VGBE Seminar on Storage System – Opportunities in India

Anup Bhargava, Banka Maswet

Dornier Group GmbH

Agenda

1. Dornier Group overview
2. Dornier experience
3. Battery Storage Design
4. India Energy Storage plan
5. Competitive bidding process

The Dornier Group a strong service provider for infrastructure - worldwide active and strong in Germany

- more than 60 years market presence
- 2,000 employees
- 1,500 projects per year
- 18 branches in 10 countries
- **India – 100% Subsidiary Dornier Group India**

Germany
- Berlin
- Dresden
- Frankfurt
- Hamburg
- Leipzig
- Munich
- Mülheim an der Ruhr
- Neubrandenburg
- Stuttgart
- Vetschau

Belgrade

Amman

Kiev

Nur-Sultan

Doha

Abu Dhabi

Riyadh

Gurugram

Companies and knowledge combined

We manage our business activities in five business units

POWER AND HEAT
Dr. Daniel Seibt

VPC GmbH
The energy experts

Dornier Construction and Service GmbH
Maintenance and operational management of energy plants

Dornier Group (India) Private Limited
Strong know-how from India

MOBILITY
Christoph Gipp

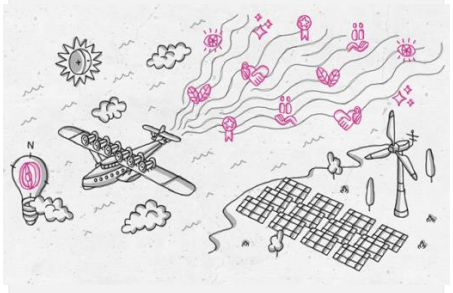
Dornier Consulting International GmbH
Pioneers in infrastructure

Dornier Group (India) Private Limited
Developing team for E-Mobility and Aviation consultancy

NUCLEAR SERVICES
Dr. Anton Anthofer

Dornier Nuclear Services GmbH
The experts for nuclear decommissioning

RENEWABLES
Tolga Özkarakas

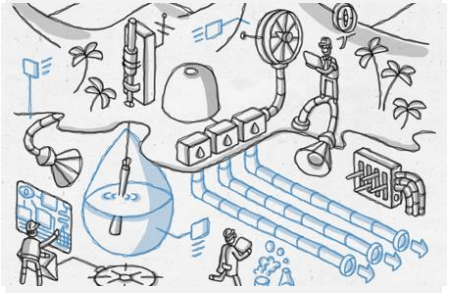


Dornier Construction and Service GmbH
Construction and operation services for offshore wind power and solar plants

Dornier Suntrace GmbH
Independent experts for renewable energies

Dornier Group (India) Private Limited
Strong know-how from India

WATER
Ulrich Schott



Dornier Consulting International GmbH
Pioneers in infrastructure

Dornier Group (India) Private Limited
Hydrology, Geotech and ground water management

Agenda

1. Dornier Group overview
2. Dornier experience
3. Battery Storage Design
4. India Energy Storage plan
5. Competitive bidding process

Dornier experience from Grid assessment, modelling etc.

Storage user	User's scope of interest	Modelling approach
Network operator	• Grid stability • Grid expansion • Congestion management/Peak shaving • Grid losses	• Pointwise • Global • Bulk • Island • Forecasts • Measurements • Seconds – years • Static • Dynamic
Plant operator Power plant Production plant	• Grid codes requirements • Uninterrupted supply • Load shifting • Peak shaving • Decarbonization • Flexibility • Electricity market	

Grid study for integration of Battery grid storage

Owner's Engineer for 3.85MW/3 MWhr Hybrid (Distributed Grid)

Big Battery Lausitz

Dornier‘s References for Energy Storage applications (1)

Grid / Energy Storage Applications

IMPLEMENTATION PLAN FOR INTEGRATION OF RES IN AZERBAIJAN POWER SYSTEM

Location – Azerbaijan

RE plan of Azerbaijan, Transmission Grid, Distribution Grid, Necessary skills – Training

GRID CONNECTION OF SHERABAD SOLAR IPP PROJECT

Location – Uzbekistan

Detailed design engineering, Grid readiness study: Network modelling

ROBEX GOLD – MALI HYBRID PROJECT (3.85 MWAC SOLAR /3.15 MWAC BESS) OWNER’S ENGINEER

Location – Mali

Owners engineer for Hybrid Energy System.

MARKET STUDY OF ENERGY MANAGEMENT SYSTEM (EMS)/HYBRID CONTROLLER

Location – South Africa

Market study for Hybrid Energy System technology.

ENGINEERING AND SUPERVISION OF 220/110 KV GRID SUPPORT SUBSTATION VILLACH SOUTH

Location – Austria

Detailed design engineering, Preparation of Tender Documents

DEVELOPMENT OF THE EAST GERMAN GRID INCLUDING ELECTRICAL RE-UNIFICATION OF GERMANY AND INTERCON-NECTION OF VEAG – UCTE POWER SYSTEMS AND INTERCONNECTION WITH DENMARK

Location – Germany

Consultancy Services

FEASIBILITY STUDY FOR SOLAR 35MWP, BATTERY (20MW/2.05MWHR) & GREEN HYDROGEN (14.5 MW) AS ADDITIONAL FUEL

Location – Romania

Feasibility study for use Green Hydrogen as supplementary fuel.

Grid study and Due Diligence for power distribution system in Western Sibiria

Location – Russia

Consultancy Services- Due Dilligence

GRID CONNECTION OF SOLAR PHOTOVOLTAIC GENERATION TO THE BERLIN DISTRIBUTION GRID

Location – Germany

Consultancy Services, grid modelling & commissioning

GRID CONNECTION OF RES GENERATION / PREPARATION OF DISTRIBUTION NETWORK DEVELOPMENT PLAN

Location – Germany

Consultancy Services, grid connection & distribution network development plan

Dornier‘s References for Energy Storage applications (2)

Grid / Energy Storage Applications

ovag Netz
Planung. Bau. Betrieb.

DESIGN ENGINEERING OF THE SUBSTATION ALSFELD

Location – Germany

Detailed design engineering

VIVO ENERGY

HPP 16MW – THERMAL, 18MWP-SOLAR PV PLANT, 10MW/30MWH BATTERY ENERGY STORAGE

Location – Guinea

Owner’s engineer from market study, PPA, EPC Contract till COD.

THINK GAS

CONSULTANCY FOR HYDROGEN PRODUCTION

Location – India

Bankable Feasibility study for hydrogen production, and by product Ammonia, Methanol

aggreko

BISHA MINE (ERITREA) SOLAR PV (7.63 MWP/6.06MWAC + DIESEL GENERATOR

Location – Eritrea

Technical due-diligence of Solr Hybrid project

KINROSS

TASIAST SOLAR HYBRID (34 MW SOLAR PV AND 18 MW BATTERY) PROJECT

Location – Mauretania

I&C Engineering Services.

intec
GOPA International Energy Consultants
УКРЕНЕРГО

MASTER PLAN FOR THE SOUTH UKRAINE REGIONAL TRANSMISSION NETWORK DEVELOPMENT

Location – Ukraine

Consultancy Services, Master Plan for Ukraine

LEAG

OWNER’S ENGINEER FOR BIG BATTERY LAUSITZ

Location – Germany

Engineering services for tendering and construction of a 50 MW / 53 MWh battery energy storage.

VATTENFALL

BATTERY ENERGY STORAGE HH, SECOND LIFE

Location – Germany

Engineering services for preparation and implementation of the 2 MW (1.6 MWh) Battery storage in Hamburg city

OSHEE

NETWORK DEVELOPMENT AND INVESTMENT PLAN FOR THE ELECTRICITY DISTRIBUTION SECTOR IN ALBANIA

Location – Germany

NETWORK DEVELOPMENT AND INVESTMENT PLAN

पावरग्रिड POWERGRID

TECHNICAL ADVISOR FOR SECI TENDER FOR BATTERY STORAGE OF 2X250 MW / 500 MWHR

Location – India

Technical Advisor for technology selection, EPC/OEM Bids, inputs to financial model.

Dornier‘s References for Energy Storage applications (2)

Pumped Storage / Energy Storage Applications

ENERGY EFFICIENCY MEASUREMENTS OF TURLOUGH HILL PUMPED STORAGE HYDROELECTRIC STATION

Location – Irland

Consultancy Services

THEMAL IMAGING MEASUREMENTS AT HPPS MARKERSBACH, GOLDISTHAL, WENDEFURTH, GEESTHACHT, HOHENWARTHE

Location – Germany

Thermal imaging camera measurements

STUDY FOR EFFICIENCY EVALUATION OF THE COUNTRY-WIDE POWER STATION PARK AND POWER GRID IN AZERBAIJAN

Location – Azerbaijan

Feasibility & Consultancy Services

Technical planning for application for new concession run of river power station Reckingen at river Rhein

Location – Germany

Technical plannings for run of river power station

ECONOMICS OF ASYNCHRONOUS PUMP-STORAGE UNITS, RUSSIA

Location – Russia

Study to evaluate the market development for pump storage in Germany and the economics for asynchronous pump storage units at the German control market.

FLEXIBILISATION CONCEPT FOR HPP PFAFFENBODEN

Location – Austria

Feasibilty study and detaild definition of preferred unit concept

PLASTIRAS HPP, GREECE

Location – Greece

Life- time extension study for 3 x 43 MW Pelton turbines

CONVERTING OF HPP TO PUMPED STORAGE SCHEMES

Location – Norvey

Concept study/ Feasibility Study

PALMIET PUMPED STORAGE SCHEME PHASE 1, SOUTH AFRICA

Location – South Africa

PLANNING FOR I&C REHABILITATION OF A 2 X 200 MW PUMP STORAGE POWER PLANT.

TECHNICAL APPRAISAL OF EMERGENCY INVESTMENT PROGRAMME, SERBIA

Location – Serbia

Technical Advisor for technology upgradation Increase in capacity of Toplodoska river HPP Pirot

Case study for LEAG BigBattery

BigBattery Lausatia

- Location:
  - Lausatia, Germany, Power Plant Schwarze Pumpe
- Europa's biggest battery storage system at the moment of commissioning (2020):
  - 50 MW
  - 53 MWh
  - 8840 lithium-ion modules
- Targeting primary control:
  - Normal State of Charge: 50 %
  - Ramp: from 0 to 50 MW within 30 s
  - Energy stored for ca. 0,5 h of operation at 50 MW
  - After 0,5 h the thermal power plant takes over

Coming up next: BigBattery Oberlausitz

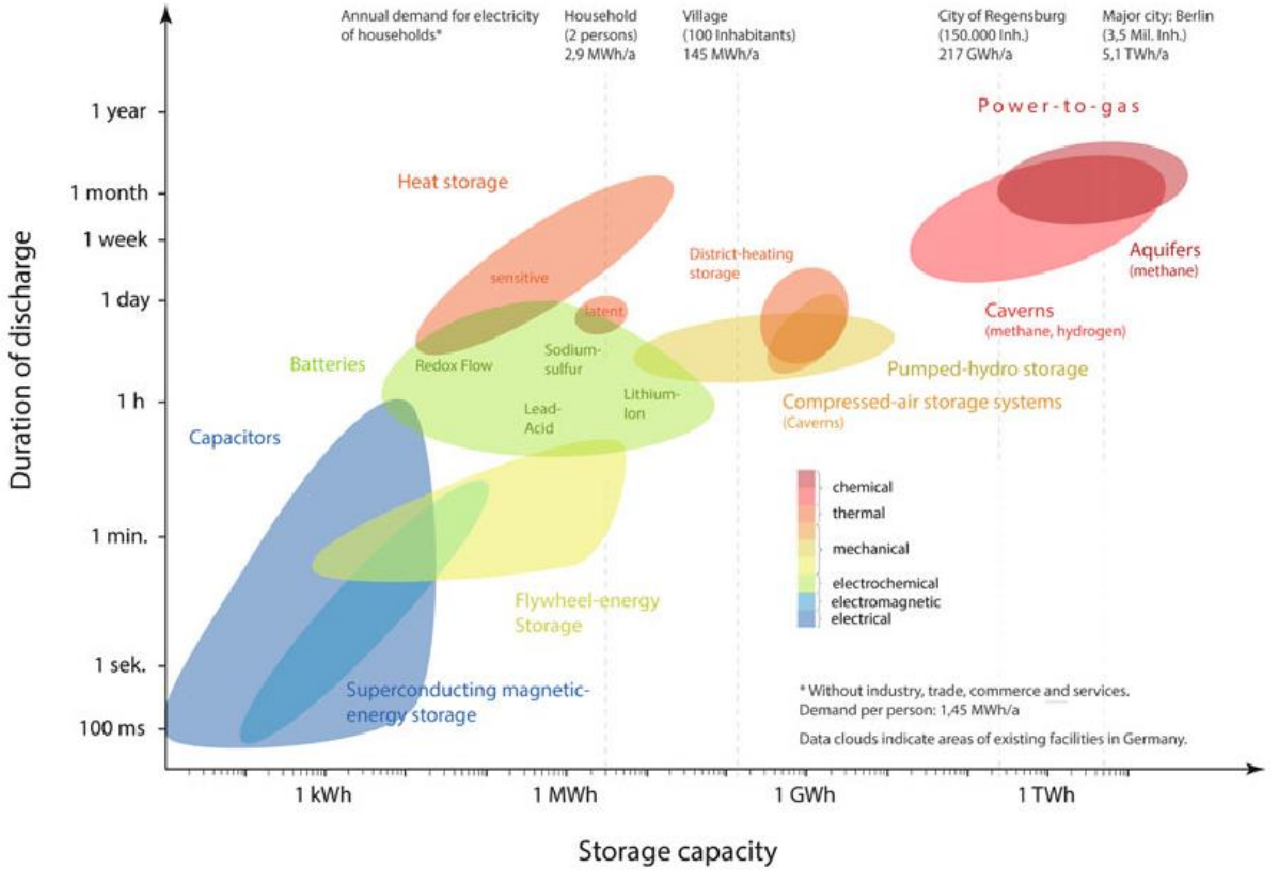
- Boxberg power plant, 137 MWh (2024)

[source: https://www.leag.de/en/gigawattfactory/bigbattery/]

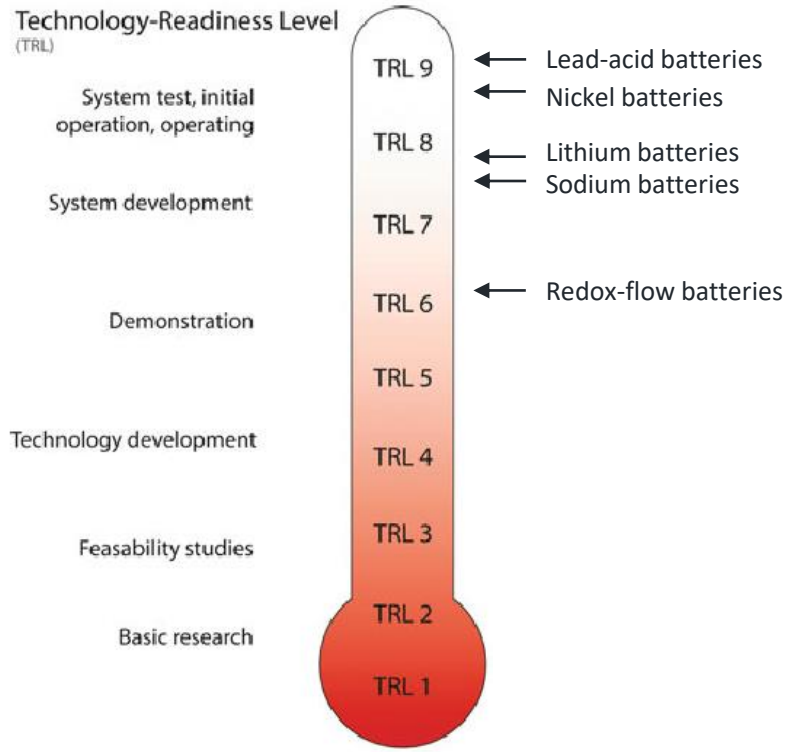
Agenda

1. Dornier Group overview
2. Energy Storage Overview
3. Dornier experience
4. Battery Storage Design
5. India Energy Storage plan
6. Competitive bidding process

Overview of Energy Storage



Storage types compared with storage capacity and discharging duration (Ragone chart): the circled areas indicate German facilities which have existed since 2013*



Technology readiness of various battery storage systems*

*[Source: M. Sterner, I. Stadler *Handbook of Energy Storage*. Regensburg, Cologne: Springer, 2019]

Energy Storage Applications

The use of technologies such as energy storage across the entire electricity value chain can support RE integration while addressing network congestion & locational operational challenges.

- Complement and support the current infrastructure while contributing to local security of supply. “Differ Capacity Enhancement”
- Provide much-needed flexibility at various locations and timescales across the system.
- Energy Storage has a key role to play as a Local Flexibility provider, supporting the reduction of redispatch costs while time shifting low carbon energy and by supporting a cost-effective electrification of the transport and heating sectors
- Energy storage assets and EV smart charging solutions can complement network infrastructure to deal with high peak demand during low to medium duration events. Enabling this application of energy storage requires adequate conditions and frameworks,
- Areas affected by systematic network constraints, inclusion of storage in network planning, adequate Flexibility market design.
- At distribution and transmission level, energy storage can provide key services [5] to support the secure, reliable, efficient, and cost-effective operation of the grid.

However, such services must be designed and tendered in such a way that they allow for a level playing field for various flexibility options.

An adequate Flexibility market design would enable the monetisation of flexibility provided by storage when acting as both demand and generation. Allowing it to be stackable with other services.

Business case of an energy storage facility – Services Overview

Category	Service / Application	Customer	Market Liquidity	Value	Duration Requirement	Contracted Revenue
Ancillary Services	Frequency Response	TSO	High	€	Short	No
	Reserve		High	€€	Short	No
	Black Start		Low	€€	72 h	Bilateral
Network asset services (Location is key)	Flexibility Market/Constraint Management	TSO/DNO	Low	€€	Long	Yes
	Reactive power (voltage control)	TSO/DNO	Low	€€	N.A.	Bilateral
Resource adequacy and arbitrage	Capacity Market	TSO	High	€	Long	Yes
	Imbalance market	Supplier / Generator	High	€€	Medium	No
	Day ahead market		High	€	Medium	No
	Back-up power	C&I customer	N.A.	€	Long	N.A.

Concept for design of utility scale battery

The key criteria for selection of “Utility Scale BESS” is **LCOS (Levelized Cost of Storage).** Some of the key factors are:

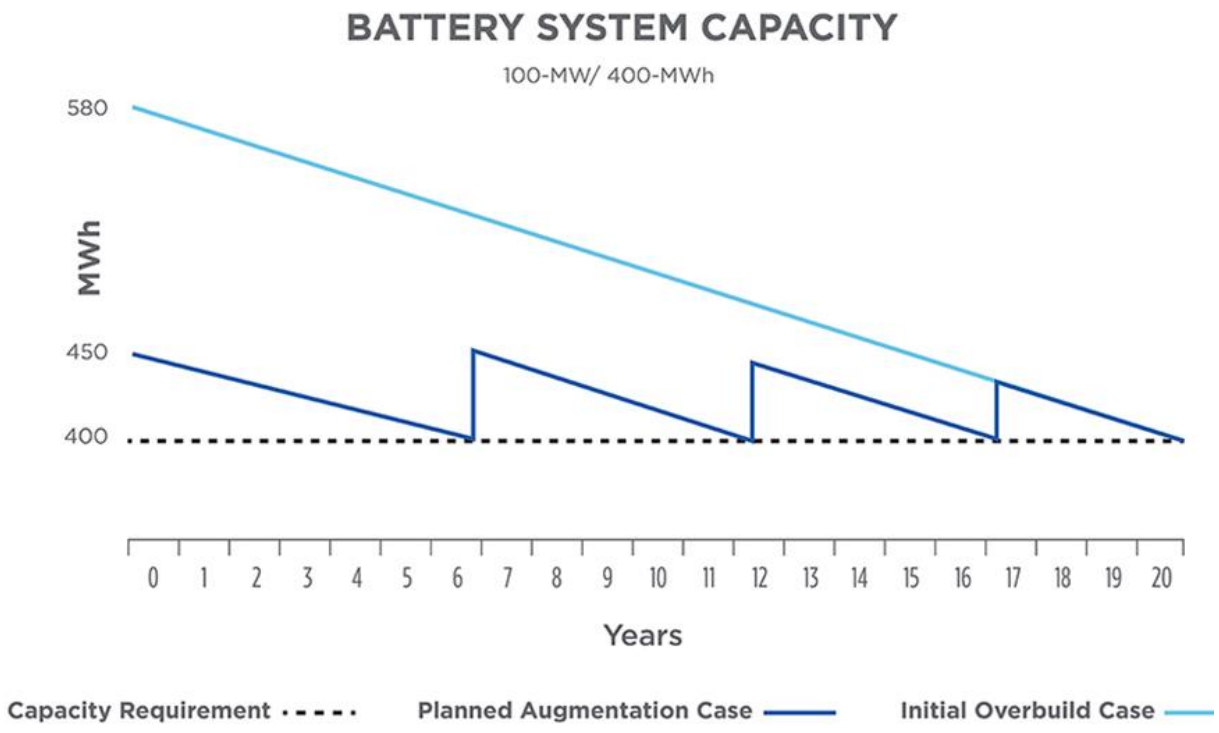
- **Selection of BESS Package**
  - Selection of Outdoor containers (AC/DC), Outdoor or Indoor Transformers and Inverters based on size of Battery.
- **Augmentation Strategy**
  - Plan Capex addition in phases
- **Variable Guarantees**
  - Customer can choose together with Consultant/OEM
- **All Inclusive Service package**
  - Provide comprehensive coverage for “Risk Averse Lenders”

BESS - Augmentation Strategy

Key Project Considerations

The battery energy storage systems in operation are in early stage of application development, and the energy storage is an evolving market. With the growth of renewables, reliable, Key considerations for designing Augmentation:

- What is the degradation profile of the batteries purchased based on the project's use case?
- What are the capacity requirements for the project)?
- At what point (how many years) will those batteries no longer be able to meet the completed project's capacity needs?
- What technology is expected to be available that can be used to augment?
- Does the site have space to augment?
- How does the augmented system tie in to the existing system and are there provisions for this?
- Can the existing balance of plant systems (communications, auxiliary power, etc.) handle the additional capacity?
- How does the augmentation impact the existing interconnection agreement?



Source: https://blog.burnsmcd.com/battery-energy-storage-augmentation-key-project-considerations

BESS – Variable Guarantees

The BESS market moves from “Fixed Guarantees” to “Variable Guarantees”, as the electricity market and BESS applications are constantly changing.

Customer can choose the complete set of variable guarantees, combining with “Augmentation Strategy” to optimize LCOS.

- Rest time
- C-Rate
- Cycle Rate
- Rest SOC
- Ambient Temperature

BESS – All Inclusive Service cost

Technology / OEM lead 15 years full function service package

- Preventive Maintenance
- Corrective Maintenance
- Availability Guarantees > 98%
- Energy Capacity Guarantees (Profile Guarantee)
- Round trip efficiency Guarantees
- 24/7 On-site Support
- Value Engineering (improvements during the lifetime)
- Remote monitoring (24/7)
- Software Support (Future Grid functions integration)

BESS Package Typical Cost breakup

BESS Capex Breakup

• Batteries (including transport)	80%
• Inverters	3%
• Transformers	3%
• Control System	0.5%
• Balance of plant systems	12%
• Others (bonds, insurance, risk)	1.5%
BESS All inclusive Service Cost	**1.5 - 2% of EPC cost**
TOTAL Price	**EUR 240 – 300 / kwhr**

Key BESS Turnkey Suppliers

- Fluence
- Powin
- Rolls Royce
- SAFT
- Trina
- Canadian Solar
- NIDEC
- Alfar

Agenda

1. Dornier Group overview
2. Energy Storage Overview
3. Dornier experience
4. Battery Storage Design
5. India Energy Storage plan
6. Competitive bidding process

India Energy Storage plan – Key points

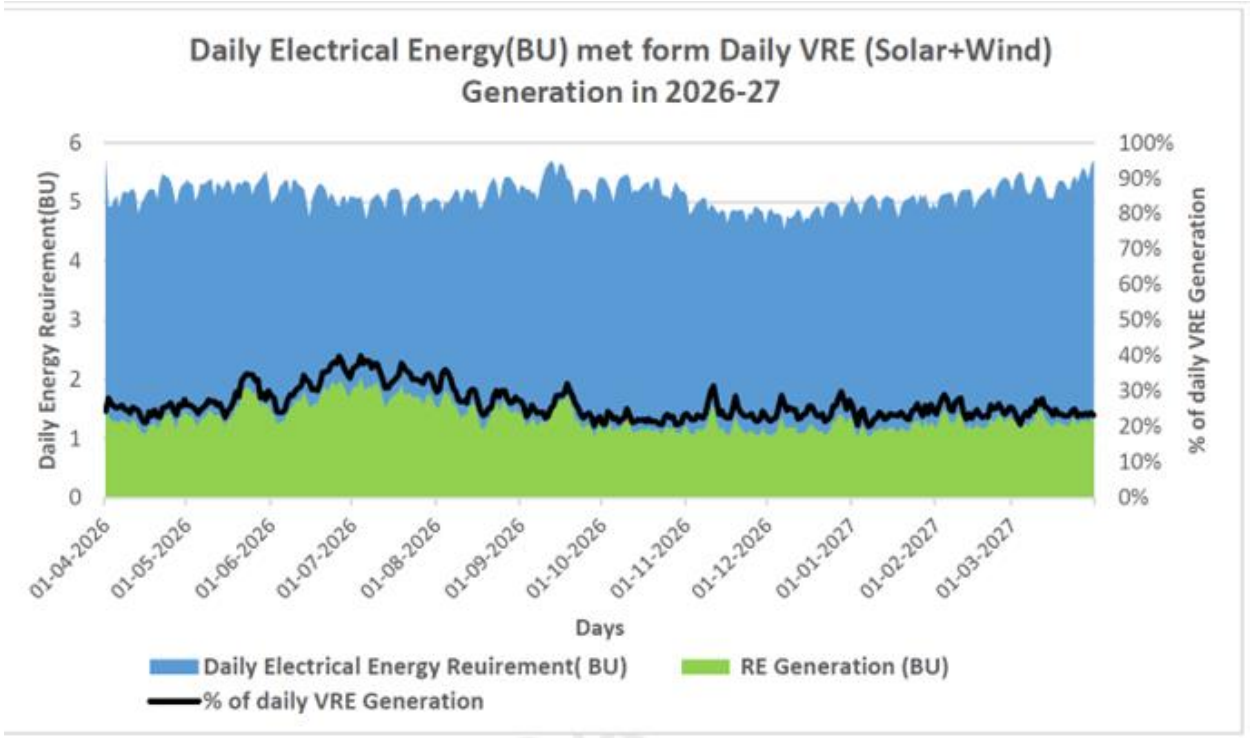
India plans to have an installed capacity of 623 GW a the end of year 2026-27, and 866 GW at the end of year 2031-32**,** which is in line with **Total Capacity projection of non-fossil based power of 500 GW by 2029-30**.

Energy storage requirement to meet peak electricity demand and energy requirement;

- PSP based storage capacity of 6.81 GW by 2026-27, and 18.82 GW by 2031-31
- BESS (5 hour) requirement in 2031-32 to be from 51 GW to 84 GW

The policy stipulates enhancing the overall availability of installed capacity by 85%, a spinning reserve of 5% at national level. The key drivers are:

- The waiver of ISTS charges for projects commissioned upto 30th June 2025, project awarded through competitive bidding process for RE projects, and extended to Hydro PSP and BESS projects, if;
  - 70% of power required for Pumping or Battery charging is through RE sources



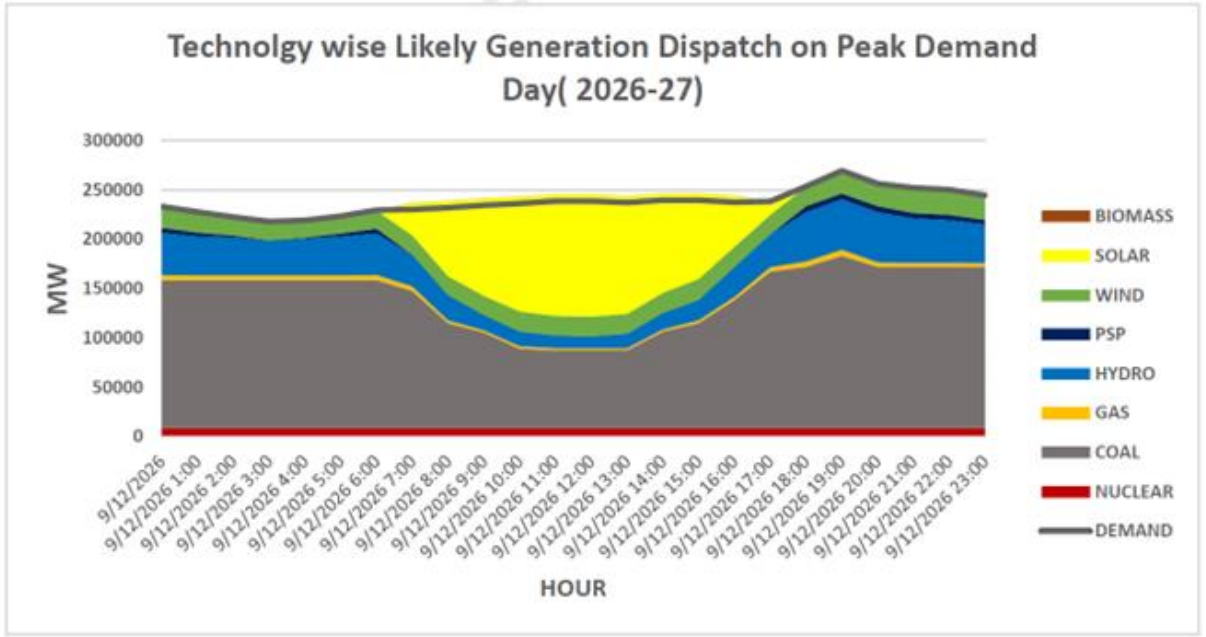
Reference: Draft_National_Electriicty_Plan_9Sep2022

India Energy Storage plan – Key points

The following were observed on a typical day when peak demand occurs, the electricity peak and energy demand is likely to be fully met with the generation mix obtained from long term studies:

- Coal capacity runs at 55% Minimum Technical load during Solar hours
- Battery storage is getting charged during excess solar generation, and discharged during non-solar & peak hours.

RE Generation could not be fully absorbed with Wind CUF @24.08% and Solar CUF @17.73%, and so BESS is needed.



Reference: Draft_National_Electriicty_Plan_9Sep2022

India Energy Storage plan – Key points

FINANCIAL PARAMETERS

Following cost parameters have been assumed in the year 2021-2022:

Resource	Capex* (in ₹/MW)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization/Life time (in years)
Coal	8.34 Cr	19.54 Lakh	4	25
Nuclear	12 Cr	20 Lakh	6	30
Hydro~	6 Cr to 20 Cr	2.5% of Capex	5 to 8	40
Solar[!]	4.5 Cr to 4.1 Cr	1 % of Capex	0.5	25
Wind(Onshore)	6 Cr	1% of Capex	1.5	25
Wind(Offshore)[$]	16.59 Cr to 13.69 Cr	1% of Capex	1.5	25
Biomass	9 Cr	2% of Capex	3	20
Pumped Storage	3 Cr to 8 Cr	5 % of Capex	7	40
Battery Energy Storage[@]	9.3 Cr to 5.24 Cr	1 % of Capex	0.5	14
Inter -Regional transmission Line Cost	10,163 /MW/Km	-	1	25

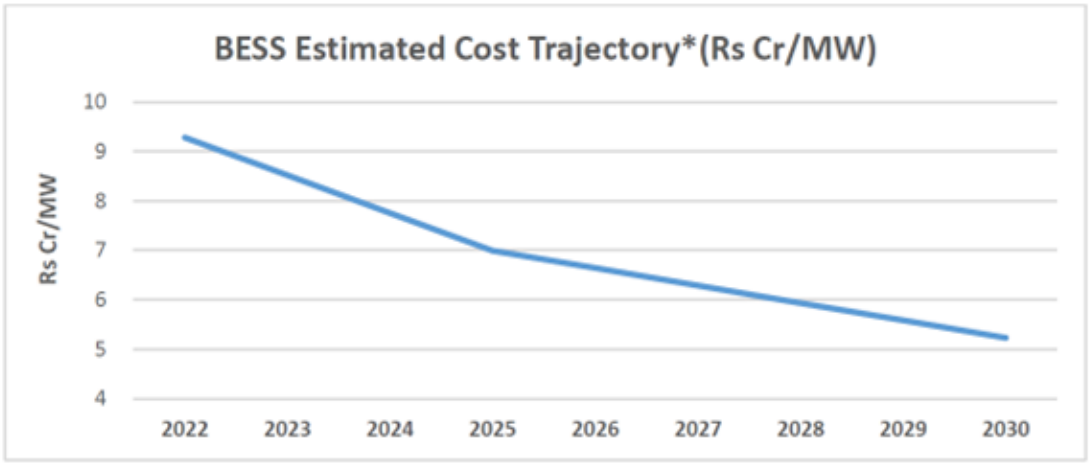
Energy Storage .. A tool for matching the grid electricity supply to the demand on a second-by-second basis.

- Provides frequency regulation and in maintaining the stability and safety of the grid
- Enables excess energy to be stored for consumption at a more convenient time.
- Provides buffer source for use in case of emergencies .. “Spinning Reserve”

The two most acceptable energy storage includes PSP Hydro and BESS

Reference: Draft_National_Electriicty_Plan_9Sep2022

Exhibit 13.4



*5-hour BESS

The Storage requirement in terms of percentage of peak demand and energy demand for the years 2026-27 and 2031-32 is given in **Table 13.3**

Table 13.3

Year	Storage in terms of percentage of Peak Demand	Storage in terms of percentage of Energy Requirement
2026-27	2.5%	0.93 %
2031-32	19.41%	5.61 %

Agenda

1. Dornier Group overview
2. Energy Storage Overview
3. Dornier experience
4. Battery Storage Design
5. India Energy Storage plan
6. Competitive bidding process

Tariff Based Competitive bidding … key projects

Project Name	Company	Size (Solar)	Capacity (BESS)	Location
2MW (AC) Solar PV Power Plant with 01 MWh BESS	SECI	2MW	1 MWh BESS	KAZA, Himachal Pradesh
500 MW/1000MWh BESS under Tariff-Based Global Competitive Bidding (ESS-I)	SECI	500 MW	500MW/1000MWh	India
20 MW (AC) Solar PV with 20 MW / 50 MWh BESS	SECI	20MW	20MW/50MWh	Ladakh, India
100 MW (AC) Solar PV with 50MW/150 MWh BESS	SECI	100MW	50MW/150MWh	Chhattisgarh, India
14 MW Solar PV 42 MWh BESS (2x7 MW / 21 MWhr) under PMDP	SECI	14MW	7MW/21MWh	Leh and Kargil
4 MW Floating PV with 02 MW/01 MWh BESS at Kalpong Dam	SECI	4MW	2MW/1MWh	North Andaman & Nicobar
5MW Solar with 5MW/16MWh BESS	KREDL	5MW	5MW/16MWh	Tumakuru, Karnataka.
8 MW Solar PV Plant with 3.2 MWhr BESS	NTPC	8MW	3.2MW/3.2MWh	A&N Island
1 MW (AC) Solar PV with 1MW /3.0 MWhr BESS	Tangedco	1MW	1MW/3MWh	Tamil Nādu

Summary of RFQ : SECI 500 MW/1000 MWh BESS System

Capacity	▶ Capacity of 500 MW/1000 MWh shall be set up at a single location, ▶ Two Projects each of 500 MWh (250 MW x 2 hrs) capacity to be set up at the identified location. ▶ A **Bidder, including its Parent, Affiliate or Ultimate Parent** or any Group Company can submit a single bid offering a Contracted Capacity of either one project **(250MW/500 MWh)** or 2 projects **(2X (250 MW/500 MWh)**
Period of concession	▶ The BESPA shall be valid for a period of 12 years from the SCD of the Project or the date of full commissioning of the Project, whichever is later. ▶ Any extension of the BESPA period beyond the term of the BESPA shall be through mutual agreement between the BESSD, Buying Entity and SECI. ▶ The BESPA shall be signed within 90 days of issuance of LoAs, if not extended by SECI.
Capacity commitment from SECI	▶ SECI's obligation shall be for off take of **60% of the Contracted Capacity** and energy ▶ Utilization of **remaining 40% capacity is to be managed by the Developer**.
Location	▶ Project capacity of 500 MWh each shall be located in the vicinity of **Fatehgarh-III Substations** of the ISTS network. ▶ Land will be provided **on lease/right-to use basis** to the BESSD through a suitable agreement with the **Transmission licensee,** and the same shall be facilitated by SECI.
Other Details	▶ The BESSD shall guarantee a minimum system availability of 95% on annual basis. ▶ The BESSD shall pay the liquidated damages for such shortfall and shall duly pay such damages to SECI to enable SECI to remit the amount to Buying Entity(ies) under BESSA. ▶ Amount of such liquidated damages shall be twice the Capacity Charges for the capacity not made available.

VENTURE THE IMPOSSIBLE
TO ATTAIN THE BEST...

PROF. CLAUDE DORNIER

Concept for design of utility scale battery

Step 1

Definition of the customer‘s technical and financial requirements based on the business model, e.g.:
- Minimal power
- Energy reserve for specific period of time
- Maximal CAPEX/OPEX

Step 2

Identification of the local grid codes‘ requirements, e.g.:
- Power gradients
- Grid supporting functions, frequency regulation, fault ride through

Step 3

Modelling the system consisting of different components and links between them, e.g.:
- Battery storage system
- Grid
- Loads
- Generations

Step 4

Simulation based optimization of the battery storage parameters to satisfy the requirements and constraints, e.g.:
- Minimization of cycles
- Maximization of captured energy
- Maximization of revenue/minimization of costs

Step 5

Selection of the best battery storage system configuration and operation strategy