METI

# Overview on Smart Grid Technology

17 August 2016

Agency for Natural Resources and Energy
Ministry of Economy, Trade and Industry
Japan

# Risk of imbalance between power supply and demand

**India's renewable energy expansion target: 175GW by 2022**
**Solar 100GW, Wind 60GW**

**Solar, Wind Power: Intermittent power source depending weather conditions**
**Difficult to quickly control output in response to demand**

## Increasing risk of supply-demand imbalance

| | Short Term Frequency Fluctuation | Long Term Imbalance |
|---|---|---|
| **Supply Shortage** | 1) Negative effect on consumers' equipment<br>2) Increasing risk of all power unit disconnection and wide-area blackout | **3) Frequent load shedding**<br>Huge burden on consumers by back-up generators (Diesel Engine) |
| **Oversupply** | | **4) Frequent unit commitment** (disconnection ) on RE<br>-- harms economic viability of RE |

# Current situation of power system in India (Japan's recognition)

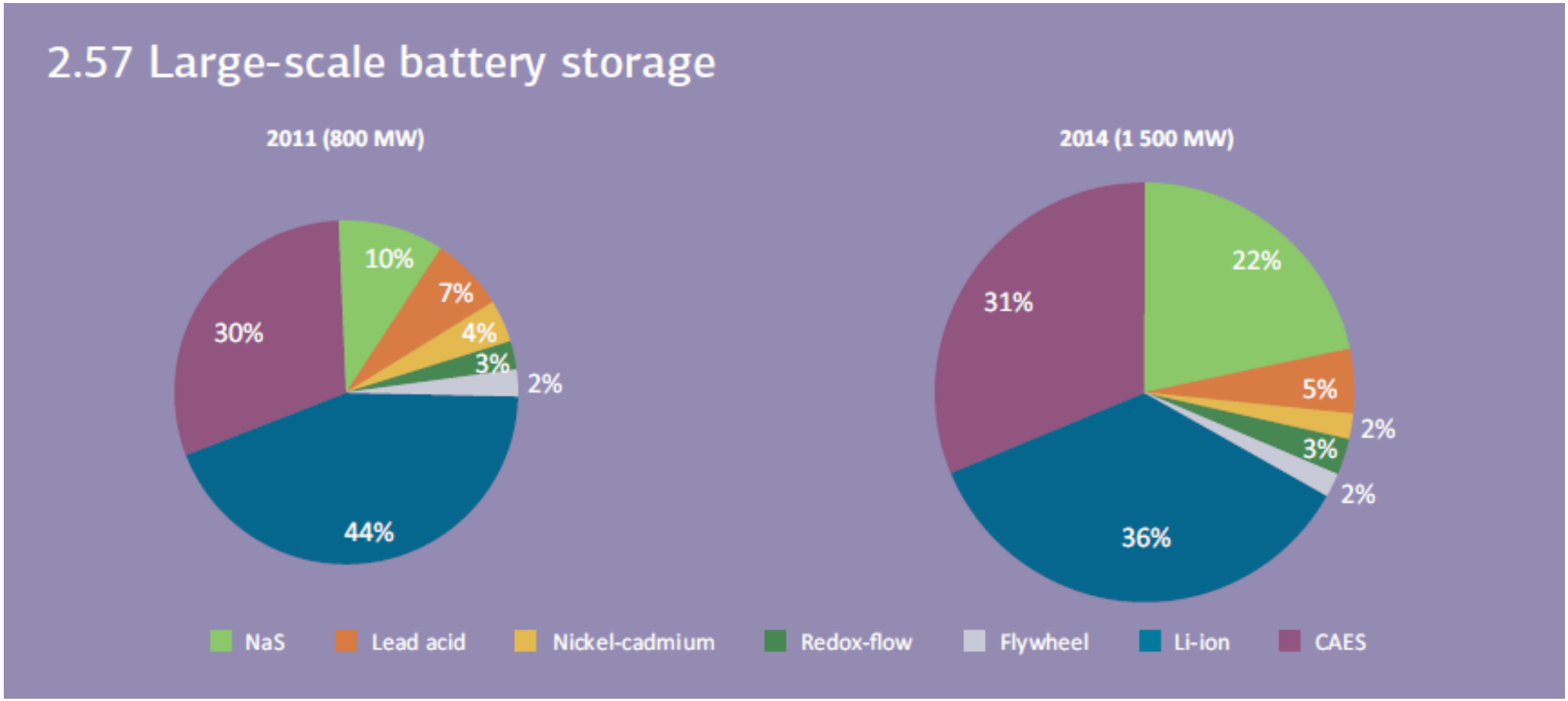
| Issues | | Current situation |
|---|---|---|
| Power quality | Outage | ✓ Total outage time in India is about 31,200 minutes/year in 2012. (around 100 minutes in developed countries) |
| | Frequency | ✓ Frequency regulation (49.90～50.05Hz) under the current Indian grid code has not been fully complied. |
| | Voltage | ✓ Voltage range (230V±10V) has not been fully complied.<br>✓ Expansion of rooftop PV will make it more difficult to control voltage in distribution grid. |
| Power system | Reserve margin | ✓ Installed power capacity seems sufficient to cover current peak demand.<br>✓ Lack in grid stability and fuel shortage may be the prime issues. |
| | T&D loss<br>Overloading | ✓ Loss rate in India is about 23%.<br>✓ Increasing congestion and overloading in transmission line enhances blackout risk. |
| Renewable | Unit Commitment | ✓ RE is placed the lowest priority in the current dispatch regulations(first choice for unit commitment). Potential of RE has not be fully materialized. |
| Manage ment | Tariff | ✓ Low tariff rate set by the government is harming the financial condition of discoms. |

# Solutions for adding flexibility in power grid

| | | Current situation in India |
|---|---|---|
| 1.Hardware | T&D Facility | ● Huge needs existing while all states' grids are interconnected. Some distributed RE are not connected to high demand areas. |
| | Pumped-Hydro | ● Construction plan in West Bengal etc.<br>● Long construction period and land acquisition can be its constraints. |
| | Thermal power | ● Currently main source for adjustment/peaking<br>● Thermal plants' operation ratio and profitability is expected to decline according to RE expansion |
| | Battery storage | ● **Fast response, short lead-time, scalability and no geographical constraint are the merits. Cost is the main hurdle.** |
| | Interstate grid connection and exchange | ● Implemented by Power Grid Corporation of India |
| 2.Software | Grid system grade-up | ● **Not only quantity but also quality of T&D is crucial. Enhancing quality can defer the huge investment.** |
| | RE Control system | ● **Fluctuating power supply from RE plants are not well monitored & controlled by transmission companies.** |
| | Demand response | ● Pilot projects going on globally. Developing stage. |
| 3.Rule & Regulation | | |

# 1. Hardware for Smart Grid -Battery storage-

- Lithium ion : Power usage type (Short-term) ←TOSHIBA
- NAS : Energy usage type (Long-term) ←NGK Insulators
- Redox-flow : Energy usage type (Long-term) ←Sumitomo Electric



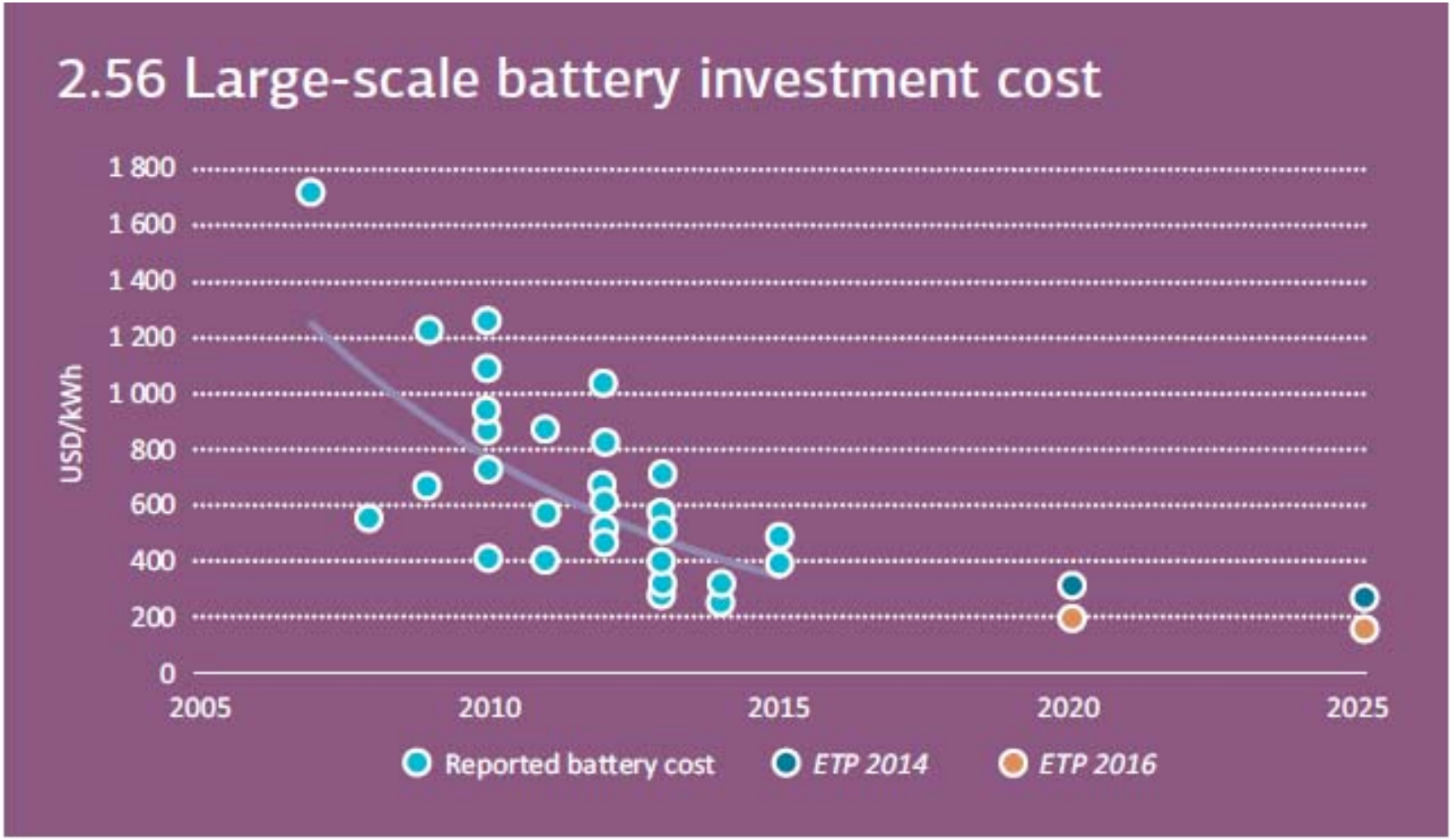

*CAES: Compressed Air Energy Storage

Source: IEA Energy Technology Perspective 2016

# Battery storage Cost

- **Since 2010, cost of lithium ion battery have followed a similar trend to those experienced by PV a decade earlier, with learning rates* averaging 22%.**

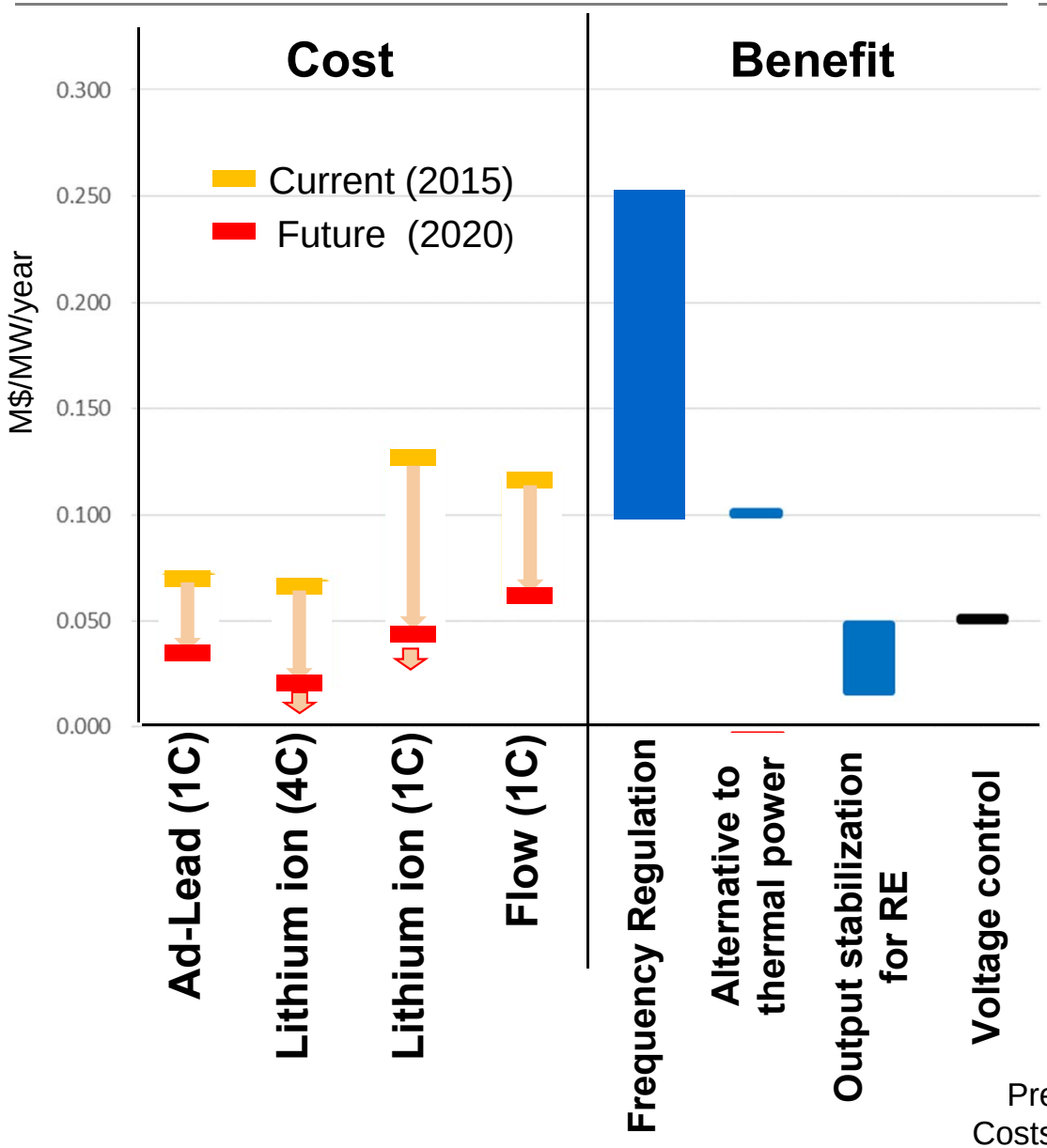
* The technology **learning rate** refers to the reduction in investment costs for every doubling of cumulative (historical) installed capacity.



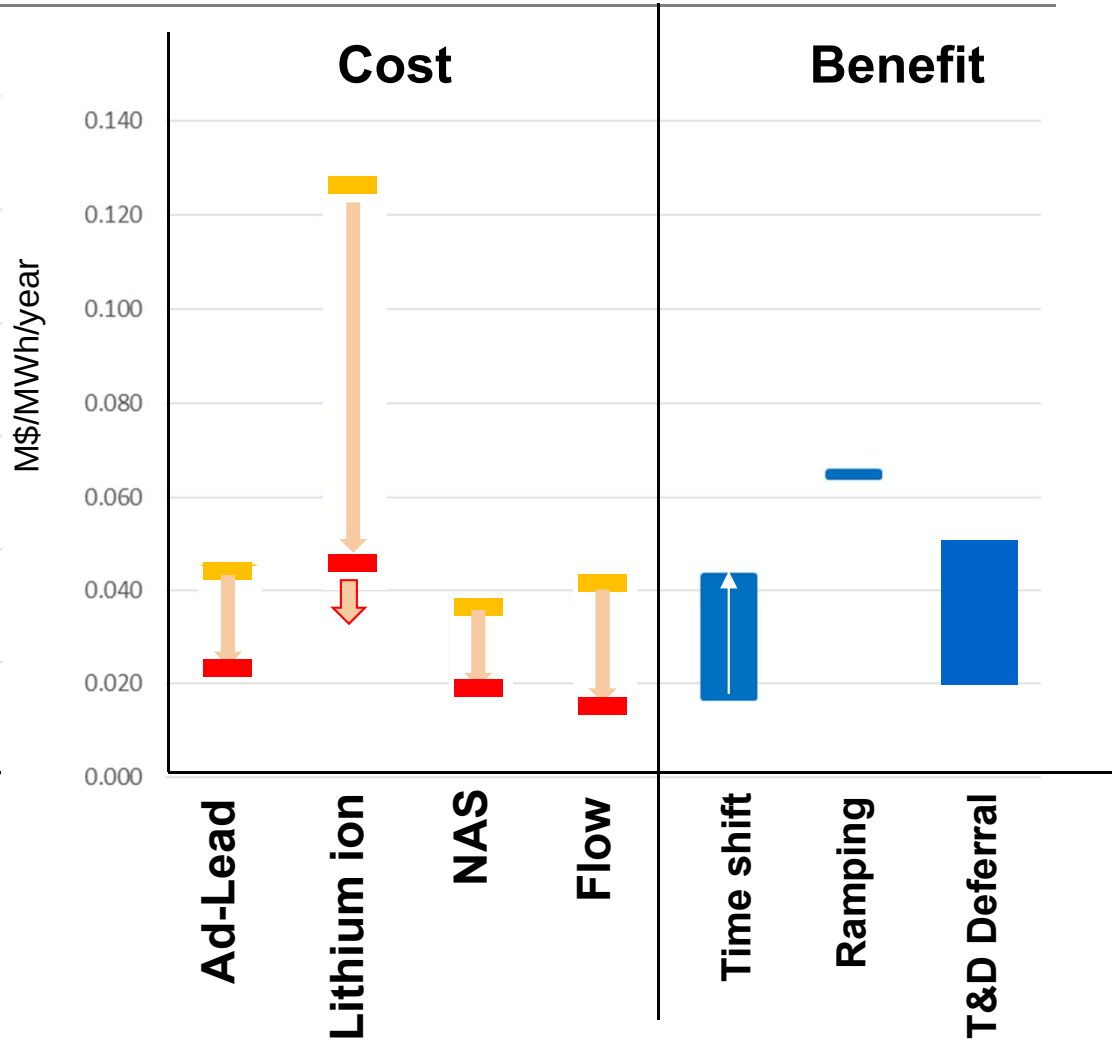

Source: IEA Energy Technology Perspective 2016

# Cost benefit analysis of battery storage

## Ancillary service (Short term)




## Energy storage(Long term)

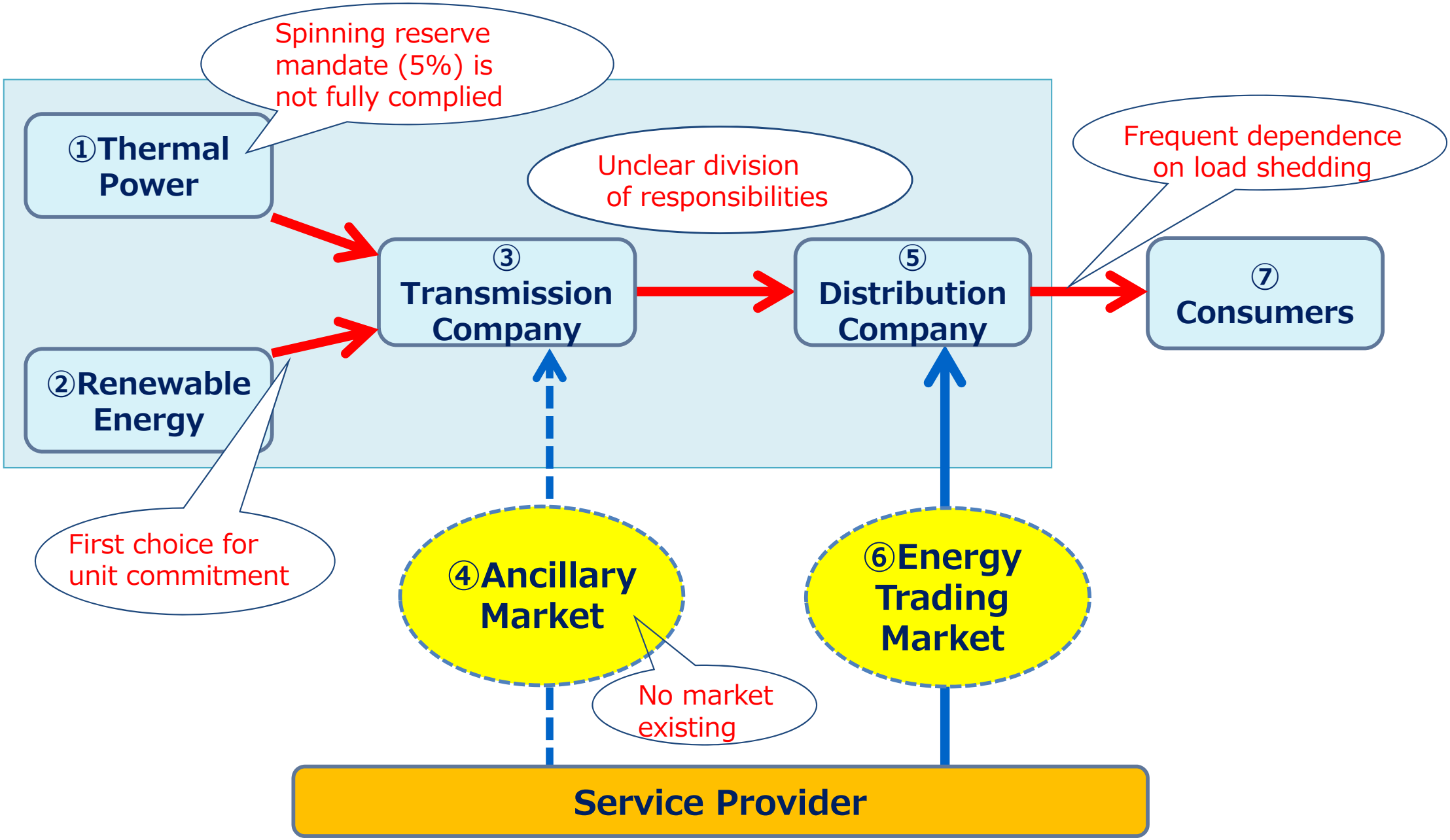



Source: NRI “Study on Battery Energy Storage in India”
Presented in India -Japan Energy Storage Task Force held in Feb. 2016
Costs are based on interviews on manufactures and with no-commitment.

# 2. Software/System for Smart Grid

| Issues | Solutions |
| --- | --- |
| 1. RE plants are not well monitored & controlled by T&D companies. | Forecasting, Monitoring & Control System for RE's fluctuating power supply<br>BESS & RECC by TEPCO |
| 2. Frequent forced outage due to vulnerable distribution grid | Distribution network monitoring system<br>SCADA by Fuji Electric<br>Planning & Operation Analysis software for Distribution network improvement<br>DSS by THE Power Grid |
| 3. Low utilization rate of T&D capacity | On-line grid stability calculation & power supply control system for maximizing T&D capability<br>Online-RAS by Hitachi |

# Issues on grid operation by RE expansion



# 3. Rule and Regulation

## （1）Avoid load shedding and maximize RE utilization

### Current Situation

1) Lowest priority on RE
 - frequent RE disconnection

2) Discoms often relying on load shedding instead of purchasing power at peak-price

### Proposals

1) **To raise priority of RE in ordering unit commitment**, e.g. setting maximum period.

2) **Rules/incentives to reduce load shedding**

- Unified metrics of forced outage rate (SAIFI,SAIDI) & target setting
- Subsidy scheme from central government to discoms in accordance with the above outcomes.
- Premium tariff for non-outage high-quality power supply to customers who request.

# 3. Rule and Regulation

## （2）Clarification of Responsibilities on power balancing

### Current Situation

1) Spinning reserve mandate(5%) is not fully complied.

2) Unclear division of responsibilities between transmission & distribution companies

### Proposals

**1) Clarify responsibilities**

**Power Producer**

- Secure spinning reserve. Strict monitoring needed
- Rules to include battery storage as substitute for spinning reserve.

**Transmission**

- Responsible for frequency control (Short tem fluctuation, normally less than 30 minutes)

**Distribution**

- Responsible for procuring power enough to satisfy demand (more than 30 minutes)

**2) allowing wheeling charges to reflect investment and outcomes for power balancing.**

# 3. Rule and Regulation

## （3）Establish market for frequency regulation –Ancillary market-

### Current Situation

1) No frequency regulation service providers exist.

2) T&D company is required to internalize the functions.

### Proposal

1)Establish **workable ancillary market**
- Market division by response speed
- pay for performance tariff for fast responsive service
- formulation of model contracts
- etc

2) Appropriate **government regulation and monitoring** for sound market growth

# (Reference) Battery Storage Applications

| Application | Description |
|---|---|
| 1. Thermal Power Plants | ✓ 5% spinning reserve mandate has not been fully complied.<br>✓ Rules to allow power plants to install batteries as part of the mandate will enable them to operate plants with its full capacity. |
| 2. RE Plants | ✓ Battery storage can be installed beside RE plants to stabilize output (load leveling) before grid connection.<br>✓ New grid codes to restrict excessive output fluctuation needs to be applied.<br>✓ Division of responsibility is simple, but certainly increase RE generation cost. |
| 3. Transmission companies | ✓ Transmission grid operators have a prime responsibility for maintaining stability, especially for frequency regulation.<br>✓ Storage attached to transmission grid can work for frequency control as well as time shift, ramping and T&D investment deferral. |
| 4. Ancillary service providers | ✓ Frequency regulation market exists in U.S. and some European countries, where private companies provide ancillary service to transmission companies by means of battery storage.<br>✓ Currently no ancillary market in India. Rule setting is necessary. |
| 5. Distribution companies | ✓ Battery storage can also be utilized in distribution grids in order to alleviate sudden voltage change and as well as to defer investment on grid capacity expansion necessary to cope with increasing rooftop PV. |
| 6. Electricity Trading Market | ✓ Private service providers can buy power at off-peak price and sell it at peak price via energy trading market. Enough gap between peak and off-peak prices is needed. |
| 7. Demand-side | ✓ Installing battery storage at consumer side in order to prepare for outage as well as for controlling fluctuating frequency and voltage. Very common in India. |
| 8. Off-Grid/ micro-grid application | ✓ Introduce combination of RE and battery storage system in off-grid and micro-grid areas (intentional islanding).<br>✓ There are some business cases worldwide which are economically viable by replacing expensive diesel generators. |