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Distributed Energy Storage System (ESS) and the Grid

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POWER AUTOMATION
A Joint Venture between SP Group and Siemens

Graduated in 1998 in Electrical Engineering in NUS and a Master's in Engineering in the following year, Mr. Kerk has been working in the electrical industry for more than 18 years. He is now the head of the Smartgrids and Metering Department in Power Automation, A JV between Singapore Power and Siemens and he is in charge and responsible for planning and development of the department.

His particular skills include the understanding of power quality, networking, smart metering, Intelligent Building Management Systems (IBMS) research and development of the next generation hardware and software products.

Distributed Energy Storage System (ESS) and the Grid

Building a Foundation for A Energy Smart City

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What's Demand Management and Spinning Reserve

To Meet Growing needs, there are a few strategies -

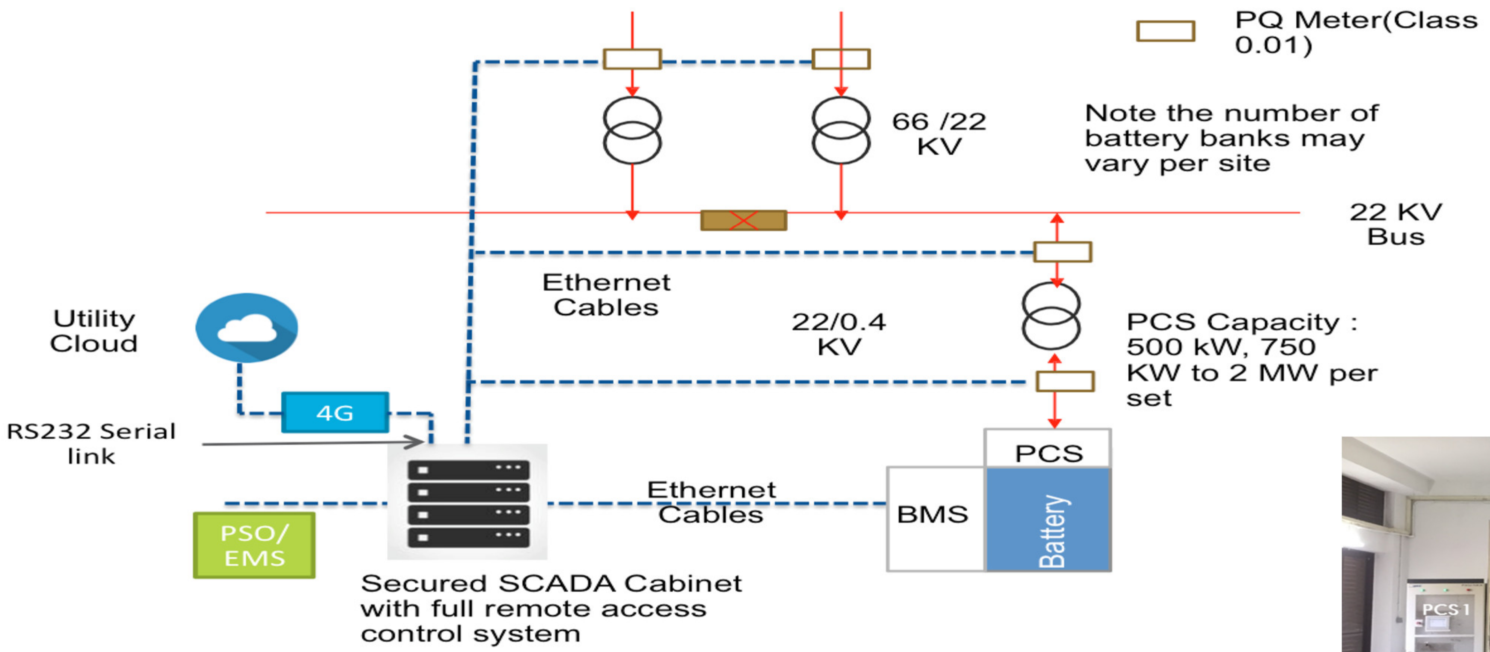
- Demand Management - also known as **demand-side management** (**DSM**) or **demand-side response** (**DSR**),is the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education. (WIKIPEDIA) – NOT CONTROLLABLE
- Peak Demand - **Peak load** or on-**peak** are terms used in energy **demand** management describing a period in which electrical power is expected to be provided for a sustained period at a significantly higher than average supply level. – Up to 60-70% of generation installed for peak loads just for the peak hours – NOT SUSTAINABLE
- Spinning Reserve - The **spinning reserve** is the extra generating capacity that is available by increasing the **power** output of generators that are already connected to the **power system**. For most generators, this increase in **power** output is achieved by increasing the torque applied to the turbine's rotor or connect more generators.(WIKIPEDIA) – EXPENSIVE BUT CONTROLLABLE
- Load Shed – To trip off, usually at the substation level, non-critical loads to balance the grid – CHEAP AND CONTROLLABLE BUT IRRITATING

BATTERIES - NO

CHEAP BATTERIES THAT LAST - YES

GRID LEVEL ESS AND DISTRIBUTED ESS (1/2)

- Grid Level ESS – Installed at the substations either at transmission and Distribution ESS – MW/MWh capacity
  - Transmission typical capacity – 75 MVA
  - Distribution typical capacity – 25 MVA
  - Utility installed/Controlled



Installed at Bedok 22 KV at one of the outgoing feeder (1 MW/3 MWh)

GRID LEVEL ESS AND DISTRIBUTED ESS (2/2)

- Distributed ESS – 3-5 kW and 10-20 kWh
- Home owner self purchased, or retailer as part of a package
- Controlled base on user needs and pricing considerations
- Safety is critical

Li-Ion batteries

Saltwater batteries

Other Battery Chemistries Pose Great Safety Risks

LITHIUM ION

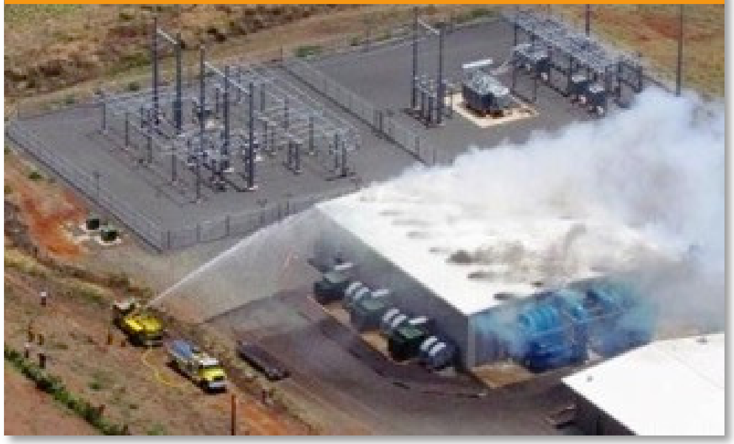
Smoky Fire Prompts Evacuations; Batteries for Wind-power System In Flames

PENINSULA DAILY NEWS

Boeing Warns Passenger Airlines That Carrying Bulk Shipments of Lithium Batteries Can Cause Major Fires Onboard

INTERNATIONAL BUSINESS TIMES

LEAD ACID



"This is a very dangerous environment to fight a fire in," explained Capt. Terry Seelig of the Honolulu Fire Department. ... Firefighters faced thick smoke, toxic fumes and other hazards.

HAWAII NEWS NOW

17 Hillsboro Workers Sent to Hospitals After Batteries Overheat, Release Acid Fumes at Business

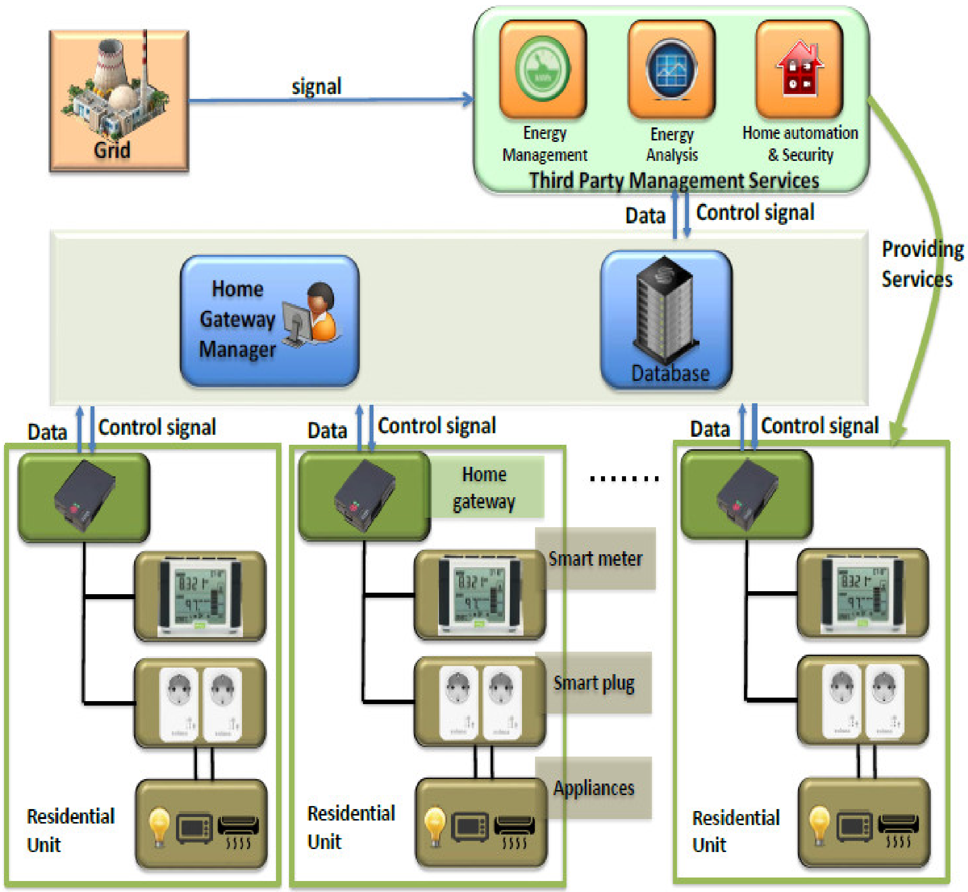
The Oregonian

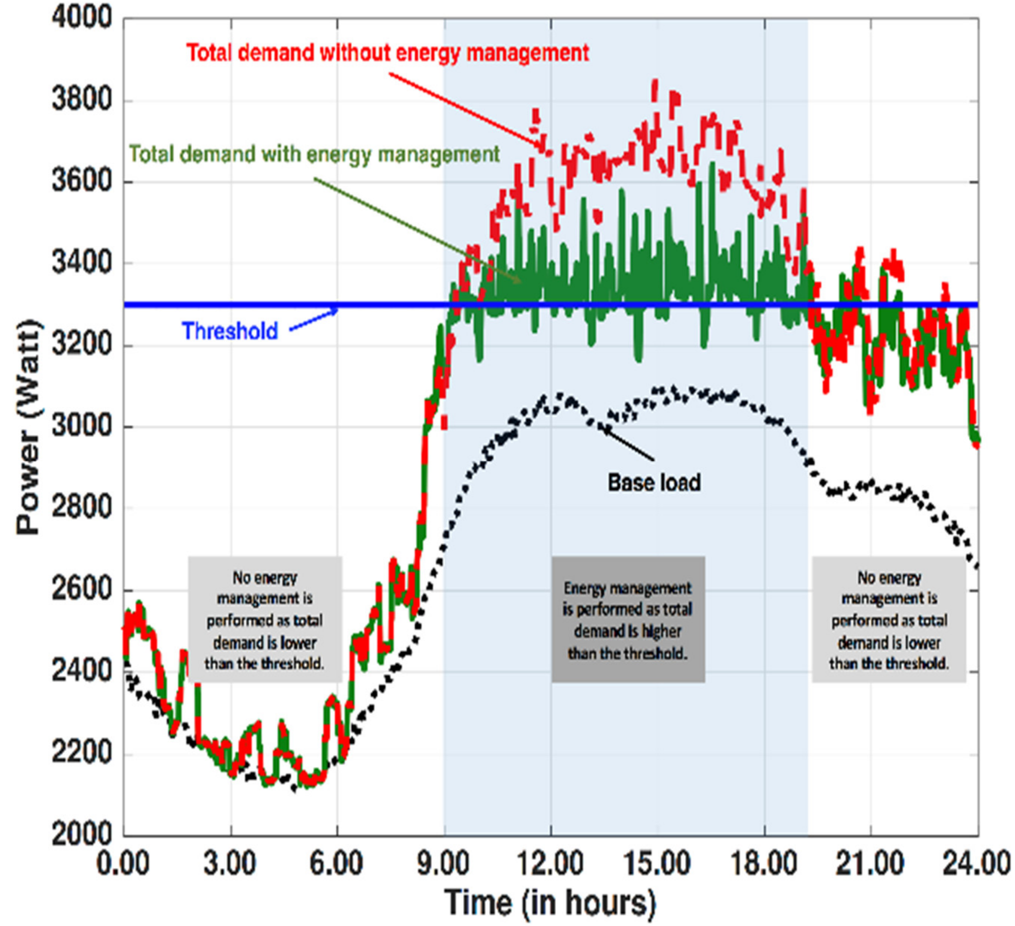
Survey Findings (1/3)

- A few surveys – 500 Households in Housing Development Board flats across the island
- 2-3 bedroom apartments (75-120 sqm)
- >7 days of usage data was captured to identify their total load profile, 2 key appliance (water heater and aircon) and their breakdown usage.
- Multi-Channel CT meter

		Recorded Data				Tabulated Data (kWh)			
No.	ID	Total kWh	AC (kWh)	Water heater (kWh)	no. of days	Avg. Total kWh per day	per week	per month	Remarks
1	85	1043.04	31.35	100.75	9.03	115.53	808.69	3234.78	
2	142	1783.79	457.18	735.65	8.97	198.83	1391.80	5567.18	
3	157	2824	167.84	316.32	9.06	311.76	2182.30	8729.20	
4	225	1491.7	631.54	79.05	7.52	198.32	1388.27	5553.07	
5	366	2512.08	830.03	340.30	10.82	232.26	1625.80	6503.18	
6	386	1943.29	655.90	136.88	8.93	217.74	1524.15	6096.60	
7	435	1547.44	205.56	42.19	9.96	155.34	1087.36	4349.44	
8	464	993.03	0.00	181.47	11.09	89.51	626.55	2506.19	no AC
9	533	310.37	0.00	60.54	8.98	34.55	241.85	967.39	no AC
10	551	2304.47	1253.99	145.22	10.78	213.72	1496.04	5984.17	
11	AVE	1675.32	423.34	213.84	NA	176.75	1237.28	4949.12	

SURVEY FINDINGS (2/2)

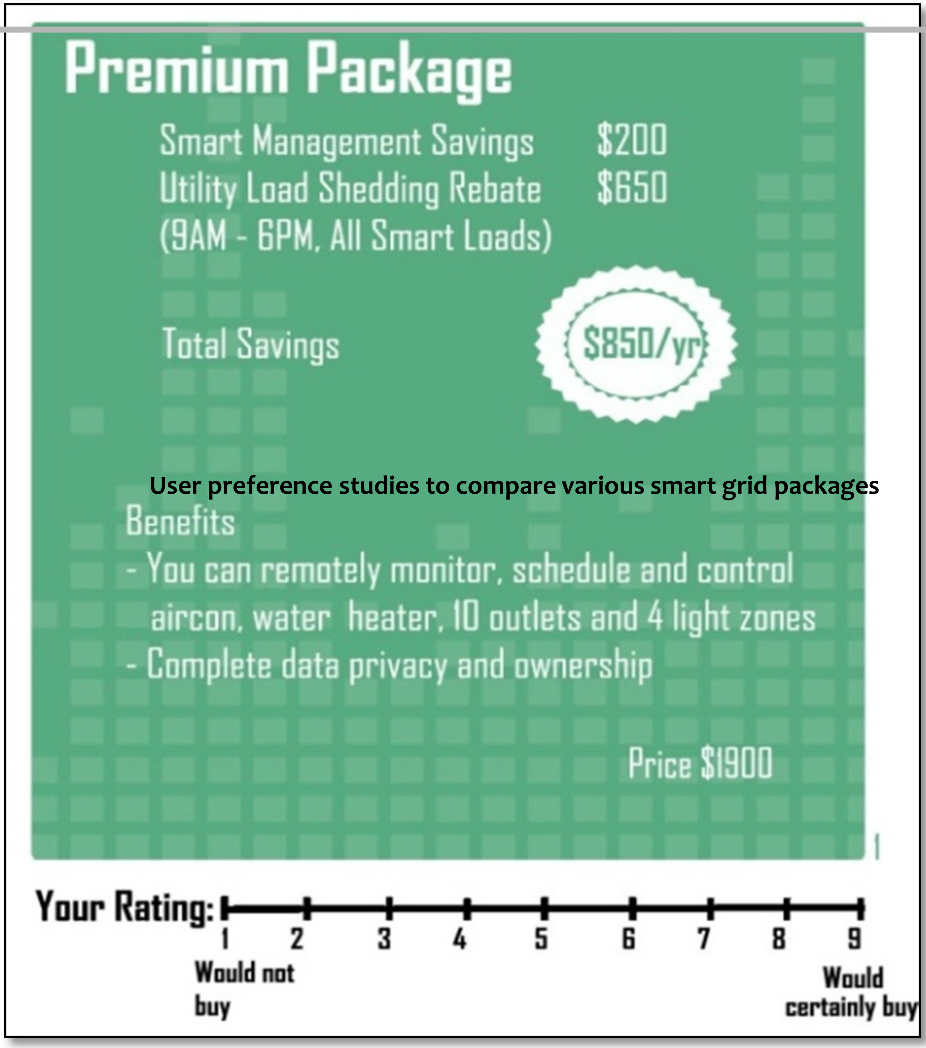




Control mechanism that are suitable for managing energy demand through smart plugs, which is capable of keeping the peak load within a range that was 14.28% lower than the original peak load during the experiment period for the considered scenario (Published in *IEEE Access, 2015*).

SURVEY FINDINGS (3/3)

- User study participants from HDB apartments are willing to accept the smart device packages with more benefits, and low break even times.
- They are willing to share power consumption information, and participate in a peak shedding program with loads that are not so critical or not critical at certain times with incentives and discounts.
- User study participants from condominiums want to use smart device packages as home automation systems.
- Participants are looking for alternative benefits such as child care, elderly care, and security.
- Cost, privacy and security are the key user concerns.

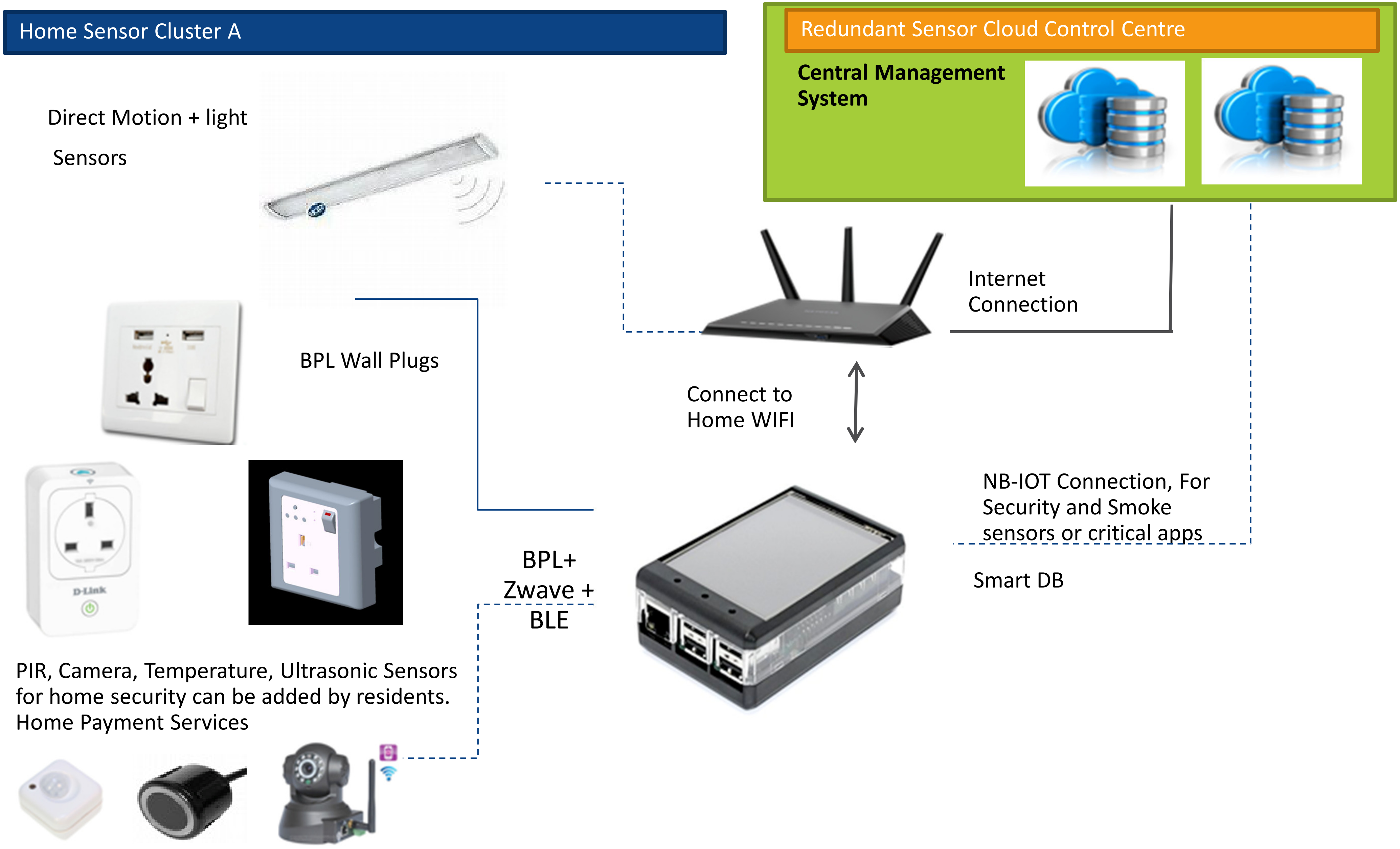


User preference studies to compare various smart grid packages

OUR APPROACH

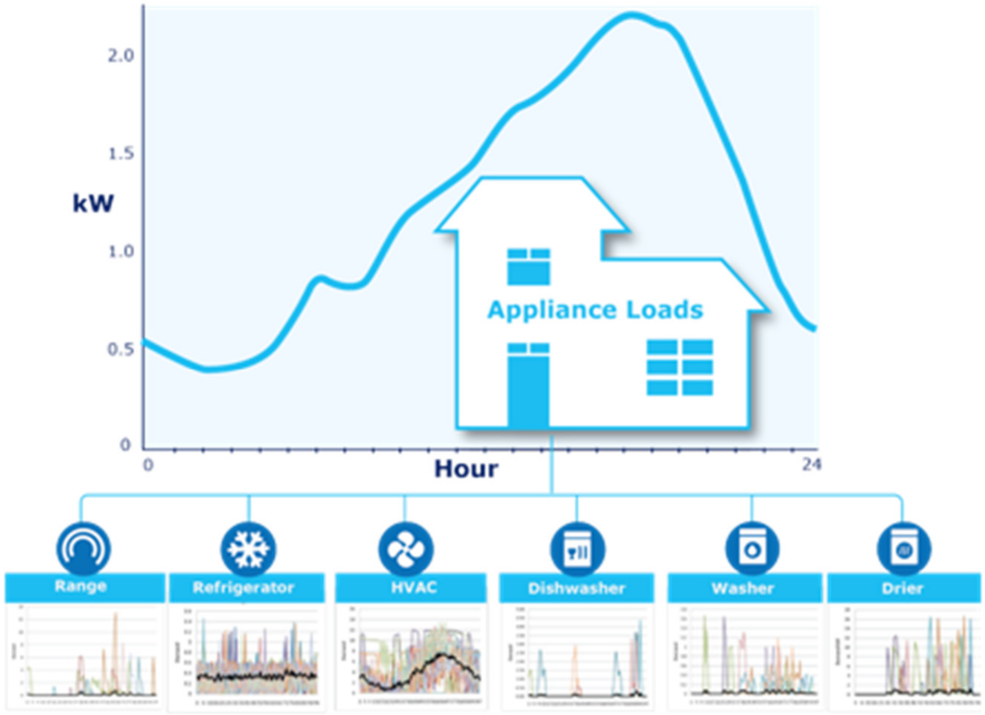
- **POC for Smart Home Management System – 3096 Smart homes in Punggol Smart Town**
- Smart Home **Universal Gateway** inside our Smart DB (SSB) to handle
  - data storage/depository, status of ALL connected devices.
  - Analytics and rules engine – perform front end analytics and upload the selected data to the cloud for deep learning and advanced analytics to build better and safer homes
  - Allow ecosystems to build other apps on Open API
  - **Secure Element (hardware security chip)** standardizing the security, connectivity and data collection in a reliable and robust manner.
- **Devices** for sensors such as sockets, motion sensors, fire/ temperature sensors, AC control, lighting control, detail load monitoring and allow "load curtailment" to turn on/off remotely as "Value Add" Services
- Non Intrusive Load Monitoring (NILM) and Game Theory – Maximizing Returns while reducing usage with and without ESS

System Architecture



NILM Analytics Platform

+ Load Analytics Intuitive control apps
+ Load Identification for Energy retailer Energy valet services
+ Load Curtailment- demand management
+ Condition based monitoring **



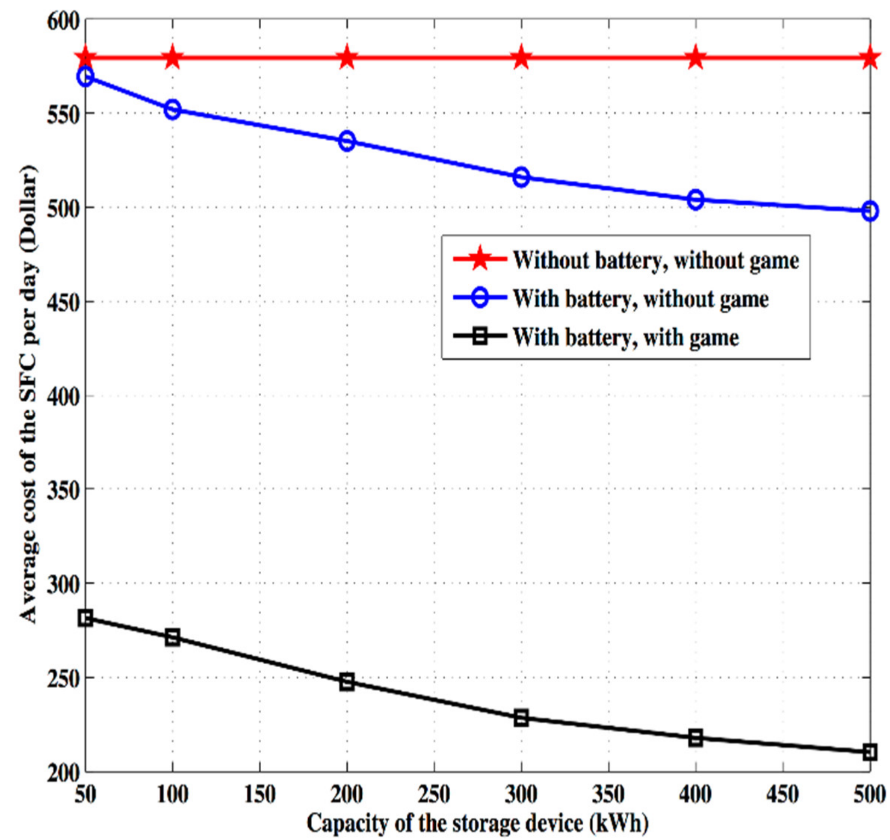
What Lies under the curve ?

The Economic Analysis of Distributed ESS

		Project Life (Years)	MW(1)	MWh of Capacity(2)	100% DOD Cycles/Day(3)	Days/ Year(4)	Annual MWh	Project MWh
In-Front-of-the-Meter	1 Peaker Replacement	20	100	400	1	350	140,000	2,800,000
	2 Distribution	20	10	60	1	350	21,000	420,000
	3 Microgrid	10	1	4	2	350	2,800	28,000
Behind-the-Meter	4 Commercial	10	0.125	0.25	1	250	62.5	625
	5 Residential	10	0.005	0.01	1	250	2.5	25

CALCULATING THE COST OF DEMAND CAPACITY

+ By Adding the IL capacity , AFTER THE METER from users preferences and adding of a simple home ESS (10 kWh), we can easily achieved MW and MWh Capacity
+ Per million household, we can easily obtain 80 kWh of an average 176 kWh usage per day of loads that are interruptible. `5-20 kWh over peak hour, we can have
  - 80 Million kWh or 80,000 MWh
  - 20,000 MWh during peak period
  - 10,000 MWh based on ESS
  - HUNDREDS OF MILLIONS IN INVESTMENTS



Conclusions

Building the universal gateway that supports energy smart applications provides the foundation for the smart city

Providing a secure device management platform that can collect data, manage data and millions of devices including SSO, lighting device, meters, allows ease of managing these devices and lowers costs by aggregating all under one platform

Utility Managed IL and ESS makes it more viable as compared to large utility level ESS.

Smart Homes/ City is gaining momentum worldwide and we intend the lead the frontier

With this, we encourage adoption by allowing partners and developers to innovate with the right policies