Integrated Renewable Energy and Energy Storage Sub-Program (under the CTF Dedicated Private Sector Program III)

1. **Country /Region**	CTF: Thailand, Philippines, Viet Nam SREP: Cambodia	2. **CIF Project ID#**	(CIF AU will assign ID.)
3. **Investment Plan (IP) or Dedicated Private Sector Program (DPSP)**	☐ IP ☑ DPSP	4. **Public or Private**	☐ Public ☑ Private
5. **Program Title**	**Integrated Renewable Energy and Energy Storage Sub-Program**		
6. **Is this a private sector program composed of sub-projects?**	☑ Yes ☐ No		

7. **Financial Products, Terms and Amount**

	USD
MPIS (for private sector only)	$ 1,900,000
Senior debt	$ 36,100,000
Total	**$ 38,000,000**

8. **Implementing MDB(s)**	Asian Development Bank (ADB)	
9. **National Implementing Agency**	N/A	
10. **MDB Focal Point**	**Private Sector Contact:** Mr Tristan Knowles Climate Finance Specialist Private Sector Operations Department	**CTF focal point:** Mr Christian Ellerman Climate Change Specialist cellermann@adb.org Sustainable Development and Climate Change Department

11. **Brief Description of Program (including objectives and expected outcomes)**

The proposed ADB *Integrated Renewable Energy and Energy Storage Sub-Program* (the "Sub-Program") *under the CTF Dedicated Private Sector Program III (DPSPIII)* seeks to catalyze the uptake of energy storage technologies by addressing barriers to private sector project development in selected Climate Investment Fun ("CIF") countries: Cambodia, Philippines, Thailand, Viet Nam. The Sub-Program aims to contribute to transformational change in energy grids by demonstrating the potential for energy storage to support higher levels variable renewable energy in selected Southeast Asian countries. The Sub-Program aims to deploy $36.1 million of investment capital over three years to multiple private sector developers to catalyze integrated renewable energy and energy storage projects. The Sub-Program presents an opportunity for CTF to play a catalytic role in adoption and scale up of energy storage technologies that are commercially available and have high potential for emission reductions. The proposed intervention would be targeted and time bound, aiming to help offset additional costs and risks faced by early entrants. Establishing a track record for energy storage technologies in Southeast Asia will help to de-risk and encourage greater private sector investment.

To date, ADB and CTF have co-invested into eight private sector renewable energy sub-projects[1] with total capacity of over 600 megawatt (MW) across ADB's Developing Member Countries. As utilization of solar photovoltaic (PV) and wind power increase in national grids, smooth integration will become a bigger challenge and a potential obstacle to continued decarbonization efforts. Energy storage technologies can help to efficiently integrate higher levels of variable renewable energy into national grids. ADB has been exploring financing options and use cases for renewable energy power and storage systems, publishing two reports in 2017[2,3] and conducting early stage discussions with potential project developers. The Sub-Program will address the additional costs and risks of deploying integrated renewable energy and energy storage projects to demonstrate use cases and help energy storage technologies scale up more rapidly across target countries.

12. **Consistency with CTF investment criteria [summary]**	
(1) Potential GHG emissions savings	With $38 million of CTF funding, the Sub-Program would support estimated emission reductions of 2.4 million tCO_2e over the Sub-Program lifetime. *Further information is available on page 12 of this proposal.*
(2) Cost-effectiveness	The Sub-Program would help to catalyze up to 105MW of renewable energy capacity with 11MW/11MWh of energy storage capacity. This would result in Sub-Program lifetime GHG emission reductions of 2.4 million tCO_2e and cost effectiveness of CTF funds of $16 per tCO_2e. *Further information is available on page 12 of this proposal.*
(3) Demonstration potential at scale	By 2030, estimates suggest that total battery energy storage capacity in Southeast Asia has the potential to reach approximately 1300MW/1300MWh.[12] If the proposed Sub-Program helps catalyse 10% of this potential growth, or 130MW/130MWh, then the scale up potential is significant. *Further information is available on page 12 of this proposal.*

[1] Four subprojects under Thailand Private Sector Renewable Energy Program, three subprojects under Indonesia Geothermal Program, and one subproject under DPSP Renewable Energy Mini-grids and Distributed Power Generation

[2] Asian Development Bank. 2017. *Energy Storage in Grids with High Penetration of Variable Generation*, February 2017, Mandaluyong City, Philippines. https://www.adb.org/publications/energy-storage-variable-generation

[3] Asian Development Bank. 2017. *Increasing Penetration of Variable Renewable Energy: Lessons for Asia and the Pacific*, November 2017, Mandaluyong, Philippines. https://www.adb.org/documents/increasing-penetration-variable-renewable-energy-lessons-asia-and-pacific

(4) Development impact	Sub-projects supported through the Sub-Program will contribute to respective country renewable energy targets and emission reduction targets expressed in Nationally Determined Contributions. Sub-projects will also support jobs during construction and operations, helping to contribute to improved livelihoods and poverty alleviation. *Further information is available on page 13 of this proposal.*
(5) Implementation potential	ADB's initial scoping of investment opportunities with project developers suggests that there is sufficient readiness for the program to succeed in deploying funds over a three-year period. *Further information is available on page 13 of this proposal.*
(6) Additional costs and risk premium	Compared with projects focused only on renewable energy generation, projects integrating energy storage will face incremental capex, development costs and complexity that the proposed Sub-Program will assist to reduce. *Further information is available on page 14 of this proposal.*
Additional CTF investment criteria for private sector projects/ programs	
(7) Financial sustainability	Integrating renewable energy and energy storage will require new private sector business and revenue models. By the early to mid-2020s, ADB anticipates that such projects should be cost competitive without any grant or concessional support. *Further information is available on page 14 of this proposal.*
(8) Effective utilization of concessional finance	Concessional finance will be used to catalyze early movers in the private sector to explore opportunities for integrated renewable energy and energy storage. Given the low levels of energy storage currently and the potential limitations to variable renewable energy grid penetration without storage, ADB expects that targeted and time bound use of concessional finance at this stage in the market will be extremely effective. *Further information is available on page 14 of this proposal.*
(9) Mitigation of market distortions	The market for energy storage in the proposed countries the Sub-Program will target is still emerging. The use of blended concessional finance will help develop the market by crowding in other sources of public and private sector capital and helping to build sector capacity. *Further information is available on page 14 of this proposal.*
(10) Risks	The main risks this program will face are technology and business model risk, owing to the still emerging nature of many energy storage technologies. *Further information is available on page 14 of this proposal.*

13. **For DPSP projects/programs in non-CTF countries, explain consistency with FIP, PPCR, or SREP Investment Criteria and/or national energy policy and strategy.**		
The program will include Cambodia as an eligible country. Cambodia is an SREP eligible country and has a target under the United Nations Framework Convention on Climate Change (UNFCCC) to reduce energy related emissions by 16% against business as usual levels by 2030. Additionally, the Country Investment Plan for Cambodia identifies solar power as the promising renewable energy resource.[4] The Sub-Program will be complementary to efforts to develop Cambodia's renewable energy potential.		
14. **Stakeholder Engagement**		
ADB-PSOD has engaged with several private sector developers in the sector to assess potential interest in the proposed Sub-Program, the feedback from which has been positive. If the Sub-Program is approved, further engagement will be undertaken with additional public and private sector stakeholders. ADB-PSOD would also undertake significant stakeholder engagement for any sub-projects considered under the Sub-Program.		
15. **Gender Considerations**		
ADB's Strategy 2020 identifies gender equity as one of the five drivers of change to achieve the vision and strategic agenda of inclusive economic growth and to make the greatest impact on the development challenges in Asia and the Pacific. ADB undertakes gender analysis to systematically assess the impact of programs and projects on men and women and on their economic and social relationships. ADB-PSOD would assess each sub-project for gender and development impacts including key gender issues and actions proposed for the sub-project. Where possible, ADB-PSOD's deal teams also include gender elements into sub-project Development Monitoring Frameworks.		
16. **Indicators and Targets**		
Project/Program Timeline		
Expected start date of implementation		2018
Expected end date of implementation		2021
Expected investment lifetime in years (for estimating lifetime targets)		20 years
Core Indicators		**Targets**
GHG emissions reduced or avoided over lifetime (tonnes of CO_2-eq)		2,369,000
Annual GHG emissions reduced or avoided (tonnes of CO_2-eq/year)		118,000
Installed renewable energy capacity (MW)		105
Installed capacity of energy storage systems - power (MW)		11
Installed capacity of energy storage systems - energy (MWh)		11
Number of additional passengers using low-carbon transport per day		N/A
Energy savings cumulative over lifetime of investment (MWh)		N/A
Annual energy savings (MWh/year)		N/A
17. **Co-financing**		
		Amount (USD million)
ADB or other public finance	Debt or equity	54.15
Private Sector	Commercial lenders and sponsor's equity	90.25
Total co- financing		144.40
CTF investment		36.10
Total project cost		180.50
18. **Expected Date of MDB Approval**		
MDB approval of the first sub-project level is expected by Q1 2019		

[4] Climate Investment Funds. 2017. *Scaling up Renewable Energy Program (SREP): Revised Investment Plan for Cambodia*. July 2017. https://www.climateinvestmentfunds.org/sites/default/files/meeting-documents/cam_srep_ip_revision_-_20_july_2017_-_final2.pdf

DETAILED DESCRIPTION OF PROGRAM

A. Regional, Country and Sector Context

1. **Variable renewable energy has significant potential across Southeast Asia.** Installation rates of renewable energy continue to increase across the Asia Pacific Region. Although some countries in Southeast Asia have reasonably high levels of hydro, biomass or geothermal capacity, levels of *variable* renewable energy utilization remain low or negligible. Member countries of the Association of South East Asian Nations (ASEAN) have set a collective goal of deriving 23% of total primary energy supply from renewable energy by 2025[5] but current country targets may fall short of this goal. The current combined renewable energy targets for Cambodia, Philippines, Thailand and Viet Nam total nearly 50 gigawatt (GW) of new build capacity in the coming decades, as shown in the table below.

Table 1: Summary of renewable energy utilization and targets in selected CTF countries in Southeast Asia

Country	**Renewable energy capacity (inc. hydro and biomass)** (% of total MW capacity as of 2016)	**Renewable energy generation (inc. hydro and biomass)** (% of total MWh generated per annum in 2016)	**Variable renewable energy generation (ex. hydro or biomass)** (% of total MWh per annum in 2016)	**Stated renewable energy targets**
Cambodia	78%	32%	<1%	**Share of renewables:** 80% of total installed capacity by 2020 **Hydro:** 2.2GW by 2020
Philippines	31%	25%	2%	**Share of renewables in electricity generation:** 50% by 2030 **Renewable energy capacity addition:** 9.9GW by 2030
Thailand	22%	12%	5%	**Wind:** 3GW by 2036 **PV:** 6GW by 2036 **Biomass:** 5.6GW by 2036
Viet Nam	45%	41%	<1%	**Share of non-hydro renewables in electricity generation:** 6.5% by 2020 and 10.7% by 2030 **Wind:** 800MW by 2020 and 6GW by 2030 **PV:** 850 MW by 2020 and 12GW by 2030 **Biomass:** 750MW by 2020 and 3.2GW by 2030
			Total cumulative long-term targets:	~48GW

Source: Bloomberg New Energy Finance country summaries, IRENA[5], ADB analysis

2. **Energy storage technologies can help to increase the level of variable renewable energy deployment and emissions reductions.** Depending on their size, energy mix, age and level of sophistication, electricity grids can absorb a certain amount of variable renewable energy with minimal issues. In countries where long-term power sector plans or emission reduction targets will require significantly more variable renewable energy generation, a range of factors will be necessary to facilitate grid integration including: a suitable regulatory framework, more flexible generation capacity, energy storage capability, increased use of demand response, enhanced grid flexibility and smart grid technologies. Because variable renewable energy sources such as wind and solar are intermittent, as their usage increases, the need for energy storage technologies also increases. In higher-income countries, examples of energy storage deployment are beginning to emerge, partly in response to higher levels of renewable energy, but also because of increasing cost competitiveness of energy storage vis-à-vis traditional alternatives for other grid services. Examples include the 2016 Enhanced Frequency Response Tender in the United Kingdom (UK) which was dominated by battery

[5] International Renewable Energy Agency. 2018. *Renewable Energy Market Analysis: Southeast Asia*. IRENA, Abu Dhabi. http://irena.org/publications/2018/Jan/Renewable-Energy-Market-Analysis-Southeast-Asia [accessed 28 February 2018]

storage providers[6]; the construction of the then largest grid-level lithium-ion battery in California in response to the failure of a gas peaking plant[7]; and the successful construction of the world's largest, as of February 2018, grid scale battery built by Tesla in South Australia[8]. The same use cases, and others, should emerge across the Southeast Asia, but will face additional country, infrastructure, institutional, regulatory and political risks not faced in more mature markets, presenting barriers to more immediate technology transfer. Supporting early mover private sector projects with storage will help address some grid integration issues and will therefore allow solar and wind projects to provide a higher share of the power mix.

3. **Energy storage is still a nascent opportunity in Southeast Asia.** The Asia Pacific region has a total installed energy storage capacity estimated at around 2.1GW/1.6 gigawatt hours (GWh), projects are focused in developed markets of China, Japan, India, Australia and South Korea.[12] Southeast Asia, however, has only negligible amounts of energy storage. Some markets, such as Thailand and the Philippines exhibit promising project pipeline opportunities. In Thailand, the Electricity Generating Authority of Thailand (EGAT) already highlights three relatively small projects that utilize battery storage.[9] Thailand is particularly suited to early mover opportunities for battery energy storage development as it would be complementary to existing automotive manufacturing capabilities. In 2016, AES developed a 10MW battery storage project in the Philippines, then one of the largest facilities in Asia. The Philippines, which in some regions has upwards of 15 per cent penetration of variable renewable energy, has proposals for over 300MW of energy storage projects but returns remain uncertain.[10]

B. Energy storage technologies: opportunities and barriers

4. **Energy storage technologies are still emerging globally.** Not including legacy pumped hydropower facilities which total around 150GW[11], Bloomberg New Energy Finance ("BNEF") estimates that global energy storage capacity in 2017 was 2.8GW/4.9GWh[12]. While certain energy storage technologies are proven at some scale or in certain regions, other technologies are still emerging. Over time, various energy storage technologies will likely be complimentary depending on system requirements for speed or power rating of despatch and overall energy storage requirements. The diagram below shows that there are a range of energy storage technologies at various stages of development and with varying capital intensity. Pumped storage hydropower is the most mature energy storage technology, reflected in high levels of installed capacity globally. Lithium-based batteries present the next frontier for energy storage technologies and in recent years have come down rapidly in cost. It is expected that the Sub-Program will invest predominantly in lithium-based energy storage technologies, integrated with renewable energy, though other energy storage technologies may also be supported.

[6] KPMG. 2016. *EFR tender results: Market briefing*. September 2016. https://home.kpmg.com/content/dam/kpmg/uk/pdf/2016/10/kpmg-efr-tender-market-briefing-updated.pdf

[7] The Guardian. 2017. *California's big battery experiment: a turning point for energy storage?* 15 September 2017.https://www.theguardian.com/sustainable-business/2017/sep/15/californias-big-battery-experiment-a-turning-point-for-energy-storage

[8] South Australian Government. 2017. *World's largest lithium-ion battery set to be energised.* https://www.premier.sa.gov.au/index.php/jay-weatherill-news-releases/8333-world-s-biggest-lithium-ion-battery-set-to-be-energised

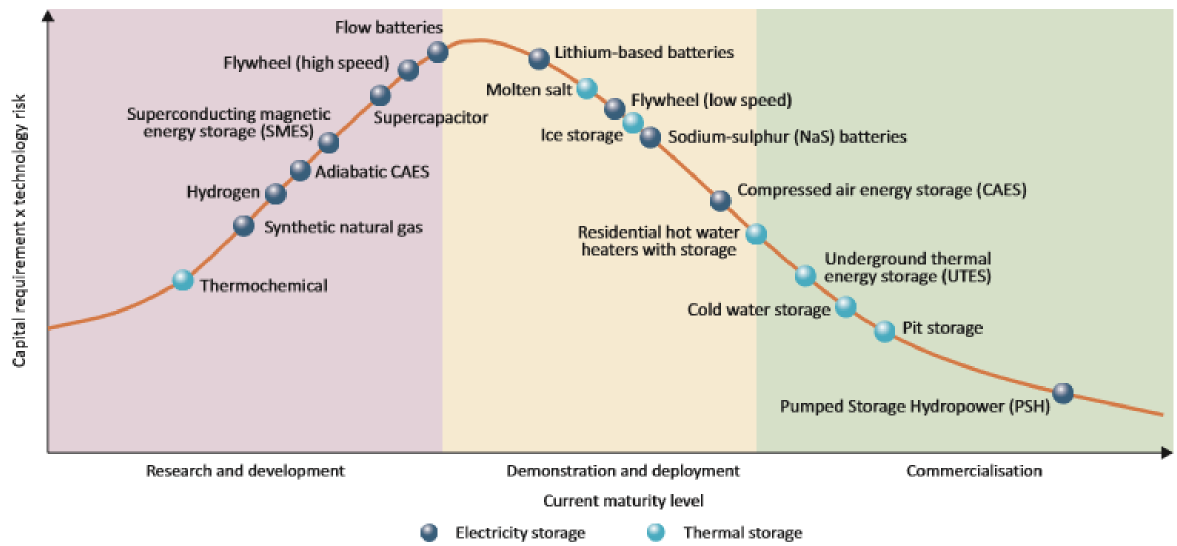
[9] Electricity Generating Authority of Thailand. 2017. *Battery Energy Storage: EGAT's New Dimension on Electricity Management System*. https://www.egat.co.th/en/news-announcement/web-articles/battery-energy-storage-egat-s-new-dimension-on-electricity-management-system [accessed 26 February 2018]

[10] Bloomberg New Energy Finance. 2017. *Economics of grid-scale batteries in the Philippines: Lots of interest, uncertain returns*, October 2017. https://www.bnef.com/core/insights/17163/view [subscription required

[11] International Energy Agency. 2017. *Tracking Clean Energy Progress*. https://www.iea.org/publications/freepublications/publication/TrackingCleanEnergyProgress2017.pdf

[12] Bloomberg New Energy Finance. 2017. *Global Energy Storage Forecast*. https://www.bnef.com/core/insights/17393 [subscription required]

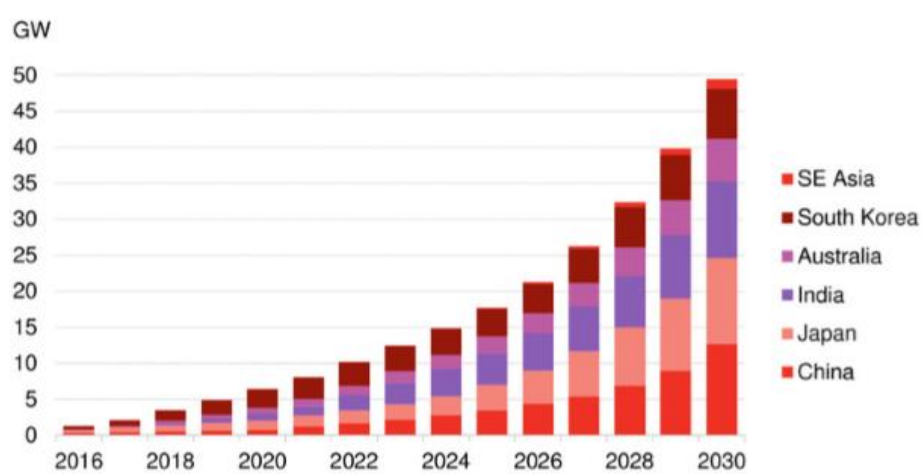
Figure 1: Energy storage technologies and level of maturity



Source: IEA[13]

7. **Significant expansion of energy storage will be required to meet renewable energy and climate targets.** The International Energy Agency estimates that 20GW of energy storage capacity will be needed globally by 2025 in scenarios consistent with keeping global temperature increases below 2 degrees Celsius.[14] BNEF estimates that the global energy storage market will grow from 2.8GW/4.9GWh in 2016 to an estimated 125GW/305GWh in 2030, requiring investment of $100 billion.[15] BNEF projections suggest that use cases will be nearly equally split between "behind-the-meter" residential, commercial and industrial applications and grid level balancing (of supply and demand) or renewable energy integration to smooth ramp rates and to reduce or avoid losses due to curtailment. By 2030, the Asia Pacific region is expected to become the biggest market for energy storage, growing from 2GW to nearly 50GW.

Figure 2: Estimated and forecast energy storage deployment in Asia Pacific Region (2016-2030, by power output)



Source: BNEF[12]

[13] International Energy Agency. 2014. *Technology Roadmap: Energy Storage*. https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapEnergystorage.pdf

[14] International Energy Agency. 2017. *Tracking Clean Energy Progress*. https://www.iea.org/etp/tracking2017/, https://www.iea.org/publications/freepublications/publication/TrackingCleanEnergyProgress2017.pdf

[15] Bloomberg New Energy Finance. 2017. *1H 2018 Energy Storage Market Outlook*, https://www.bnef.com/core/insights/18067 [subscription required]

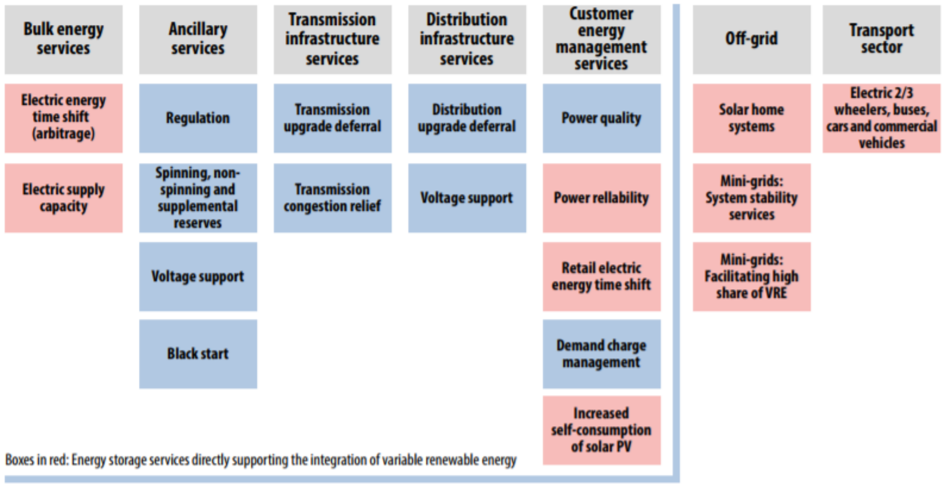
5. **The cost of storage technologies such as lithium-ion batteries has fallen rapidly, but bankable business models are still emerging and installed capacity is low.** Between 2010 and 2016, average lithium-ion battery prices fell by over 70 per cent.[12] Despite this, battery energy storage still adds incremental capital costs to renewable energy projects, with uncertain revenue streams. Because potential revenue streams for energy storage services can be diverse and policies in many markets are still nascent, financing models are still at an early stage. Storage is typically discussed in terms of either peak power capacity (MW or kW) or maximum energy storage capacity (MWh or kWh). The relationship between power and energy ratings for batteries can be understood through the following equation: Power x Time = Energy. The cost of a battery system will depend on the power rating and energy capacity. Fully-installed system costs for a grid-scale storage project in 2017 have been estimated at US$ 400-1400/kWh, depending on the power-to-energy ratio and software control requirements.[16] Analysis suggests that lithium-ion continues to provide the least cost solution for all energy storage use cases assessed, though other technologies such as flow batteries could prove more economic for high energy requirement storage projects.[17] Analysis of levelized cost of energy storage over various assumed applications and lifespans suggests a cost range for lithium-ion energy storage systems of between US$ 184-1274/MWh depending on the use case. Lazard's estimates are based whole of life levelized cost allowing for usable energy, whereas BNEF's estimates are based on upfront capex. Because the cost of energy storage is highly dependent on system specifications, the potential level of energy storage the Sub-Program will be able to support is more difficult to estimate than for renewable energy generation technologies alone. See *Appendix 4 – Estimates for cost of battery storage technologies*.

6. **Energy storage technologies can provide a range of services to energy markets, helping to increase renewable energy penetration and reduce emissions.** Energy storage technologies can help reduce grid emissions by facilitating higher levels of large- and small-scale variable renewable energy utilization. At a grid-level, energy storage can provide services including frequency support, voltage support, ramping support, peak-shaving, time-shifting of power despatch, transmission or distribution deferral, and reduce curtailment. For residential, commercial, industrial 'behind the meter' applications, energy storage can help increase reliability of power supply, support time shifting of power despatch, and even offer improved resource visibility and control for grid operators. Energy storage technologies can also provide services that have typically been provided by thermal generators, such as ancillary services including frequency control. The most common emerging uses of energy storage at a large-scale are for peak power or voltage support, or to assist with integration of variable or intermittent renewable energy technologies such as wind and solar in part by smoothing out ramp rates and allowing for more control over timing of despatch. On a smaller-scale, energy storage is typically being used to increase self-consumption of rooftop solar PV systems and can promote the installation of larger solar PV systems. Over time, the potential for many small-scale solar and storage systems to be aggregated into 'virtual power plants' is also possible.

[16] Bloomberg New Energy Finance. 2017. *Storage System Costs: More than just a Battery*. June 2017. https://www.bnef.com/core/insights/16561 [subscription required]

[17] Lazard. 2017. *Lazard's Levelized Cost of Storage Analysis – Version 3.0*. November 2017. https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf

Figure 3: Energy storage services



Source: IRENA[18]

7. **Increased project cost, complexity and regulatory uncertainty are barriers to higher uptake of energy storage technologies.** Not including legacy pumped hydro assets, energy storage is a relatively new addition to the clean energy investment landscape. Although the costs of certain technologies such as battery storage are falling, adding storage will still result in additional project capex, which could reduce project returns. Adding storage may also increase project complexity, resulting in project development costs. Additionally, in many markets, developers, regulators and system operators may still be relatively unfamiliar with the technologies. Once deployment of these technologies increases in scale and can various use cases and financing structures have been demonstrated, private sector developers will be more likely to implement energy storage projects without concessional support.

C. Overview of the Proposed Program

8. **The proposed Sub-Program would focus on "Renewable Energy Plus (RE+)" opportunities.** CTF aims to provide scaled-up financing to contribute to the demonstration, deployment, and transfer of low-carbon technologies with a significant potential for long-term emission reductions. Dedicated Private Sector Programs are intended to deliver scale (in terms of development impact, private sector leverage, and investment from CTF financing) and speed (faster deployment of CTF resources, more efficient processing procedures), while at the same time maintaining a strong link to country priorities and CTF program objectives. This particular CTF Dedicated Private Sector Program ("DPSPIII") proposal is focused on the Renewable Energy Plus (RE+) window identified in the December 2017 CTF DPSP III Proposal.[19] The RE+ window identified solar, energy storage and distributed generation as potential priority sub-sectors. As per the 2012 CTF Private Sector Operational Guidelines, potential investments or sub-projects supported by the proposed Sub-Program would be subject to comprehensive due diligence as part of the internal ADB private sector approval process. The Sub-Program would aim to deploy CTF funds into up to three transactions over an investment period of three years. The Sub-Program has good alignment with the respective target CIF Country Investment Plans, which all have a strong emphasis on renewable energy and/or grid modernization.

[18] International Renewable Energy Agency. 2017. *Electricity Storage and Renewables: Costs and markets to 2030*. http://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf
[19] Climate Investment Funds. 2017. *CTF DPSP III Proposal*. December 2017. https://www.climateinvestmentfunds.org/sites/default/files/meeting-documents/ctf_tfc.20_5_ctf_dpsp_iii_proposal.pdf

9. **Investment will occur on concessional terms alongside other sources of capital.** The Sub-Program would include $36.1 million of CTF funds to be invested in the form of debt or as guarantees alongside cofinancing from public and private sources totalling an estimated $180.50 million. CTF funds would be invested into integrated renewable energy and energy storage sub-projects in which ADB Ordinary Capital Reserves ("OCR") are also expected to be deployed. CTF funds, the purpose of which is to overcome additional costs or risks faced by integrated renewable energy and energy storage projects, would be made on different terms to other investors.

10. **Investment modality and structuring will be determined by the nature of the transactions.** Due to the nascent nature of the market for energy storage investments, the appropriate investment modality and structuring will be determined on a case by case basis. Financing instruments will include senior or subordinated debt and guarantees. Project or corporate finance structures could be used depending on the nature of the project and sponsor. It is important that this Sub-Program has the flexibility to adapt to market needs over the implementation period, especially given the rapidly evolving trends in energy storage.

D. Financial Instruments and Procedures

11. **The Sub-Program use debt instruments in cases where there is a marginal gap to reach bankability.** Because of the high upfront capex required for Integrated Renewable Energy and Energy Storage projects, availability of long-term debt is very important to project economics. The Sub-Program would seek to identify transactions for which project economics or risk allocations are preventing bankability. Any investment would be subject to ADB's internal due diligence and approval process including environmental and social safeguards and Know Your Customer assessments.

12. **CTF funds would be deployed according to the principle of minimum concessionality.** Investments would be made on a case-by-case basis to catalyze projects that would not have occurred without CTF support. Initial identification of projects potentially suitable for CTF funding would be undertaken by ADB's Private Sector Operations Department. A separate team would then be assigned to the concessional finance investment to assess its merits. CTF investments would likely be on different terms or even timing to ADB's OCR investment, depending on the characteristics of each sub-project or transaction. (*For more information, see section viii. Effective Utilization of Concessional Finance on p.14)*

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E. Fit with CTF investment criteria

i. Potential GHG Emissions Savings

13. With $38 million of CTF funding, the Sub-Program would help to finance GHG emission reductions estimated at 118,000 tCO_2e annually. The reduction in GHG emissions over the duration of the Sub-Program is estimated at 2,369,000 tCO2e. For more information, please see section *xii. Performance Indicators*.

ii. Cost Effectiveness

14. With total CTF funds of $38 million and estimated GHG emission reductions of 2.4 million tCO_2e over the Sub-Program life, the cost effectiveness of CTF funds is $16 per t$CO_2$e. Energy storage technologies are expected to continue to fall in cost as global production volumes increases. At a country level, this Sub-Program could also help accelerate the technology learning curve and cost reductions for nearly all components of total energy storage system costs including; grid connection, developer margins, financing costs, engineering, procurement and construction (EPC) and balance of system or battery pack components if they are locally manufactured. Please see *Appendix 4 – Estimates for cost of battery storage technologies*.

iii. Potential Replication and Scale up

15. The Sub-Program has significant transformation potential. Early demonstration of integrated renewable energy and energy storage projects could help in two ways. Firstly, by reducing the perceived higher levels of project risk and secondly, through reducing perceptions regarding the limitations of variable renewable energy. By 2030, BNEF estimates that total battery energy storage capacity in Southeast Asia has the potential to reach approximately 1300MW/1300MWh.[12] If the proposed Sub-Program helps catalyse 10% of this potential growth, or 130MW/130MWh, then the scale up potential is significant. The implementation of the Sub-Program will also contribute directly to reduced electricity sector emissions and therefore to progress towards 2030 Nationally Determined Contributions for greenhouse gas emission reductions. Nationally Determined Contribution targets are shown in the table below. Demonstration of energy storage technologies could also potentially lead to higher ambition to reduce power sector emissions and more supportive policies for variable renewable energy.

Table 2: Selected country targets for emissions reductions

Country	Nationally Determined Contribution
Cambodia	Contingent reduction in greenhouse gas emissions of 27 per cent from the projected business-as-usual level by 2030.[20]
Philippines	Contingent reduction in energy, transport, waste, forestry and industry sector greenhouse gas emissions of about 70 per cent from the projected business-as-usual level by 2030.[21]
Thailand	Economy-wide reduction in greenhouse gas emissions of at least 20 percent from the projected business-as-usual level by 2030. Contingent target of 25 per cent.[22]
Viet Nam	Economy-wide reduction in greenhouse gas emissions of at least 8 per cent per cent from the projected business-as-usual level by 2030. Contingent target of 25 per cent.[23]

[20] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Cambodia/1/Cambodia%27s%20INDC%20to%20the%20UNFCCC.pdf
[21] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Philippines/1/Philippines%20-%20Final%20INDC%20submission.pdf
[22] http://www4.unfccc.int/ndcregistry/PublishedDocuments/Thailand%20First/Thailand_INDC.pdf
[23] http://www4.unfccc.int/ndcregistry/PublishedDocuments/Viet%20Nam%20First/VIETNAM'S%20INDC.pdf

iv. Development Impact

16. Energy storage can improve the utilization of variable renewable energy, reducing economic costs to society above and beyond the benefits attributable to reduced emissions. At a grid level, energy storage can help reduce or avoid curtailed electric energy. At a household or business level, increased self-generation and consumption of electricity can result in cheaper and more reliable energy supply. Additionally, energy storage can make grids more resilient by turning households and businesses into sources of energy supply as well as demand. This is connected to Sustainable Development Goals (SDGs)[24] #7, #9 and #11.

- *SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all*;
- *SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*
- *SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable*

17. The Sub-Program will help to accelerate the rate of technology transfer to eligible CTF countries. NDC targets above are in all cases contingent upon, or include, higher aspirational or conditional targets subject to increased levels of international support including technology transfer and capacity building. The Sub-Program could, therefore, play a part in increasing the overall emissions reduction ambition of target countries. This is connected to SDG #13: *Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy*.

18. Energy storage, when paired with renewable energy, can result in positive localized environmental air quality co-benefits by reducing emissions of air pollutants resulting from the use of fossil fuel generation of electricity, including diesel generators for backup power. This is connected to SDG #3: *Ensure healthy lives and promote well-being for all ages*.

19. Implementation of the Sub-Program is expected to have a direct effect on local incomes and poverty alleviation within the vicinity of individual projects. During construction and then operation of electricity generation facilities, the employment opportunities for local skilled and unskilled labor will provide a source of income for men and women who qualify for employment. This effect has been observed in other CTF programs including the ADB Thailand Private Sector Renewable Energy Program. This is connected to SDG #8: *Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all*

v. Implementation Potential

20. Of the four countries identified for this proposed Sub-Program (Cambodia, Philippines, Thailand and Viet Nam), Thailand and the Philippines are showing the highest potential readiness. It is not surprising that Thailand and the Philippines are showing higher readiness for energy storage as they have relatively higher levels of variable renewable energy utilization. Over the proposed three-year implementation period of the Sub-Program, the private sector investment environment in Cambodia and Viet Nam may improve as levels of variable renewable energy increase. Thailand is already demonstrating a supportive policy environment for energy storage. As mentioned above, the Electricity Generating Authority of Thailand (EGAT) already highlights three relatively small projects that utilize battery storage in the country.[9] In late 2017, Thailand also successfully ran a tender focused on 'firm capacity', with some energy storage solutions bidding in, albeit unsuccessfully based on the program requirements, which better suited biomass. Several Thai companies have also stated ambitions to develop energy storage manufacturing capabilities and Thailand's automotive sector has the potential to capture a portion of the global electric vehicle market, which is complementary to energy storage for stationary power applications. Because of this, regulators and key stakeholders, including potential counterparties, in Thailand and Philippines are well positioned to demonstrate potential for support and participation in the proposed Sub-Program.

[24] http://www.un.org/sustainabledevelopment/sustainable-development-goals/

vi. Additional Costs and Risk Premium

21. The Sub-Program is designed to address the additional costs and risk premium faced by developers of integrated renewable energy and energy storage projects in target countries in Southeast Asia. ADB-PSOD expects that developers of projects incorporating storage will face incremental costs above those just focused on renewable energy generation, without certainty of adequate returns. As a result, ADB-PSOD expects that the rates of return will be either below market thresholds or above the normal market threshold for renewables but below the required risk premium for adding energy storage. Additionally, developers considering integrated renewable energy and energy storage projects as opposed to just renewable energy projects may face additional project development costs due to greater project complexity.

22. Additional costs are highly project specific and depend on energy storage system requirements. Figures highlighted above suggest this could range from US$ 400-1,400/kWh for a grid-scale battery. The table below demonstrates illustrative incremental costs of implementing battery storage alongside renewable energy generation for various potential power to energy configurations. This is an estimate of the potential incremental capital costs borne by project developers.

Table 3: Illustrative estimated incremental costs of integrated renewable energy and energy storage

Renewable energy generation capacity and cost	Assumed energy storage system configuration[25]	Illustrative incremental cost of adding energy storage[26]	Illustrative incremental cost of adding energy storage (%)
10MW = ~$10m	1MW/1MWh	~$0.58m	~6%
	1MW/2MWh	~$1.2m	~12%
	1MW/10MWh	~$5.8m	~58%

Note: This table is provided as an illustrative example only, to demonstrate how differences in battery energy storage system specifications can increase project costs.

vii. Financial Sustainability

23. The viability of individual projects comprising the Sub-Program will be ensured through available off-take arrangements in PPAs, potential for additional revenues from regulatory support focused on energy storage (e.g. supplemental feed-in tariffs) and improved economics for rooftop systems due to higher self-consumption of solar generation. CTF cofinancing will be structured to enhance the financial viability of the project by reducing the weighted average cost of capital. By 2030, energy storage technologies, and in particular battery storage, is expected to see further reductions in cost as manufacturing capacity scales up. The Sub-Program will support individual sub-projects that can help catalyse and accelerate uptake of these technologies in the target countries.

viii. Effective Utilization of Concessional Finance

24. When deploying CTF resources, ADB will adhere to the DFI agreed Blended Concessional Finance Principles for Private Sector Projects.[27] Concessionality will be targeted at reducing the incremental costs related to the installation of storage alongside renewable energy, in order to incentivize developers to consider technologies which may not currently meet expected equity hurdle rates or generate cash flow sufficient to service debt payments.

[25] Assumes that 10% of the rated generation capacity is added as peak power output capacity (MW) for the energy storage system, with varying levels of energy storage capacity (MWh)

[26] Based on BNEF cost estimates for grid-scale battery costs in 2018 provided in the Appendix 4 (@$581/kWh). Note that these prices may differ from vendor prices available in the target countries for this Sub-Program

[27] African Development Bank; Asian Development Bank; Asian Infrastructure Investment Bank; European Bank for Reconstruction and Development; European Development Finance Institutions; European Investment Bank; Inter-American Development Bank Group; Islamic Corporation for the Development of the Private Sector; and International Finance Corporation. 2017. *DFI Working Group on Blended Concessional Finance for Private Sector Projects: Summary Report*, October 2017. Note: "DFI" refers to Development Finance Institution. http://www.ifc.org/wps/wcm/connect/corp_ext_content/ifc_external_corporate_site/solutions/products+and+services/blended-finance/blended-finance-principles

Similarly, for any revenues that are dependent on new or untested assumptions about technology performance, CTF funding may be used in a subordinated basis from either a cashflow and/or security perspective.

ix. Mitigation of Market Distortions

25. Because there is very little private sector involvement in energy storage finance in the target countries, ADB-PSOD believes the likelihood of any market distortions is low. In-fact, the Sub-Program should help catalyse the market by demonstrating viable business and financing models for integrated renewable energy and energy storage projects.

x. Risks

26. **Lack of adequate pipeline:** Energy storage is an emerging technology in the target countries. As a result, project sponsors are less likely to be familiar with the technology and could be more apprehensive about making investments. Early scoping and conversations with potential project developers suggests there is enough interest to begin work in H1 2018 on the first sub-project under this Sub-Program. ADB-PSOD expects interest and activity in energy storage to increase over the Sub-Program implementation period. Overall, ADB-PSOD believes there is a sufficient pipeline and further sector engagement with project developers will be undertaken to mitigate this risk. Approval of CTF funding for the Sub-Program will be a necessary pre-requisite to further engagement.

27. **Technology risk:** Energy storage does not have a long-term operating history in the target markets. As a result, there is a risk that technologies may not perform to expectation. To mitigate this risk, ADB-PSOD will pay particular attention to the proposed technology used for each sub-project and precedents for its use in other markets. Extensive technical diligence will be undertaken for all potential sub-projects and ADB-PSOD will engage specialist expertise and lenders' technical advisors to assist with technical due diligence for sub-projects.

28. **Legal and regulatory risk:** The legal and regulatory framework for energy storage is still nascent in target countries and may change over Sub-Program implementation or investment period. Legal due diligence for each sub-project will include a review of the regulatory framework for energy storage use in the target country and include consideration of the risk of change in law during the term of the financing. Legal due diligence will also include a review of all major project documents, including those relating to offtake or power purchase agreements, equipment and maintenance contracts and grid connection agreements.

xi. Fit with principles identified in the DPSP III Proposal[19]

Readiness:	See "Section v. Implementation Potential" above
Fit with priority thematic areas identified:	The program will target the Renewable Energy Plus (RE+) thematic area with a focus on energy storage either in isolation or alongside solar, wind or other renewable energy generation technologies.
Innovation:	Energy storage is an emerging area for renewable energy markets and financiers and so this Sub-Program will result in significant innovation at a project level but also at a grid planning level.
Leverage:	This Sub-Program is expected to leverage $4 of cofinancing for every $1 of CTF support. Leverage is lower than might be expected for a purely renewable energy focused sub-program because of the early nature of energy storage resulting in higher upfront capex and so higher levels of concessional finance to catalyze projects.
Impact:	See "Section iv: Development Impact" above

xii. Performance Indicators

29. The performance indicators outlined below are derived from the CTF Results Measurement Framework and will be tracked according to CTF guidelines at least annually. ADB notes, however, that there is no specific guidance on results measurement for energy storage sub-projects and so we have provided supplementary indicators for energy storage.

Table 4 – Sub-Program performance indicators[28]

Core Indicator		Performance
GHG emission reductions	- Annual (tCO_2e/year)	118,000
	- lifetime (20-year cumulative tCO_2e)	2,369,000
Electricity production	- New RE capacity (MW installed)	105
	- Additional Power Generation (MWh/year)	207,000
Cost effectiveness of CTF funds ($/t CO_2)		16
CTF leverage ($ of cofinancing for each $ of CTF support)		4
Employment	- Number of construction and operations jobs	960

Table 5 - Supplementary energy storage indicators

Energy storage	- Additional power capacity (MW)	11
	- Additional energy capacity (MWh)	11

[28] Other performance targets and indicators quantifying developmental impacts will be included in the formulation of ADB's Project Design and Monitoring Frameworks for each individual sub-project to be supported under this program.

Appendix 1 – Pipeline of potential sub-projects

[SECTION REDACTED]

Appendix 2 – CTF Investment criteria calculations

Expected financing and leverage

	USD m
<u>Renewable Energy and Energy Storage capex</u>	180.50
-	
Sources of funds	
CTF	36.10
ADB*	54.15
Private sector debt and equity	90.25
Leverage - total project capex	4
Leverage - total private sector	2.5

***** Note: As per the pipeline table above, ADB's overall support for a project may be higher than this amount but for the purpose of this estimate we only consider the cofinancing of the integrated renewable energy and energy storage component.

CTF cost effectiveness

CTF Funds	38	USD m
Emission reductions for Sub-Program (lifetime)	2.4	MtCO2e
Cost effectiveness of CTF funds	16	USD per tCO2e

Assumptions

Total capital available for integrated renewable energy and energy storage projects and capacity supported	**Total capital for energy storage system capex and capacity supported**	**Annual renewable energy generation**	**Annual greenhouse gas emissions reduction potential**
$171.5 million @ $1.6m per MW* = 105MW **average assumed cost of utility and rooftop solar*	$9m (5% of total project capex) @ 0.8MW/MWh (1:1 power to energy ratio = 11MW/11MWh	105MW @ 22.5% capacity factor = 207,000 MWh	207,000MWh * 0.5710 tCO2e grid emissions factor = 118,000 tCO2e

Note: Emissions reductions are based on the renewable energy capacity, which the energy storage capacity will help to support. Any potential incremental emissions savings from the energy storage capacity will depend heavily on the individual sub-project use case and charge/discharge applications.

Jobs created

ADB estimates that Sub-Program could support an estimated **960 jobs** including construction and operational roles.

Appendix 3 – Causality between battery storage services and emission reductions

Table 6: Direct causality between energy storage services and emissions reductions

Note: it is likely that energy storage is required across all these services to increase overall renewable energy penetration levels. A single system could in-fact provide multiple services. This analysis, however, only seeks to establish the potential causality for each individual use case.

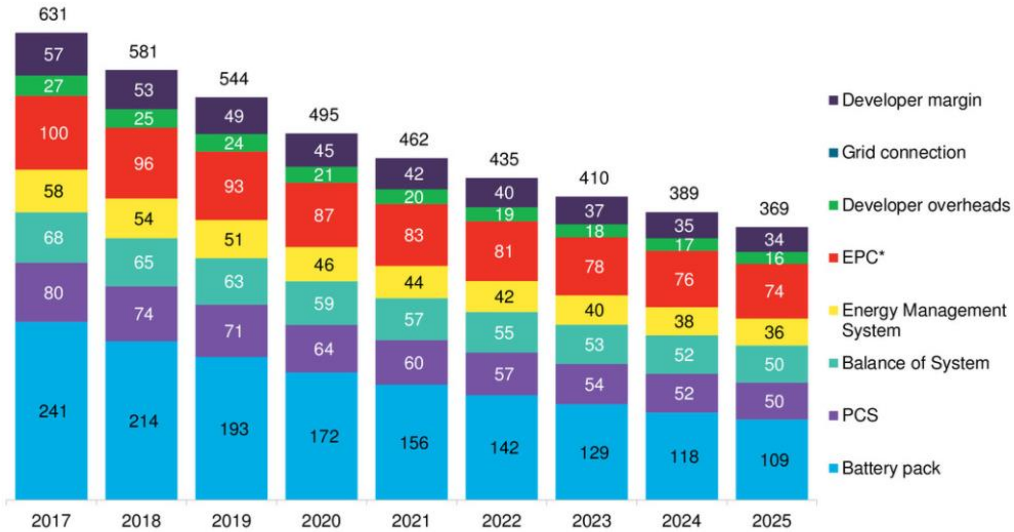
Category	Service	Potential for emissions reductions	Nature of direct emission reductions
Bulk energy services	Electric energy time shift (arbitrage)	**Yes**	If energy storage avoids or reduces curtailment, there would be additional emission reductions to the extent the additional renewables displaced higher emissions sources of generation. Where a renewable generator is able to shift grid output from one-time period to another, it may be result in higher or lower emissions reductions depending on the difference between grid-emissions factors at time of despatch.
	Electric supply capacity	**Yes**	To the extent that energy storage technologies allow for higher levels of renewable energy generation, additional emission reductions are possible.
Ancillary services	Frequency regulation	**Maybe**	Where energy storage technologies can replace frequency regulation services traditionally provided by fossil fuel generators, there may be potential to reduce emissions. In this case, it depends on the source of the power used to charge the energy storage system which is then used periodically for frequency regulation services.
	Spinning, non-spinning and supplemental reserves	**Maybe**	As above, potential for emission reductions depends on the source of the power used to charge the energy storage system
	Voltage support	**Maybe**	As above
	Black start	**Maybe**	As above
Transmission infrastructure services	Transmission upgrade deferral	**Maybe**	Depends on analysis of various options and source of power used to charge energy storage system
	Transmission congestion relief	**Yes**	Where energy storage technologies can help avoid curtailment of renewable energy sources due to transmission congestion, there is potential for contribution to emissions reductions
Distribution infrastructure services	Distribution upgrade deferral	**Maybe**	Depends on analysis of various options and source of power used to charge energy storage system
	Voltage support	**Maybe**	As above, potential for emissions reductions depends on the source of the power used to charge the energy storage system
Customer energy management services (Residential and C&I)	Power quality	**Maybe**	As above
	Power reliability	**Maybe**	As above
	Retail electric energy time shift	**Maybe**	If time shifting, using the energy storage system was undertaken when grid-emissions intensity was low and discharged when grid-emissions intensity was higher, there could be potential for additional emission reductions
	Demand charge management	**Maybe**	Demand charge management is a form of time shifting and so as above, the potential for emission reductions depends on the source of the power used to charge the energy storage system
	Increased self-consumption of solar PV	**Maybe**	If the availability of an energy storage system leads households to install larger solar PV systems, there is potential for contribution to additional emission reductions. Otherwise, time shifting per se will not in itself reduce emissions
Off-grid	Solar home system	**Yes**	Where off-grid energy storage systems replace biomass or fossil fuel alternatives, emission reductions will be possible
	Mini-grids: System stability services	**Yes**	As above
	Mini-grids: Facilitating high share of variable renewable energy	**Yes**	As above
Transport sector	*Transport applications of energy storage are not a focus of this Program*		

Source: ADB based on IRENA taxonomy of energy storage services

Appendix 4 – Estimates for cost of battery storage technologies

Figure 4 – Benchmark capital costs for a fully-installed grid-scale energy storage system

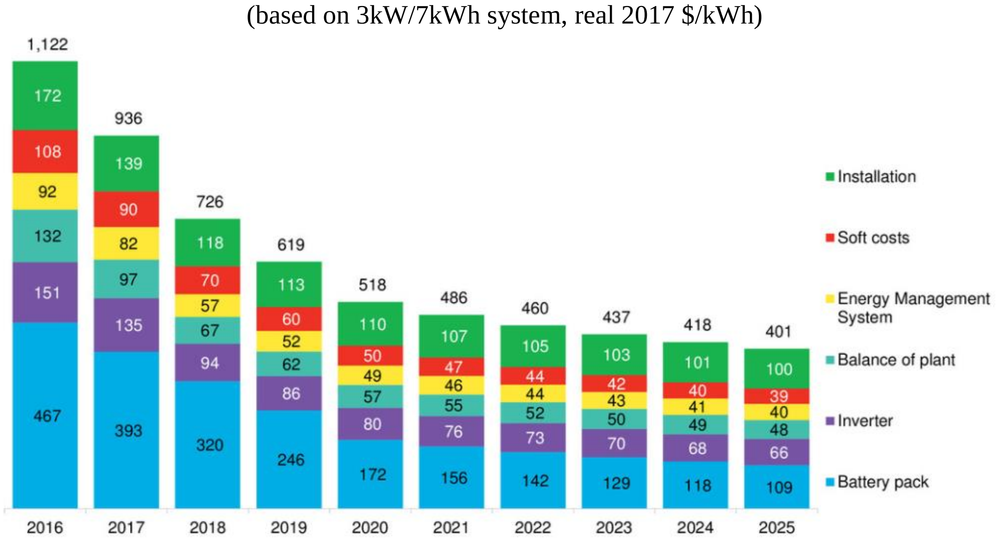
(based on 1MW/1MWh project, real 2017 $/kWh)



Source: BNEF[12]

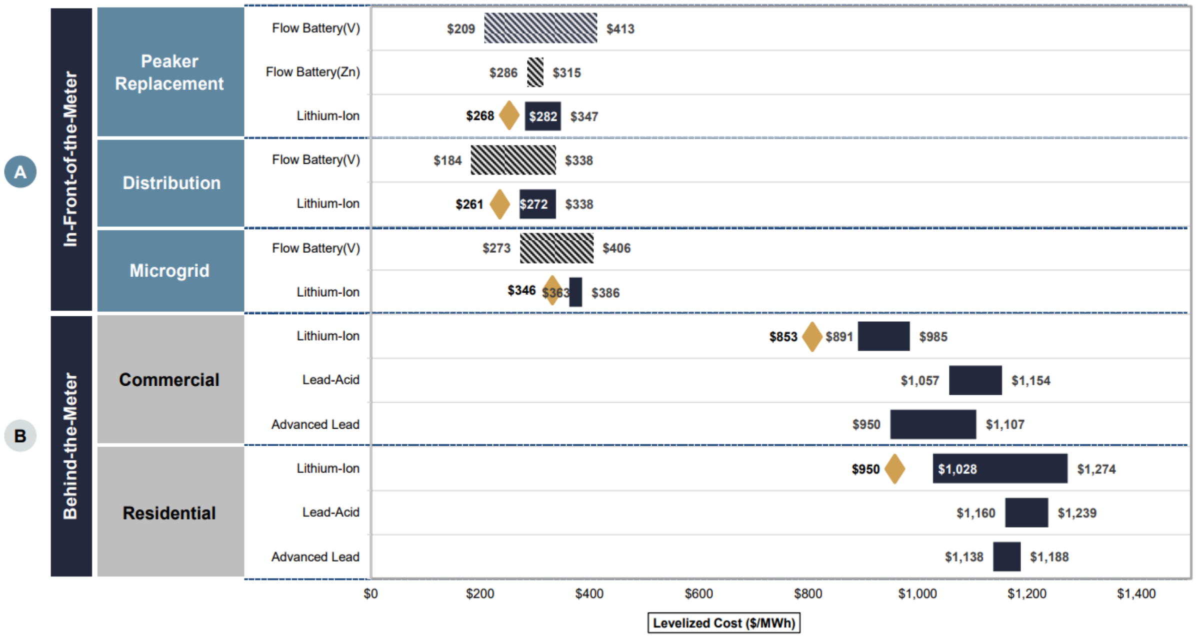
Figure 5 – Benchmark capital costs for a fully-installed residential energy storage system

(based on 3kW/7kWh system, real 2017 $/kWh)



Source: BNEF[12]

Figure 6 – Lazard's unsubsidized levelized cost of storage comparison for various use cases and technologies - $/MWh



Source: Lazard[17]