Analysis of infrastructure and electric power services from ESS solutions

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Abstract

We tend to imagine the infrastructure of electric power companies as power plants and power transmission lines. However, it has recently included services and solutions according to evolving technologies and changing governmental regulations. We have considered the services and infrastructure at an electric power company by analyzing the solutions that the electric power company would provide using energy storage systems (ESS) in this paper. Regional electric power companies in Japan had been required to provide highly reliable and uniform services before the industrial electric power market was opened in 2000. After that, electric power companies were required to provide high quality and inexpensive services. In addition, electric power companies faced new regulations where the market for electricity was fully open. Regulation changes created opportunities for service innovation. For example, our company could provide peak shaving services to our customers by using ESS. This service could reduce electrical charges and avoid power outages by ESS being installed at 100 customer sites. When we analyzed the characteristics of these services, we found two keywords. The first was distributed and the second was co-operation. We created a model of electric power services and we would like to expand electricity services with this model.

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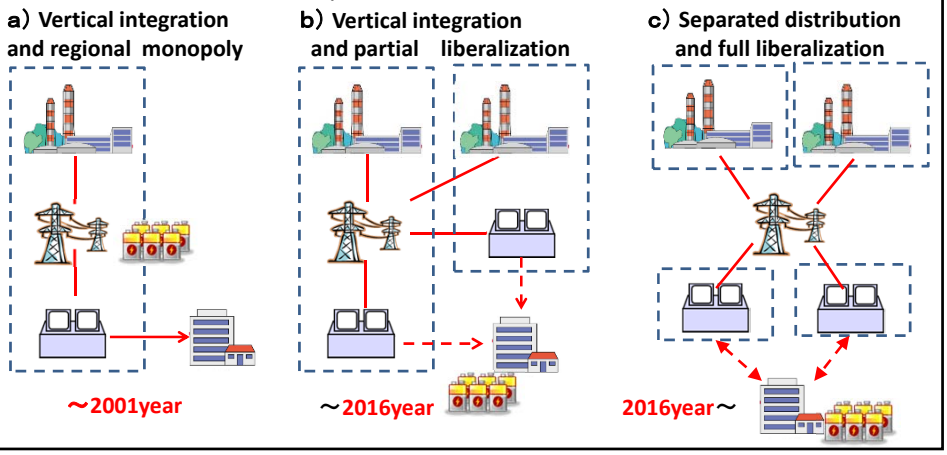
1.1 Background (Change the electric power regulation in Japan)

a) Customers cannot select companies, and there are few price plans
b) Large volume customers can select companies and price plans.
c) All customers and entrepreneurs can also select power supplies.[1]

＊A co-operative environment is created by interaction between the entrepreneur and customers.



1.2 Objections and Issues

(Objections)
"Is the infrastructure of an electric power company only its facilities such as power stations and power transmission lines?"

(Issues)
・The definition of **infrastructure** changes according to **social regulations and innovations.**
◎How did the social regulation and the innovations change an infrastructure and service?

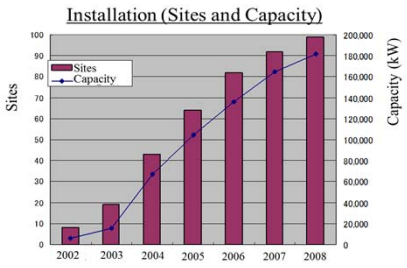
Research method is
to analyze solutions by using batteries(ESS*) at TEPCO

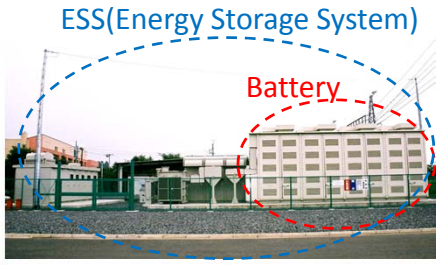
Our objective is
to find knowledge on electricity infrastructures and services.

*Energy storage systems

2.1 ESS services at TEPCO since2002

TEPCO had provided services to about 100 customers in a combination of PQ solutions and LL solutions. The feature of our service was to provide the package of leased ESS and an special electric rate plan.[2]

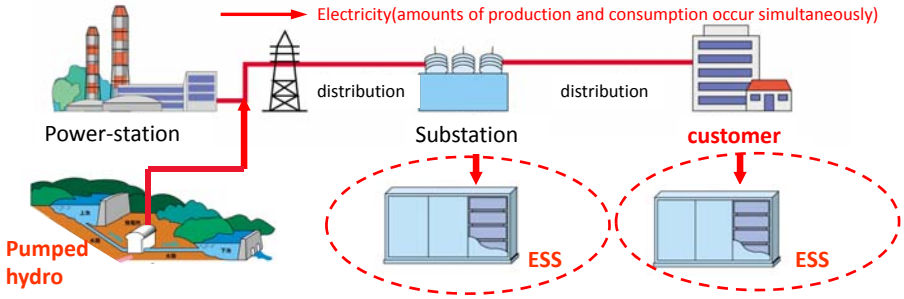




Solutions	Customer Advantages	TEPCO Advantages	Package
LL & PQ (Additional value)	Reduced electricity bills and electric PQ improvements	Investment control, capacity utilization improvements, and prevention of customer secession	Special electric rate plans and leased ESS(batteries)

2.2 Point of our ESS Services (Service Location)

- Electricity is a commodity with characteristics where the amounts of production (supply) and consumption (demand) occur at the same time. Therefore, production of electricity has been supplied according to demand.
- Energy storage systems (ESS) used to be built and controlled on the supply side to correspond to sudden changes on the demand.
- We had developed EES Services in which our batteries are installed on the customer side to acquire customer value. We lent them out.



2.3 Point of our ESS Services (technology innovation)

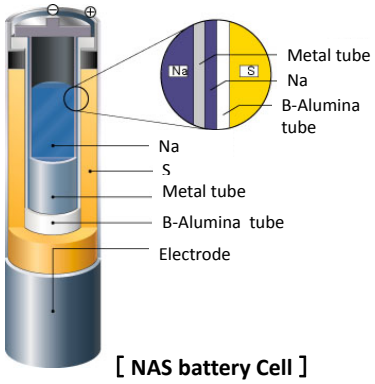
- TEPCO had been developed new battery called "NAS" since 1984.
- We succeeded in development of NW-scale commercial EES for the first time in the world in 2002. [3]

[Features of NAS battery]

- **High energy density**
- **No self discharge and high efficiency**
- **Long-term durability**
- **Easy maintenance and no moving part**
- **Completely sealed structure**
- **High temperature operation**
- **Hazardous material (Sodium and Sulfur)**

[Result of development]

- **Durability: 15 years with 4500 charge-discharge cycles**
- **Safety: Multiple protection for hazardous material**
- **Cost reduction: 200-250 thousands yen/kW (30 thousands yen/kWh)**

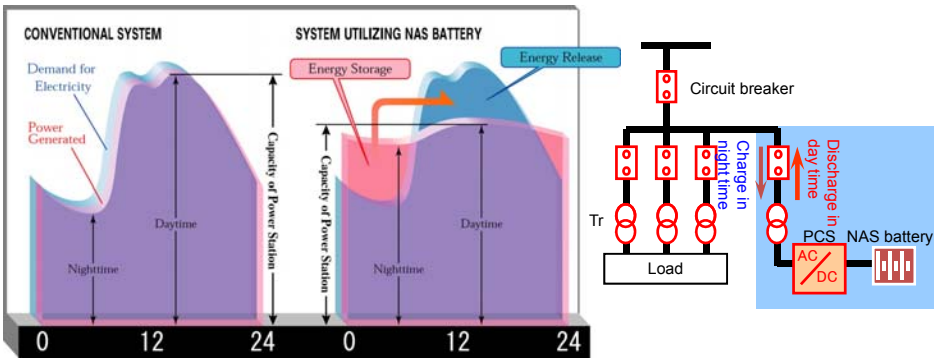


[NAS battery Cell]

2.4 Point of our ESS Services (Solution-1)

Load Leveling（Peak Shaving）solution (LL) [4]

- Customer Side: Reduce kilowatt charges by suppressing peak demand and make use of cheaper electricity supplied during off-peak time
- Utility Side: Reduce cost of generation and make efficient use of network facilities



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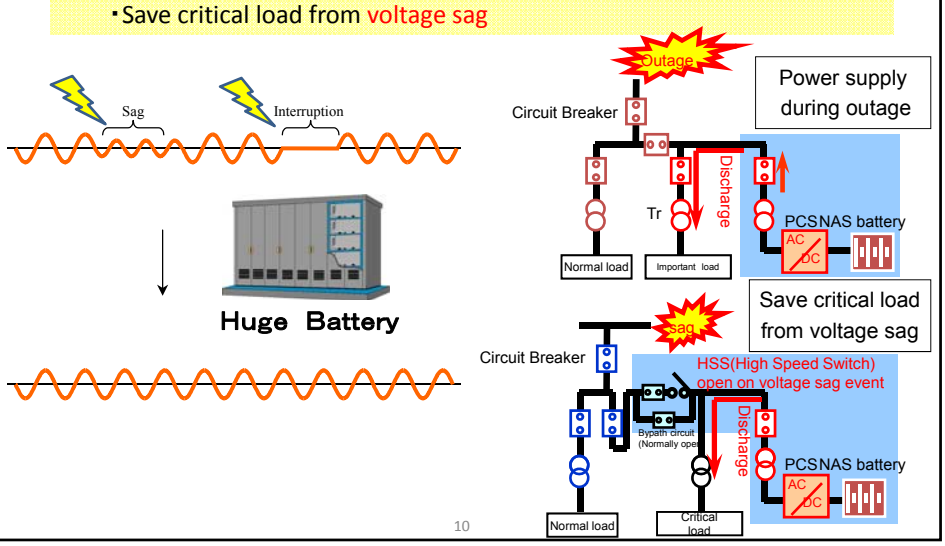
2.5 Point of our ESS Services (Solution-2)

Power Quality solution (PQ) [4]

- Power supply in case of grid outage
- Save critical load from voltage sag



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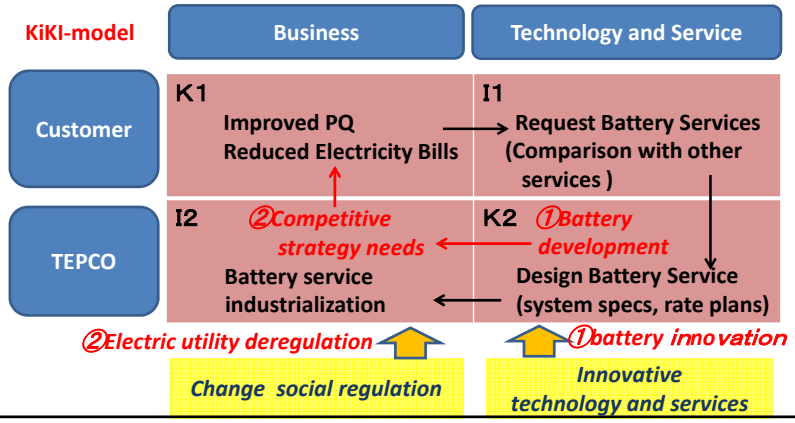
2.6 Creation process for ESS Services [5][6]

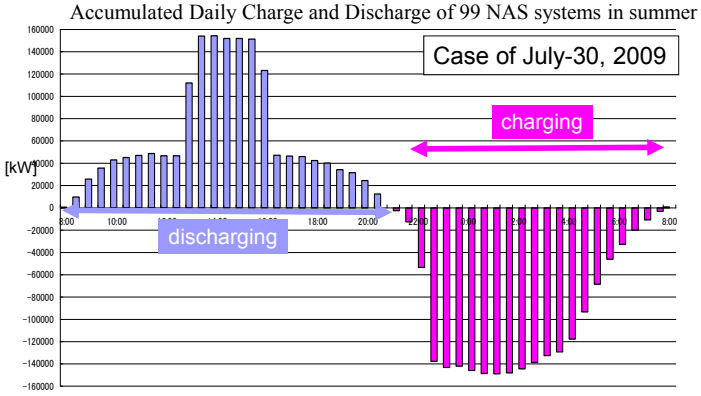
①Technology innovation (We had developed huge new battery NAS)
②Change social regulation (We had designed strategic battery services)
This service started to make user potential needs (K1) remarkable.
We advanced the co-operation process with customers and constructed a new service. (Service value creation model: KIKI-model)



2.7 Utility Advantage (Accumulated Peak Shaving Capability)

Accumulated charging & discharging results for 99 huge battery (NAS) systems within TEPCO area in 2009

- Peak shaving effect of nearly **160MW** by discharging at full power during summer peak hours (13:00 to 16:00).
- Around 73% of annual capacity factor. Yearly discharged electricity of 99 huge battery systems **equals to 600MW pumped hydro** .

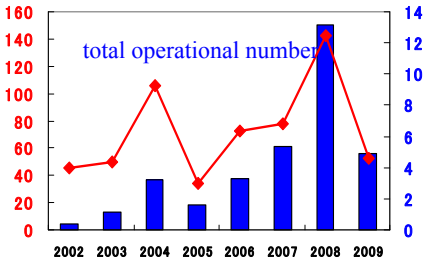


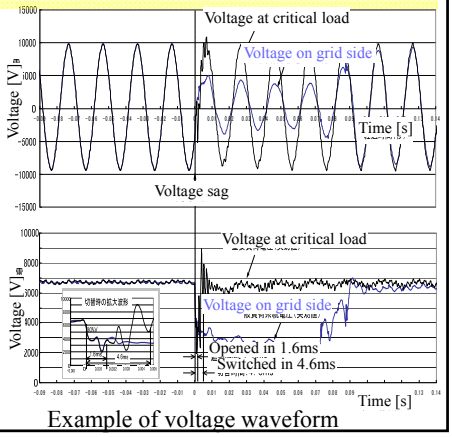
2.8 Customer Advantage (PQ improvements at customers)

Operational experiences of saving critical load from voltage sag

- Located at **12 sites** and operated **483 times** by September 2010.
- Voltage sag protection functions work mainly in summer due to lightning, and start within several mili-seconds.
- Highly appreciated by customers at semi-conductor and liquid crystal display factories, etc.

Annual operational number (2002 to 2009)





Example of voltage waveform

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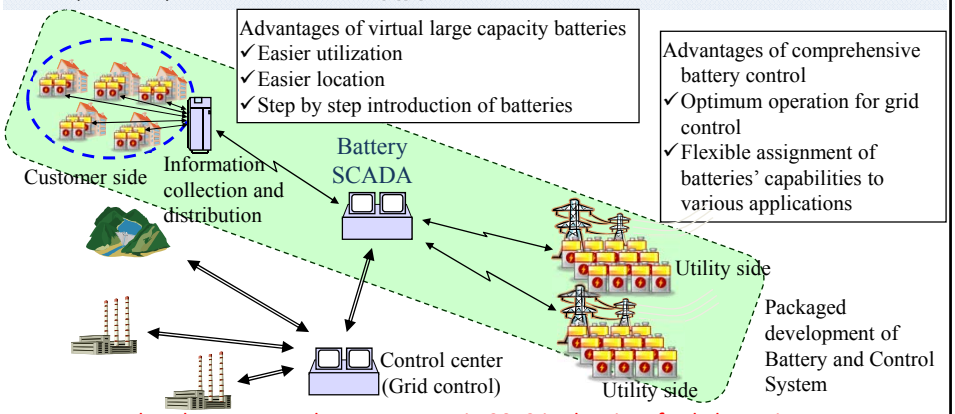
3.1 Next-generation ESS services Concept

We are developing a system that enables the grid operator to utilize batteries simply and efficiently. We plan to develop new solutions for which customer batteries are interactively utilized by using this system.

- Grid operators and battery manufacturers cooperatively join in developments and demonstrations.
- Distributed batteries can be dealt with like virtual large capacity batteries by being assembled.
- This enables grid operators to utilize batteries comprehensively with different specifications provided by different manufacturers. [4][7]



* We started to demonstrate the new system in 2012 in the city of Yokohama in Japan.

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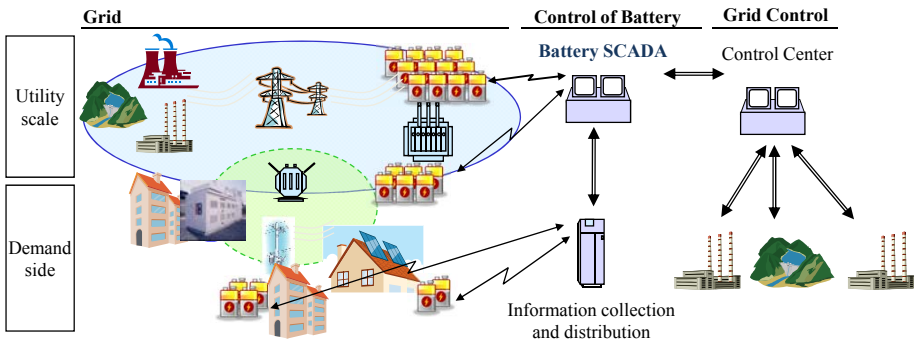
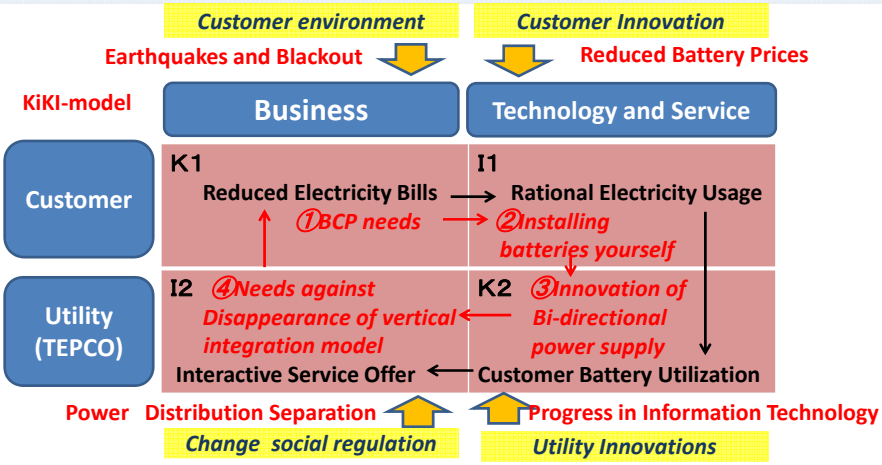
3.2 Point of new ESS Services

- We can utilize the customer own batteries using IT technology.
- We can form the virtual ESS by aggregating a customer batteries, and can use for LL or distribution control.
- Since we can reduce plant-and-equipment investment of our ESS, power generation, and distribution, we can make a charge cheap according to a contribution. (It likes Demand Response)



3.3 Creation process for new ESS services [5][6]

① Environment (We experienced an Earthquakes and blackout)
② Decrease of battery price and increase in subsidy
③ Innovation of IT ④Change social regulation
This background made us promote new service co-creation.



4.1 Conclusion

◎How did the social regulation and the innovations change an infrastructure and service ?

- ○The infrastructure varies from solid facilities to lightweight facilities including software.
- ○The service varies from a one-way to a bi-direction cooperatively.

☆The utility company causes innovation in correspondence with regulation by oneself, and It is important to promote a constant infrastructure remodeling.

Regulation	Innovation		Infrastructures	Services
Vertical integration (　～2001)	Development of ESS(NAS battery)	⇨	ESS	Load leveling for power companies
Partial liberalization (2001～2016)	Development of ESS service	⇨	ESS service Pack (ESS + Price Plan)	PQ +LL for customers (value creation)
Full liberalization (2016～)	Progress in IT-Control	⇨	New ESS service Pack (SCADA + Price Plan) Leasing of customer batteries	Adjustment Supply and demand (value co-creation)

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