associated with RE and would allow companies to operate during electricity supply interruptions.

Another popular response was that energy /tariff arbitrage will have the greatest potential. The reasons were that it would allow RE to become dispatchable and would bring about tariff optimisation. The least popular response was the option to introduce BESS capacity as a grid investment deferral use case. One stakeholder mentioned that transmission investment deferral can be used in the west, south-west and south parts of South Africa where large scale renewables have transmission capacity constraints.

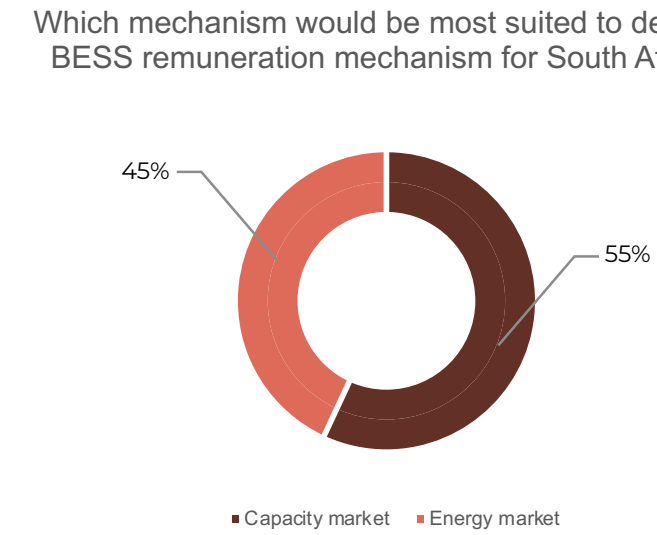
Many stakeholders expressed that all the possible BESS use cases were important and mentioned that behind the metre BESS applications should receive more attention as it can introduce new business opportunities in the BESS value chain, for example, BESS rental models, BESS technology aggregation, BESS operation and maintenance as well as BESS recycling.

***Question 3: BESS procurement**: BESS applications can either be independent/standalone where the storage is not paired with a specific source of renewable energy or it can be paired with a specific renewable energy source. Within the context of South Africa's energy crisis, which option (standalone or paired) would make BESS applications more commercially attractive?*

The majority of the responses favoured pairing BESS applications with specific sources of renewable energy, as BESS technologies and applications are still in the establishment phase and standalone applications are not considered feasible in the short term. It was mentioned that no new grid capacity would be required if BESS technologies are paired with renewable energy applications and that existing grid capacity can be fully utilised during the night when renewables like solar power are not generating power.

Some stakeholders preferred a balance of both configurations and that if the BESS is co-located it must also be able to charge from the grid. The advantage of a standalone system is that they can charge and discharge independently of generation and can be located anywhere on a power system. Restricting BESS applications to co-location only, would be detrimental to the broader use case or applications of BESS. Some stakeholders recommended that behind the meter applications should be paired with renewable energy resources to get a better dispatchable profile. Stakeholders also mentioned that the type of battery needs to be considered before deciding as well as which use case will improve the performance of the grid. Further considerations proposed was that BESS should be standalone with wheeling and standalone BESS to facilitate economic growth in remote places.

***Question 4: BESS tariff and remuneration**: Sustainable development of BESS applications will not occur unless tariffs for the various services provided by energy storage are established, and the tariffs are sufficient for energy storage investors to recover cost and make an acceptable return on investment. When considering remuneration based on a capacity market (capacity markets aim to ensure grid reliability by paying participants to commit generation for delivery years into the future) vs an energy market (pay generators only when they provide power day-to-day), which mechanism would be most suited to design a BESS remuneration mechanism for South Africa?*



Source: PwC Survey Data

Figure 4: Which mechanism would be most suited to design a BESS remuneration mechanism for South Africa?

Graph 2 above shows the response to the question stated. 53.85% stakeholders favoured the capacity market while 46.15% favoured the energy market.

***Question 5**: In your opinion, what are the three key policy recommendations that would accelerate BESS application in South Africa?*

Further recommendations made were that BESS should not be regarded as generation and that it should have its own set of regulations and a government incentive program. Another recommendation was that the deregulation of BESS would encourage uptake and that it should be taken out of any ministerial approval process and the IRP framework. It was also mentioned that Eskom should be deregulated as the Supply Authority in RSA, the policy on wheeling tariffs should change and that independent bidders should be allowed to trade on a "energy stock exchange" 24hrs in advance and the lowest bid should be allowed to provide energy. If they are unable, a penalty must be paid. It was also recommended that BESS should also be mandated as part of the REIPPP.

Another recommendation was that BESS should be environmentally sustainable, reliable and cost effective. Updating and including more BESS in the IRP as well as, updating the IRP modelling with latest BESS pricing and performance models was also recommended. Incentives regarding tariffs and ancillary/grid support for BESS where recommended. Eskom should look at BESS instead of upgrading T&D to allow more RE in grid constrained regions. Nodal pricing was also recommended.

It was mentioned that BESS should support Grid-interactive Efficient Buildings. The South African economy should invest more into the BESS value chain as there is sufficient technical and financial readiness. Two of the ways they can achieve this is by having an integrated national energy storage strategy and enabling a competitive environment for all actors of the BESS value chain.

Key findings of stakeholder engagement process:

- A desire to better understand the use case for energy storage in South Africa and the total opportunity size. Stakeholders did however view capacity and peaking capacity as the most commercially feasible BESS use case in the short term.
- The regulatory or market framework has no specific mechanisms to motivate companies to invest in such projects and give them a consistent and reasonable return on investment. Without adequate compensation for peaking services, energy storage projects lack the revenue opportunity to make the project viable. Energy storage projects must be able to acquire long-term contracts for providing energy storage services (e.g., balancing services, ancillary services, and peaking capacity) at a sufficient price point that allows traditional project financing to enter into the deal.
- The availability of project financing and the fact that the domestic financial sector is not experienced in new energy storage technologies creates a financing barrier for the country.



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