Accelerating toward Competitive Landscape for Battery Energy Storage in India: Analysing Cost Dynamics of Li-ion Batteries

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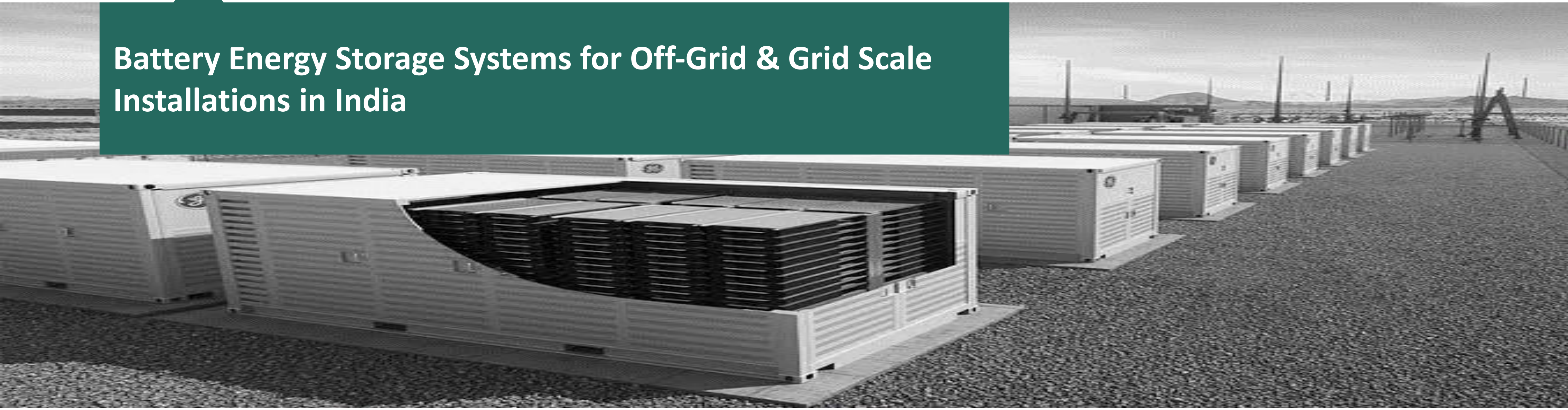
Battery Energy Storage Systems for Off-Grid & Grid Scale Installations in India

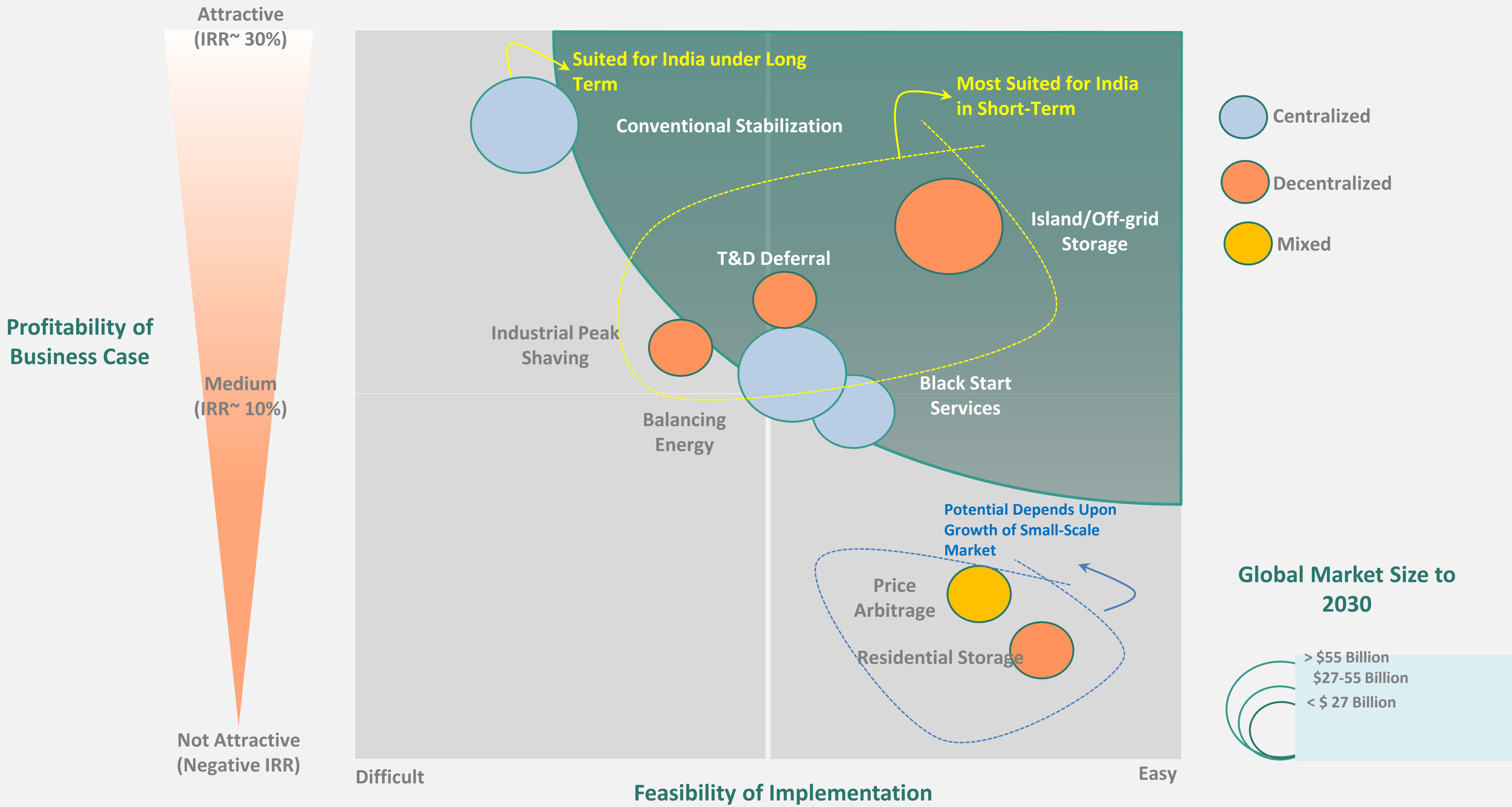


UNEARTHING POWERFUL POTENTIAL OF BATTERY STORAGE FOR RENEWABLE ENERGY IN INDIA

STORAGE BUSINESS CASE MASSIVE IN NEAR FUTURE WITH CLOSE TO $160 BILLION CUMULATIVE MARKET SIZE GLOBALLY, WITH INDIA SET TO BE THE LEADING CONTRIBUTOR

With growing solar PV installations and further gaining up in renewable power capacity additions clubbed with enticing business for electric vehicles in India, the rationale behind the battery energy storage systems (BESS) is certain to embellish and gather momentum in the country. The storage market is already making sustained gains and is expected to flourish with near term market size of close $160 Billion and grow further to $ 300 Billion by 2030. Interestingly this entire energy storage market shall see BESS being the largest contributor in terms of share of above 50% globally. This shall be no different in India either and shall be not be a surprise that it might stand scaled up to 70-75% in the country. Having said that with India being still in the nascent phase for the BESS there are certain push elements desired for the market gain momentum and unwind it's entire market potential in the country for there are terrific benefits for its application.

Exhibit 1 Storage Business Case Attractive Indices for Near Future – Off-Grid & Grid Scale Installations



Source: eninrac research & analysis, BCG Analysis

BESS Market : Value Chain Analysis

The stability of the power grid depends on various actors working in concert to maintain a balance between electricity supply and demand. Traditionally, electricity assets are categorized based on their function; i.e., generation, transmission, or distribution. Storage systems differ in that they have the ability to balance supply and demand across the segments that comprise the value chain. The new control points offered by storage systems enable operators to selectively respond to fluctuations in grid inputs and outputs. Such functionality is essential to realizing the vision of "smart cities" where producers and consumers are equally informed and equipped to respond to market dynamics in real time. However, many electrical grids were not originally designed to accommodate assets that can both generate and consume electricity. The implications of two-way power flow and the role of energy storage within a modern electricity ecosystem have been studied by many institutions.

Exhibit 2: Energy Storage and its Application across the Power Sector Key Value Chain

1. Generation
Storage offers an emission free alternative to plant additions as utilities face aging plants & stringent environmental regulations

Technologies: PHS, CAES, Flow Batteries, Hydrogen

Application: Electric energy time shift, Electric supply capacity

2. Transmission & Distribution

Storage enables the deferment of T&D investments as utilities seek to maintain reliability while satisfying growing loads and integrating renewable energies

Technologies : Traditional electro thermal, SMES, super capacitors, flow batteries, CAES

Applications : Transmission support, congestion relief, deferral , substation on site power

3. Renewables

Storage addresses the intermittency issues of renewables by delivering energy only when the grid requires it

Technologies : PHS, CAES, Traditional Electro thermal, Flow Batteries, Hydrogen

Applications : Time shift, capacity firming, wind integration

4. Consumers

Storage ensures power quality and reliability during outages as well as enables "behind the meter" energy management practices

Technologies : Li-ion, NaS, Pb-Acid, Flywheel, Flow Batteries

Applications : Time of use energy cost management, Demand charge management, Electric reliability, Electric power quality

5. ISO

Storage improves the quality and stability of a grid that seeks to accommodate disparate and dynamic supply and demand points

Technologies : Fly wheels, Li-ion, SMES, Super capacitors, Pb Acid

Applications : Load following, Area regulation, Electric supply reserve, Voltage support

Source: Deloitte, eninrac research

Li-Ion Module Cost Trends & Outlook

Since their introduction into the mass market in 1990, Li-ion batteries have been used in applications such as electronics, medical devices and power tools. By 2010, their total market volume increased one order of magnitude (from about 2 to 20 GWh), reaching a total annual market value of about Euros 6.5 Billion largely owing to portable electronics. From 2010 onwards Li-ion batteries have been growing annually at 26 % in terms of production output and 20 % in terms of value.

Global Market Size for Li-Ion Batteries in FY 2019-20

130 GWh

BESS with li-ion batteries can be utilized in front-of-the-meter (FTM) as well as behind-the-meter (BTM) applications, while BESS using flow batteries are generally found in FTM applications.

Electric Vehicles Segment being the emerging driver for Li-Ion battery in world

More than 3 Million Passenger EV's are on road as on FY 2018 which constitutes only 0.2% of the total fleet size

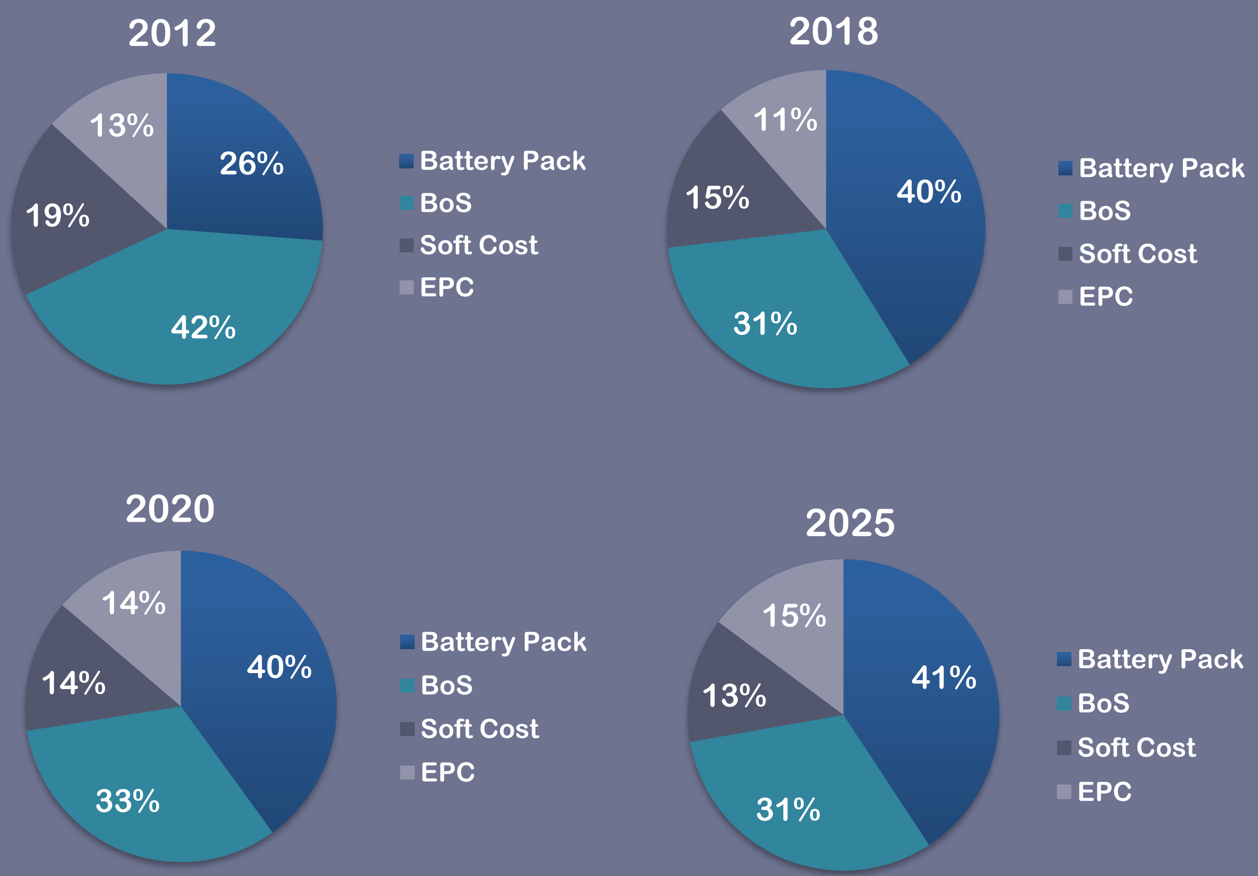
Stationary storage shall be another big boost for Li-Ion battery in the global scenario and even more for India

The global stationary storage market currently exceeds 160 GW in FY 2018 which is dominated by pumped storage plants & in future shall have batteries play a leading role

Large scale peaking capacities for wholesale-market sales and enabling front of the meter applications in the world

The application of Li-Ion in the front-of-the-meter application (FTM)) shall result in massive savings potential for the power transmission and distribution utilities in India

Exhibit 3: Share of Major Cost Components for BESS in terms of MWh from 2012 to 2025 (Forecasted)



Cost Component Analysis

If we look onto the cost contributors of BESS (for 1MWh) systems the leading driver has been the battery pack from 2018 as there was a shift from 2012 and has increased to 40% in the space of 6 years from 2012-18. It is anticipated that from 2018 and beyond till 2030 and is expected to be in the limit of 40-42%. The second driver of cost for BESS is the balance of system (BoS) for which there again has been a decline trend observed and is expected to remain in between 31-33% till 2030.

The other components like soft costs have seen a marginal decline while the EPC costs have seen a marginal increase from 2012 levels and is expected to be ~13% and 15% respectively by 2030.

BoS- Balance of Systems; EPC – Engineering , Procurement & Construction Cost

Source: eninrac research & analysis

Levelized Cost of Storage as per front-of-the meter (FTM) & back-of-the-meter (BTM) Applications

Levellized Cost of Storage (LCOS) reflects the total cost of the BESS divided by the energy it is projected to provide over the course of its useful life. When comparing a BESS against an alternative resource, the LCOS is the preferred unit of measurement. The LCOS includes all of the aforementioned installed costs, and adds the projected operational expenditures, such as maintenance costs and battery degradation over time. While batteries are certainly not the only technology to suffer from degradation, the industry has relatively little experience with its effect on battery life, especially with the newer li-ion battery chemistries. As such, estimates of the energy portion of LCOS (i.e., the divisor in the LCOS ratio) are likely to become more precise in the coming years as more BESS operational data becomes available for evaluation.

BESS with li-ion batteries can be utilized in front-of-the-meter (FTM) as well as behind-the-meter (BTM) applications, while BESS using flow batteries are generally found in FTM applications. The typical FTM and BTM applications are indicated as below:

i. FTM Use - The applications typically include large scale peaking capacity sold into a wholesale market, transmission & distribution, and utility-scale solar PV + battery energy storage

LCOS is analogous to the Levellized Cost of Energy (LCOE) calculation but uses charging cost as fuel cost and takes the discharged electricity instead of generated electricity.

$$LCOS = \frac{\sum(Capital_t + O\&M_t + Fuel_t) * (1+r)^{-t}}{\sum MWh_t * (1+r)^{-t}}$$

.... Equation (i)

Where,

$Captial_t$ = Total capital expenditure in year 't',

$O\&M_t$ = Fixed operations and maintenance costs in year 't',

$Fuel_t$ = Charging cost in year 't'

MWh_t = The amount of electricity discharged in MWh in year 't'

't' = Measure of the capacity factor

$(1+r)^{-t}$ = The discount factor for year 't'

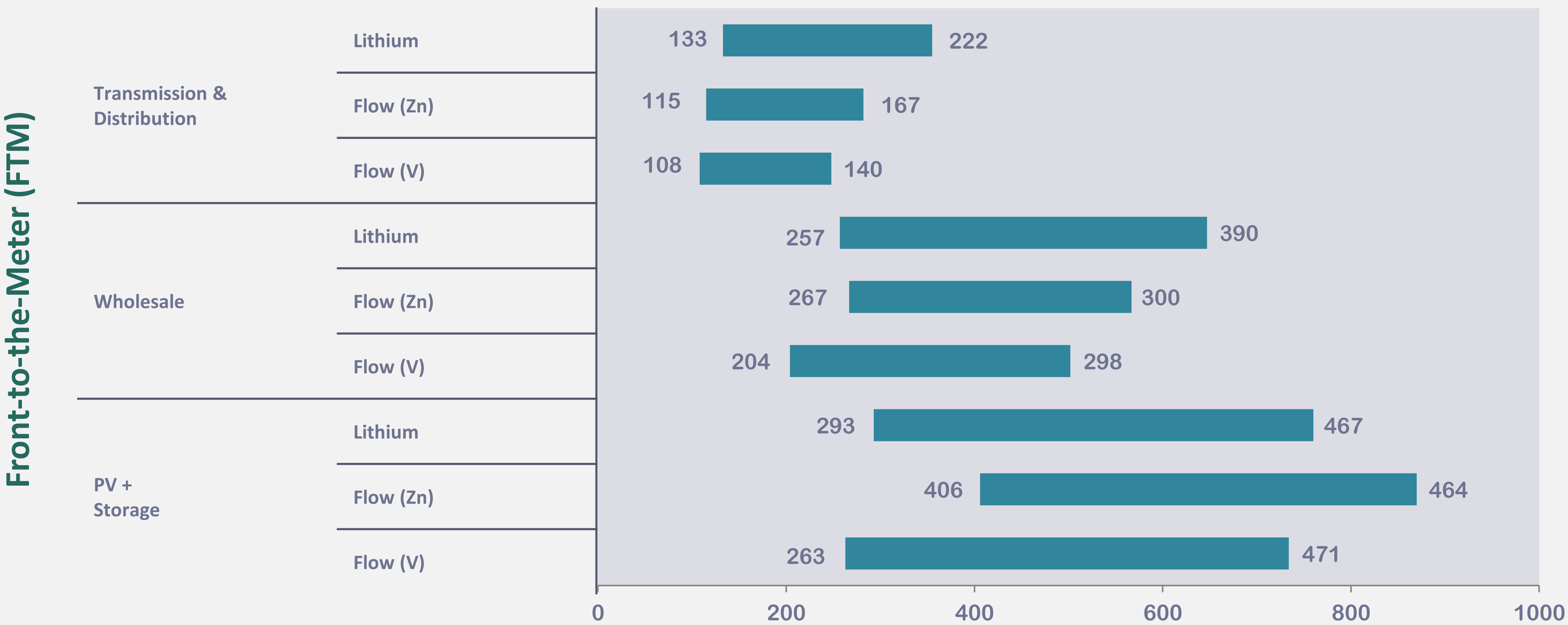
ii. BTM Use - The applications typically pertain to commercial and industrial (C&I) and residential facilities, with or without solar PV.

The levellized cost of storage for the unsubsidized LCOS averaged upon the global basis is indicated in the following section as per FTM and BTM and their respective usage.

Exhibit 4: Comparison of Unsubsidized Levellized Cost of Storage (LCOS) (In $/kWh) for FTM Application

FTM Use & Application – Battery Wise LCOS Mapping

Cost Range for Use of Batteries in $/kWh

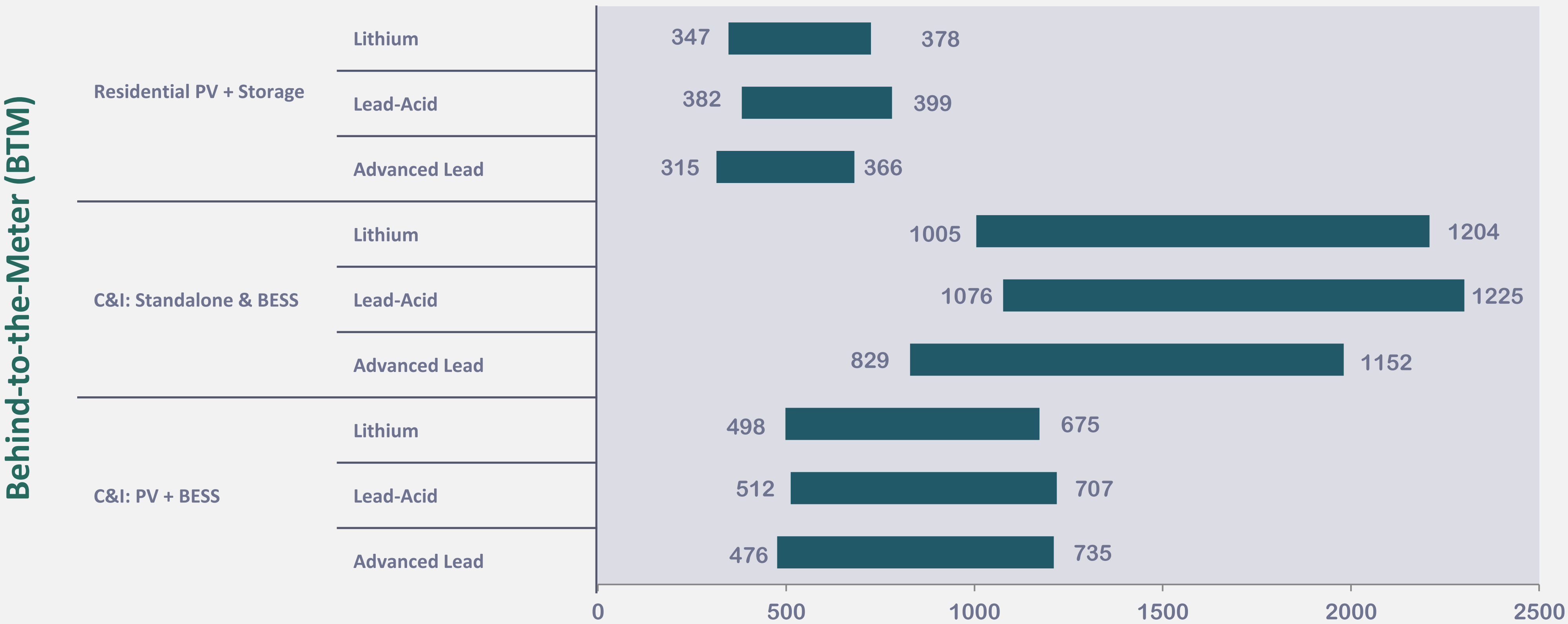


Source: Channel Checks and eninrac research & analysis

Exhibit 5: Comparison of Unsubsidized Levellized Cost of Storage (LCOS) (In $/kWh) for BTM Application

BTM Use & Application – Battery Wise LCOS Mapping

Cost Range for Use of Batteries in $/kWh

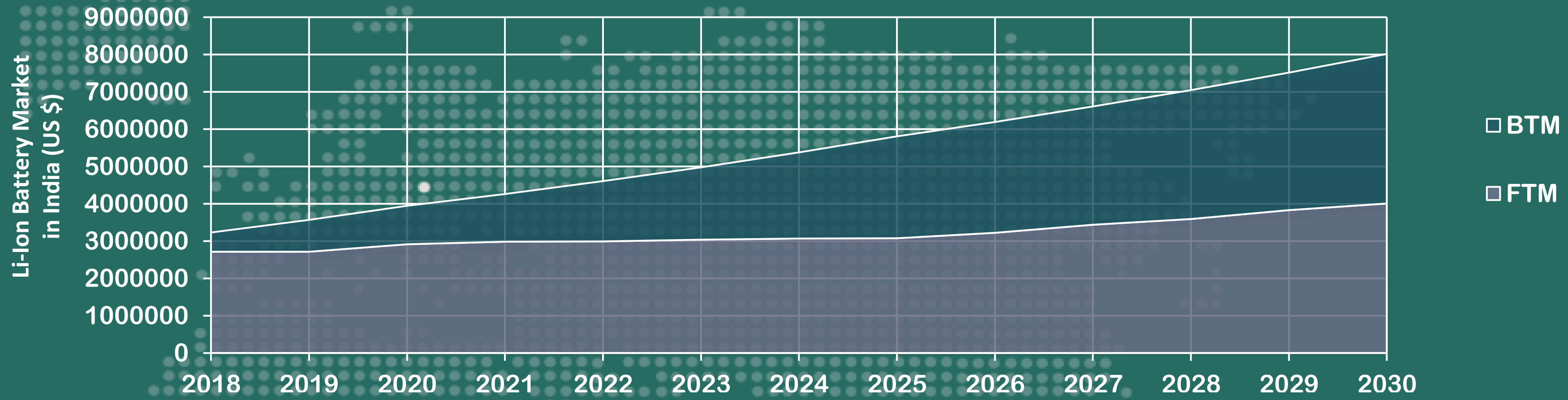


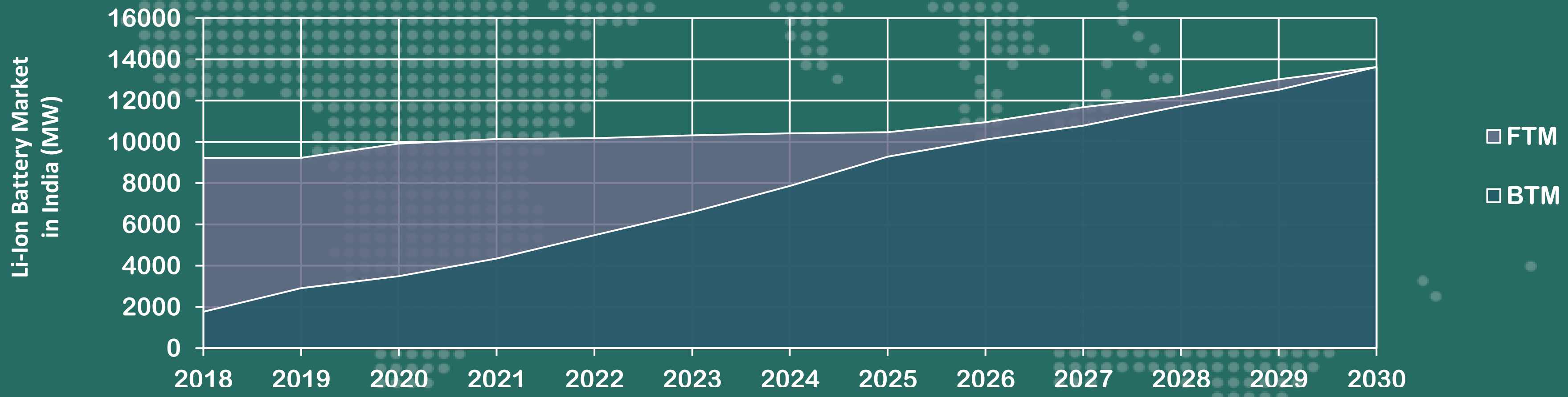
C&I – Commercial & Industrial Users/Consumers

Source: Channel Checks and eninrac research & analysis

Market Estimates for Li-Ion Battery in US $ & MW – For FTM & BTM Applications till 2030 (Contd.)

Exhibit 6: Li-Ion Battery Market in India in US $ and MW as per FTM & BTM





Source: Channel Checks and eninrac research

Creating Competitive Landscape for Battery Energy Storage in India

Three integrated development stages planned by government of India can actually address barriers that exist to growing a competitive battery manufacturing industry in India:

- Stage 1
  - *Incentivize and encourage direct investment in the growth of a battery pack assembly industry.*
  - *Develop partnerships and a multi stake holder consortium for joint research, investment pooling, and development of battery technology and battery recycling.*
  - *Form a consortium to serve as a resource to government and industry on future action plans for recycling, battery standardization, and end-to-end strategy.*
  - *Individual companies selectively pursue battery cell manufacturing where a business case exists.*
- Stage 2
  - *Consortium leverages research results from battery cell research to advise and help develop cell manufacturing growth strategy.*
  - *Consortium establishes best-practice plans for end-to-end battery manufacturing (including cells) and recycling in India, considering investments in current and evolving battery chemistry.*
  - *Development of supply chain connected to consortium battery manufacturing strategy*
- Stage 3
  - *Consortium-led coordination between battery manufacturing and countrywide infrastructure (charging, swapping, recycling, etc.).*
  - *Rapid scaling of battery cell manufacturing infrastructure through investment strategies, coordination with OEMs, incentives and policies, and coordination with existing battery assembly industry*

These stages are pathways to support the development and build-out of manufacturing capability over time. Each stage represents a key aspect of India's potential long-term battery manufacturing opportunity. Throughout these stages, government and industry actions will need to be coordinated to align strategic priorities, manage interconnections, and organize and prioritize research efforts for maximum benefit to India's economy and society.

> The life of a man consists not in seeing visions and in dreaming dreams, but in active charity and in willing service
>
> **- Henry Wadsworth Longfellow**

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