India SMART GRID Week 2017

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Preparing for High-mix of Renewables in India's Power Generation

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When Renewables mix with Grid Power

- Coal and Renewables likely to dominate India's energy mix
- Intermittent power-generation leads to power fluctuations
  - The state DISCOMs or utilities refuse to sign a Power Purchase Agreement (PPA)
  - Most renewable generation has high upfront capital investment and small operational cost.
  - With no Utilities absorption, cost of unassured demand will pass on to the selling price

Incentives for going to Solar and Renewables will Dilute.

Issues with High energy Mix

Solutions to combat Power Mix Issues

- Enable using ALL the renewable power generated, even if it is intermittent.
- No Power plant be forced to back-down because of lack of demand.
- What is done today?
  - Battery Storage: grid-level storage to arrest power-generation fluctuation beyond "affordability"
- Proposed Solutions:
  - Demand side load-management : responding to grid status
  - Storages : Explore all types of different possible storages

Exploring Alternatives

Energy Management for High Energy Mix

1

Use of Renewables is inevitable

- Take up peak load during day time
- No Transmission and distribution losses
- Solar cost is rapidly falling, thus becoming economical
- Adding Storage gives an option to store energy and use during load shedding

2

Different types of storages

- Can we store for air conditioning?
- Can we adjust with slight cooling variation in the comfort zone and pay lesser?
- Storages for rest of appliances and equipment

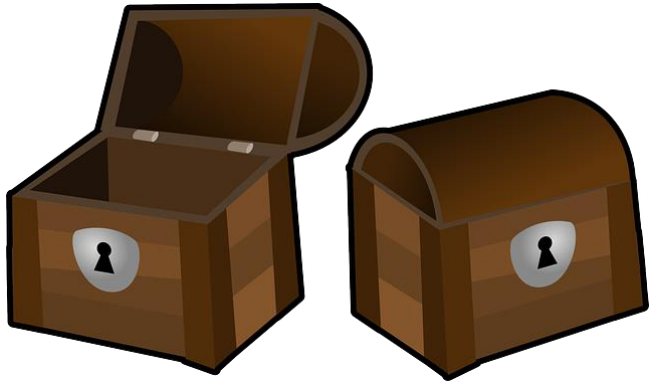
3

Demand Load Management

- Work around to benefit from the variation in Grid status
  - Renewables and storages to work hand in hand to aid this benefit

On 2 : Storages

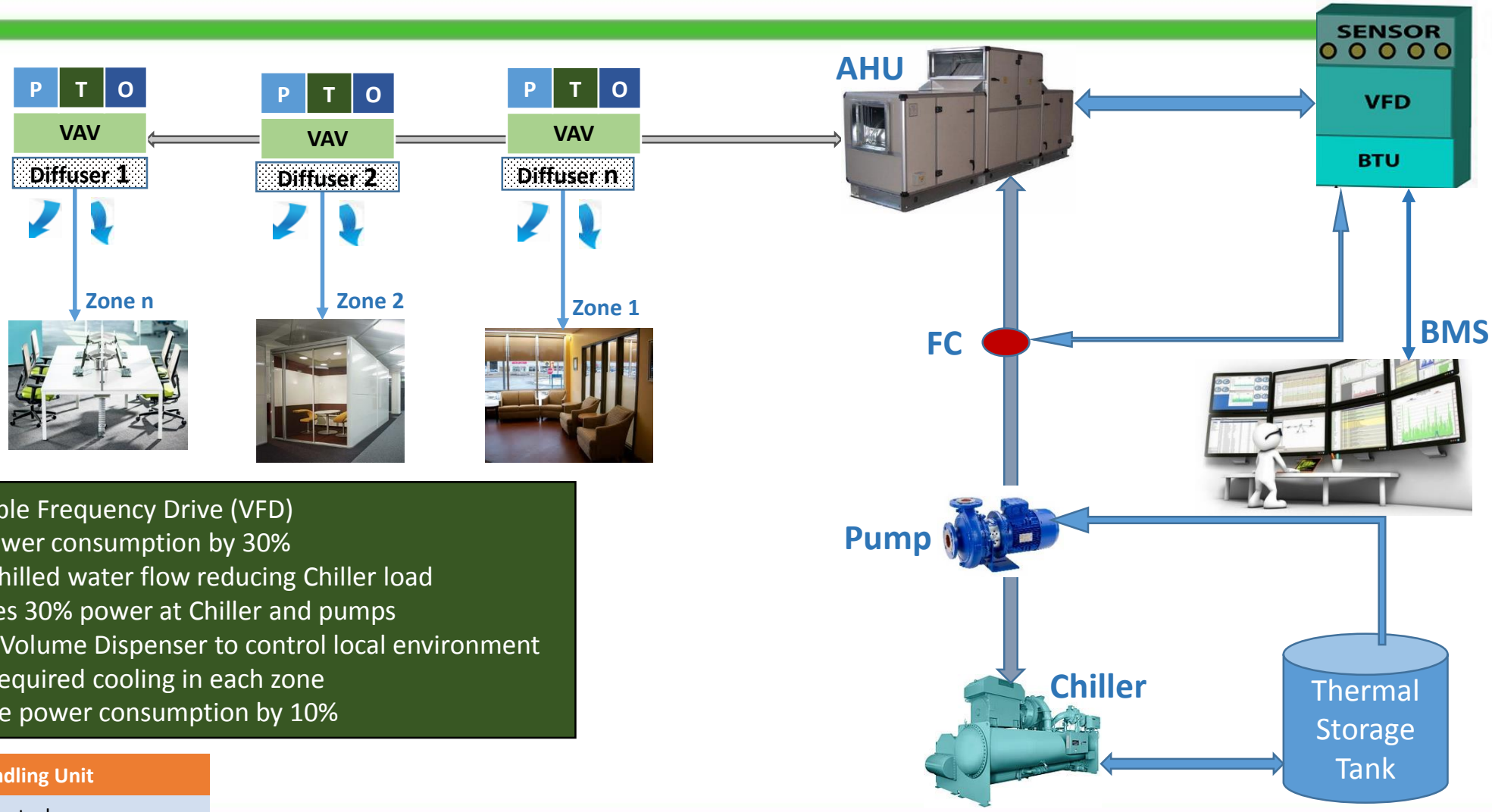
- Chilled water storage: Air conditioning is one of major energy consumers in a building and almost 80% goes in chilling water
  - Insulated thermal storage tanks at night/surplus state
  - When in deficit state, use this chilled water



- Cold air storage: control the cooling amount with help of VAVs, VFDs to vary office temperatures without impacting comfort
  - Division of large areas into zones, proximity sensors
  - Cool slightly more than set temperature during surplus grid and slightly less when grid is deficit

- Battery storage: centralize as well and decentralized
  - Not only as power backup but also as load balancer
  - Charge/discharge batteries in accordance with Grid state

Green Cooling System: DC for AHU and VAVs



AHU driven by Variable Frequency Drive (VFD)

- Reduces AHU power consumption by 30%
  - Controls chilled water flow reducing Chiller load
    - saves 30% power at Chiller and pumps
- Variable Airflow Volume Dispenser to control local environment
  - Provides required cooling in each zone
  - Can reduce power consumption by 10%

AHU	Air Handling Unit
FC	Flow Control
P, T, O	Pressure, Temp., Occupancy

On 3 :Demand Energy Optimization

- Building with **Available-Power Responsive Loads (APRL)**
  - Load management in response to the grid supply-demand mismatch
  - When grid-supply exceeds demand, consume without restraint
  - When demand exceeds supply, use minimal electricity without significantly impacting the functionality and life-style of users

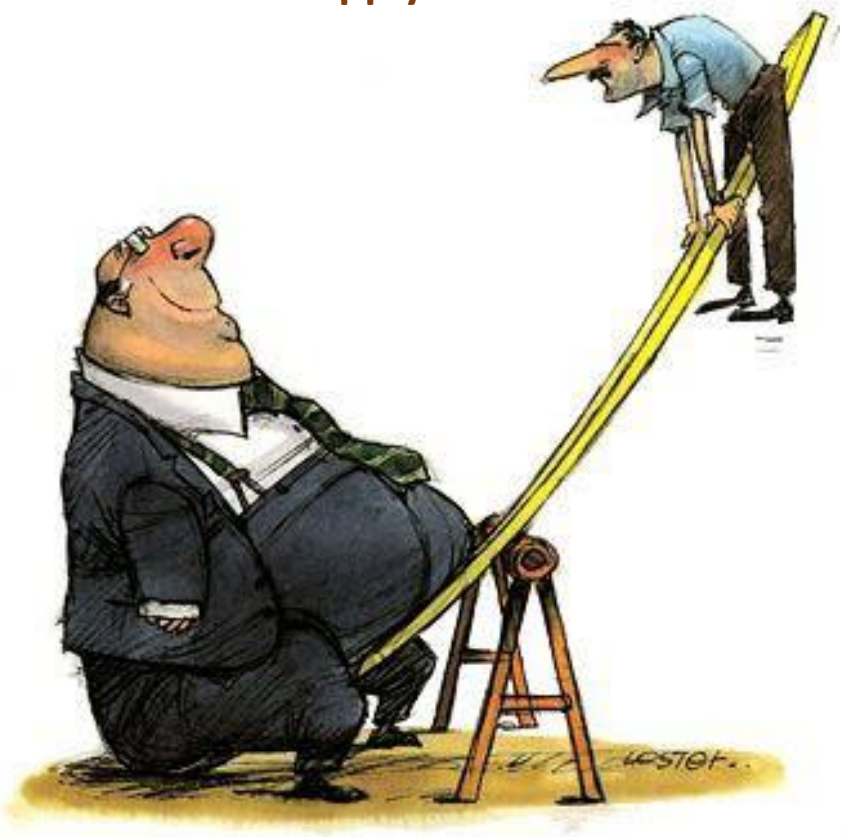
- Use Grid-prices to drive APRL Adoption
  - **When grid-power is deficit** (₹12 per unit scenario)
    - Use chilled water from storage and not use chiller
    - Increase set-temperature in offices by a degree, and use VFDs in AHUs and VAVs to reduce power-consumption
    - Use stored battery power to drive Load rather than grid
    - Cut-off secondary output power to reduce consumption
    - Draw power from centralized battery, rather than from grid (of-course use solar power to maximum)

Economic Incentive to use APLR

- **Surplus grid** (₹4 per unit scenario)
  - Chill water and push it to chilled water storage
  - Use slightly more Air cooling control
  - Charge Centralized battery to maximum
    - Charge office battery at each office to maximum

- **Normal Grid (₹8 per unit scenario)**
  - Depending on state of chilled water stored, use chiller to chill water being currently used.
  - Use office power from grid, but not charge battery (of course, solar is to be used first)

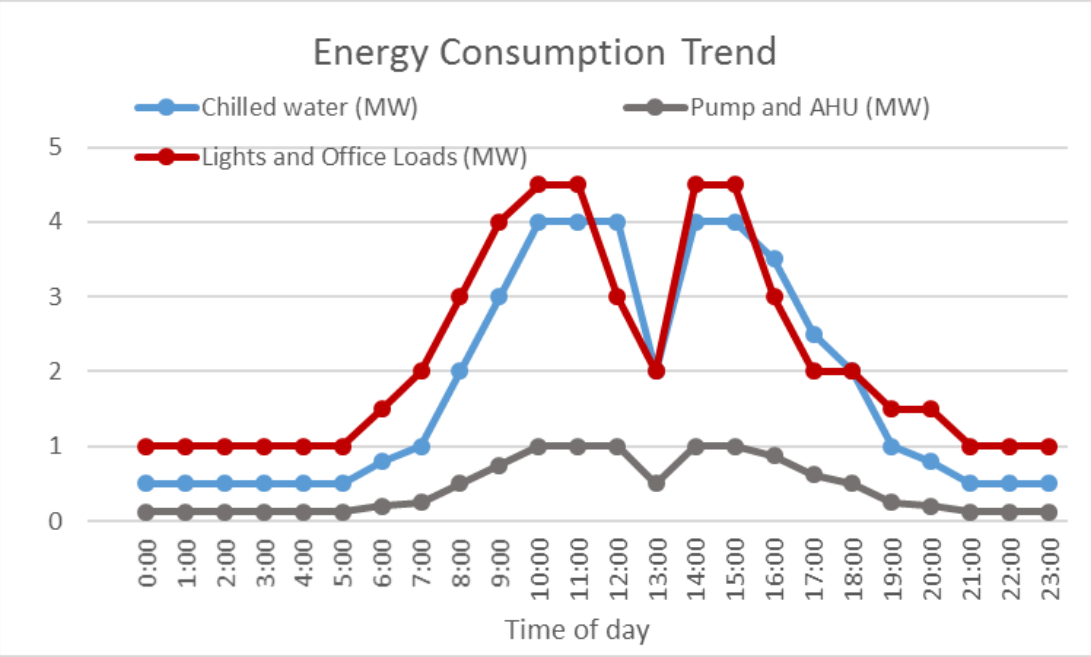
Load – Supply Mismatch



Building Designed with APRL

Category	Parameters	Value	Remarks
Building Load with usage varying at different times	Peak Chiller power used	4 MW	Total energy used in 24 hours: 43.1 MWh
	Max power used by Pumps and AHUs	1 MW (25% of chiller power)	Total energy in 24 hours is 10.775 MWh
	Maximum power used for lights and for office equipment	5 MW	Total energy in 24 hours is 52.5 MWh
Rooftop Solar	Plant capacity	1 MW(p)	
Storage used	Electrical Battery storage distributed across different offices effective	10 MWh	I. 50% is assumed to be used as power back-up; 50% is used for APLR (8% of energy used in 24 hours) II. Maximum charge and discharge rate of 0.15 MW is assumed
	Chilled water Storage	20MWh	charged / discharged at a maximum rate of 4 MW. Storage is almost 50% of chilled water energy used in 24 hours
	Cold Air Storage in different offices		assumed to be able to reduce power consumption for maximum of 2 consecutive hours giving 25% savings in chilled water usage and pump and AHU power usage; also needs 2 hours to restore before used again.

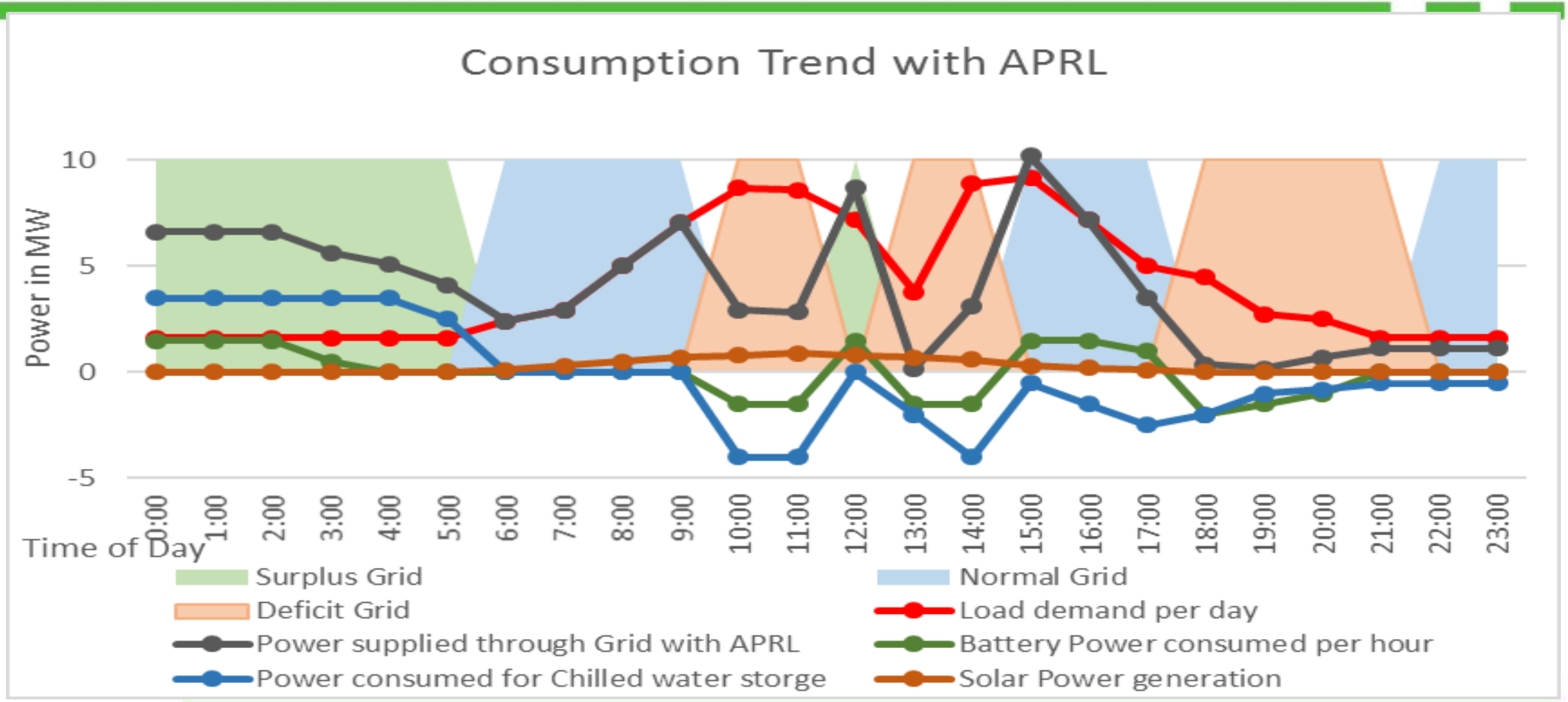
APRL through Grid Control



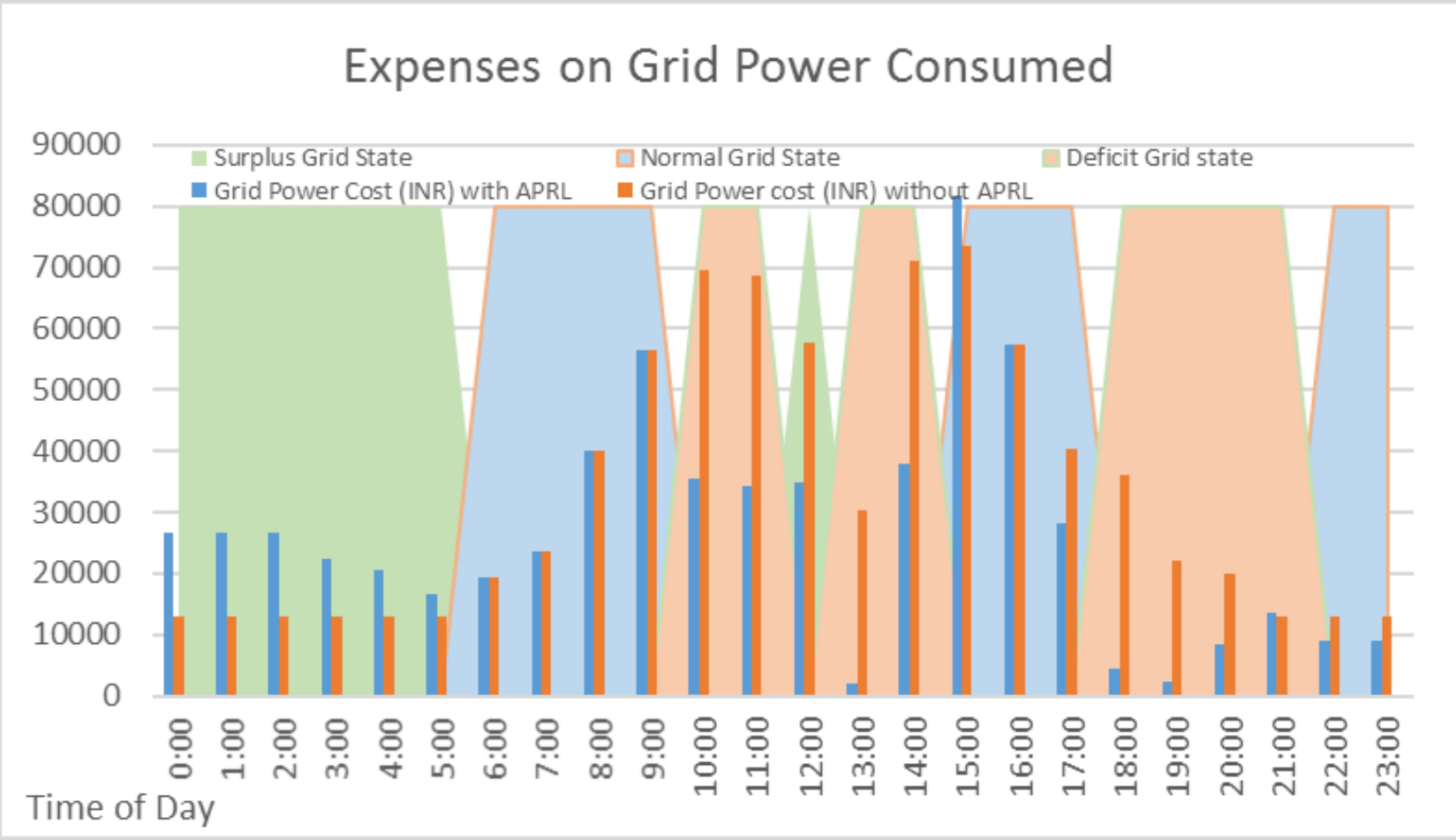
Logic used:

- Charge storage (electrical battery, chilled water storage and Cold Air storage) at maximum rate, when power is surplus.
- Use storage to the maximum extent during deficit grid date.
- charge or discharge storage during Normal grid state, taking account grid-state pattern learned from previous days, so as to enable minimum power usage during deficit state.

Generation, Storage and Usage with APRL



Consumption with and without APRL



- The total cost saving due to APRL amounts to ₹1.6 lakhs per day or about ₹50 lakhs per month.
  - Amounting to a little over 20% of the total electrical costs.

Note: Savings shown are over and above the savings envisaged due to use of DC equipment, use of VFD in AHU and VAVs and use of roof-top solar.

Summary and Conclusion

- Demand load management and Optimized consumption through APRL clubbed with different types of storages is a huge electricity cost saver
  - Bridges load demand gap during peak times and flattens demand, not only beneficial to consumers but also to DISCOMS
- Helps promoting a good mix of Renewables with Grid, while taking care of the intermittent nature of renewables and promised usage
- Expandable to all sectors of energy consumption:
  - Industry, domestic and transport sector

Backup Slides

Understanding Loads

- Built up areas and Industry are growing and so is the Energy demand
- Electricity Consumption trends