

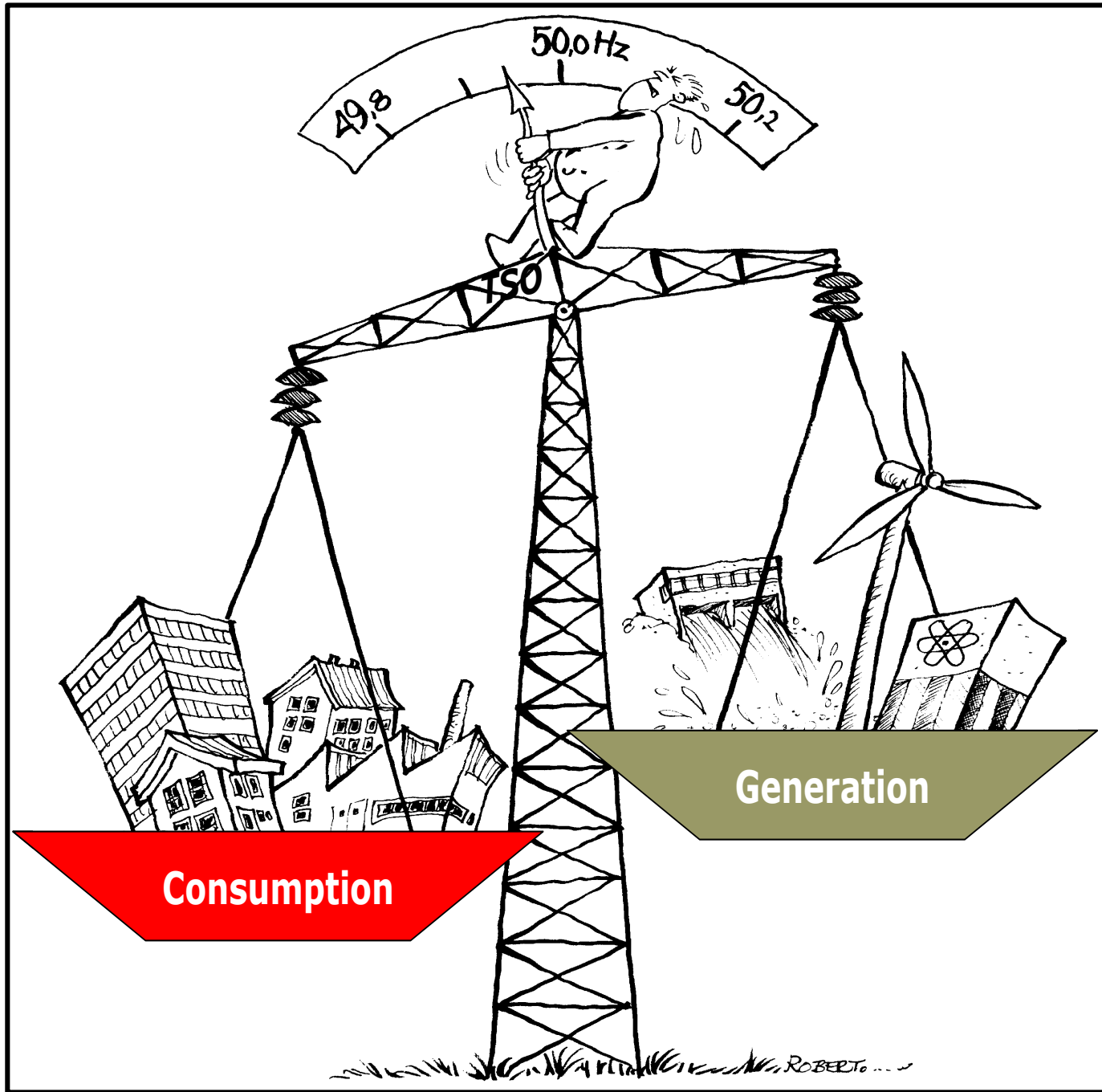
“Energy Storage: Nepalese Perspective”.

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OUTLINE OF PRESENTATION

- Integrated Nepal Power System(INPS)
 - Power system
 - Typical demand characteristics of INPS
 - Typical Supply Characteristics of INPS
 - Typical Problem of demand supply unbalance of INPS
- Importance of Storage Hydro
 - Shifting preference
 - Deficiencies in preferential source
 - Role of storage hydro in changed context

THE POWER SYSTEM



POWER SYSTEM: SOURCES OF DEMAND AND SUPPLY

Demand (Global reference)

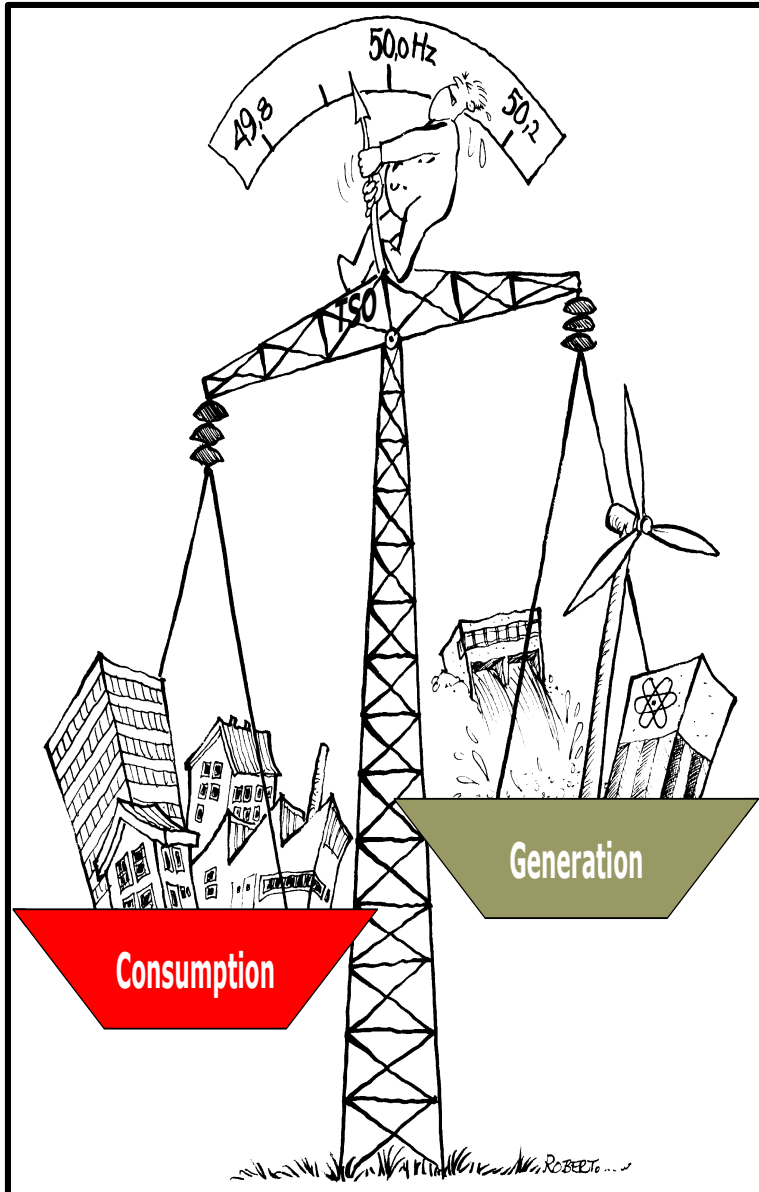
- **Human Activity**
 - Changes with motion of earth
- **Motion of Earth**
 - Spin
 - Rotation
- **Corresponding Demand Patterns**
 - TOD, Seasonal

Supply (Nepal reference)

- **Domestic**
 - Hydro ROR
 - Hydro Storage
 - Thermal
 - Renewable
- **Himalayas as large reservoir**
- **Imports**

We have paradoxical situation of supply against demand

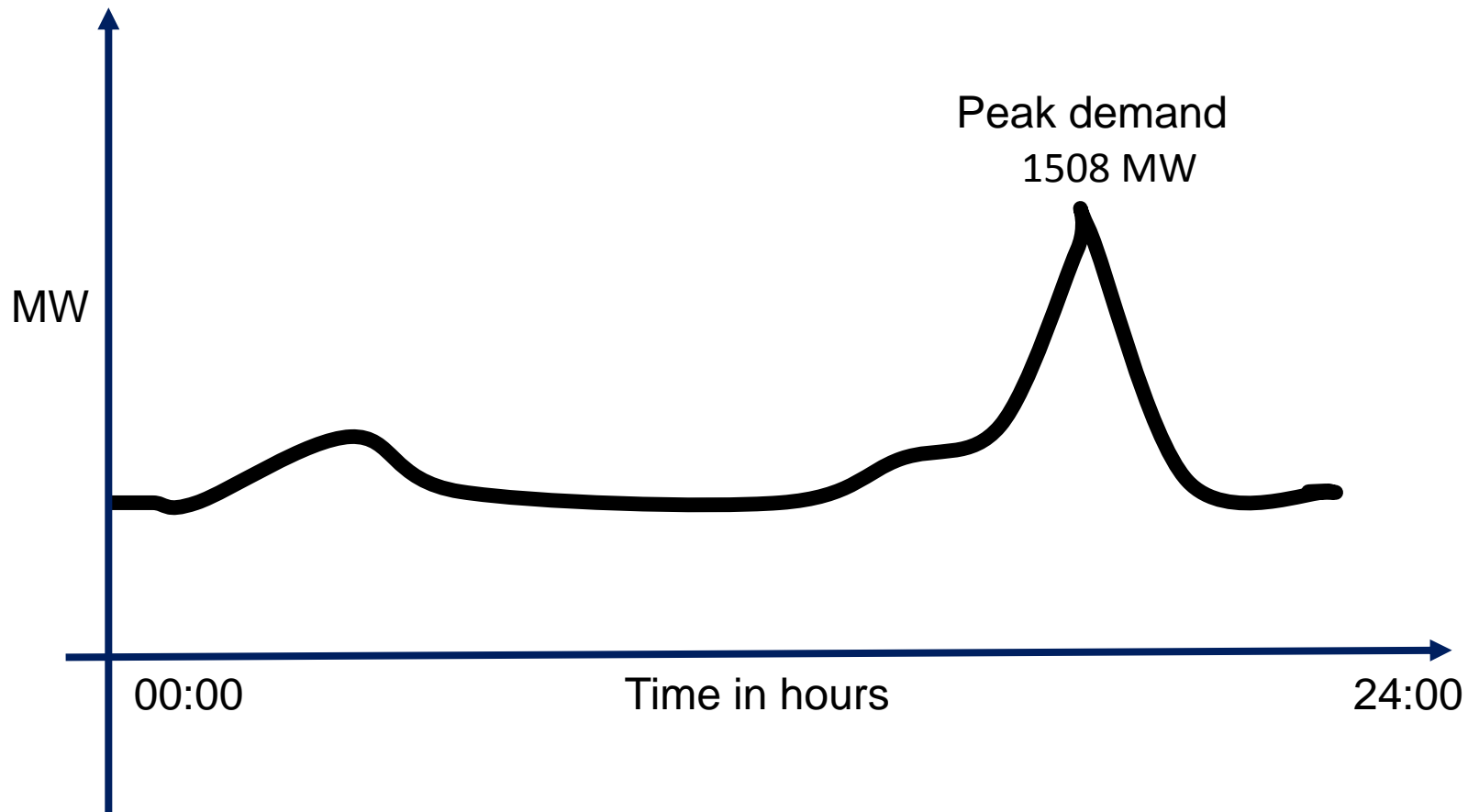
POWER SYSTEM: BALANCE OF DEMAND AND SUPPLY



- **At any moment**

- Either supply or demand high (both not equal)
- Higher pan will lean and tend to touch ground resulting in system collapse
- In supply deficit (demand higher), demand pan tends to touch ground
- To save total system collapse, some load from this pan is thrown out
- Throwing out of load means disconnect few consumers
- Disconnecting few consumers is the unpopular word **LOAD SHEDDING**

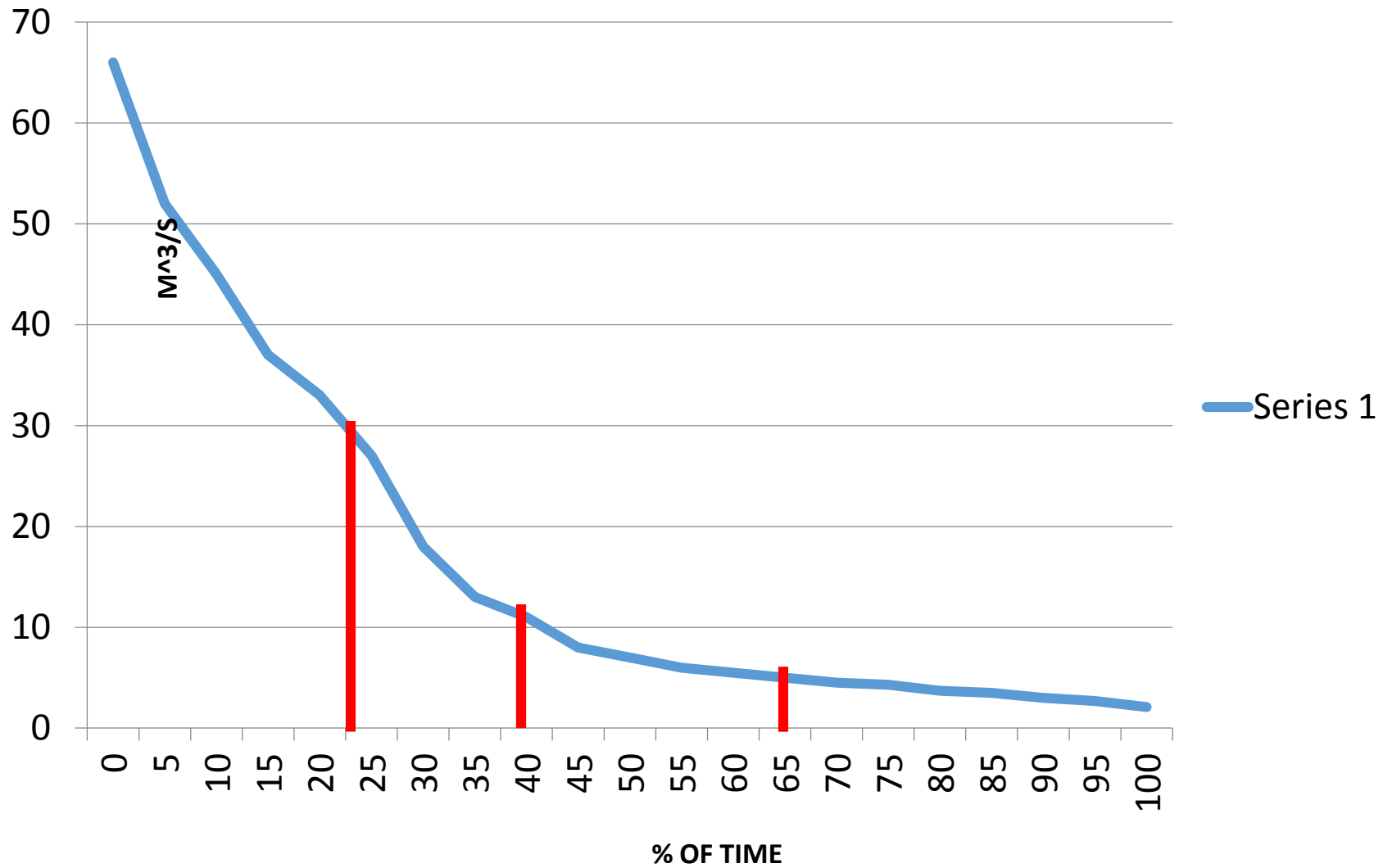
INPS: TYPICAL DAILY DEMAND CURVE



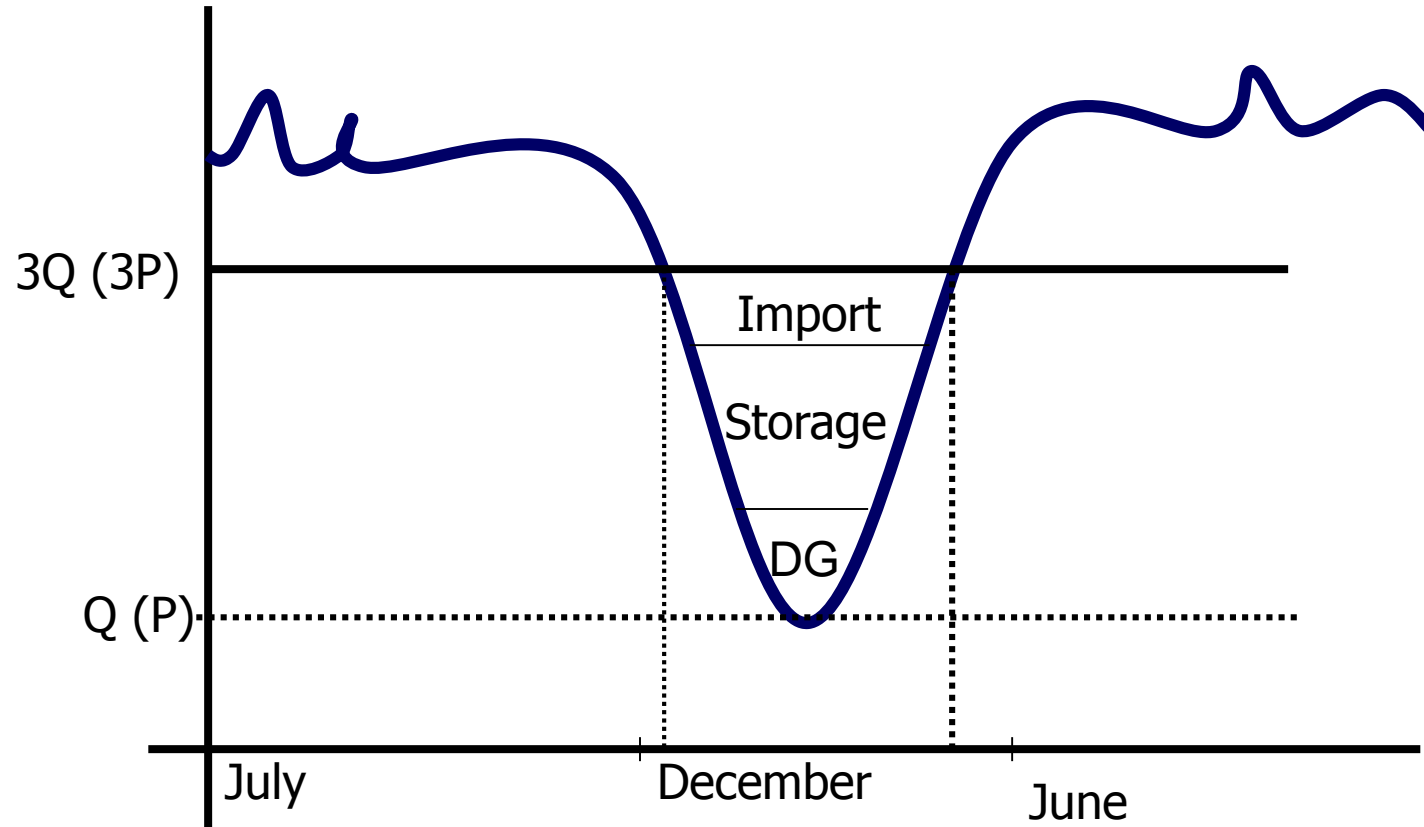
Daily Load Factor < 55%

INPS: TYPICAL FLOW DURATION OF RIVERS

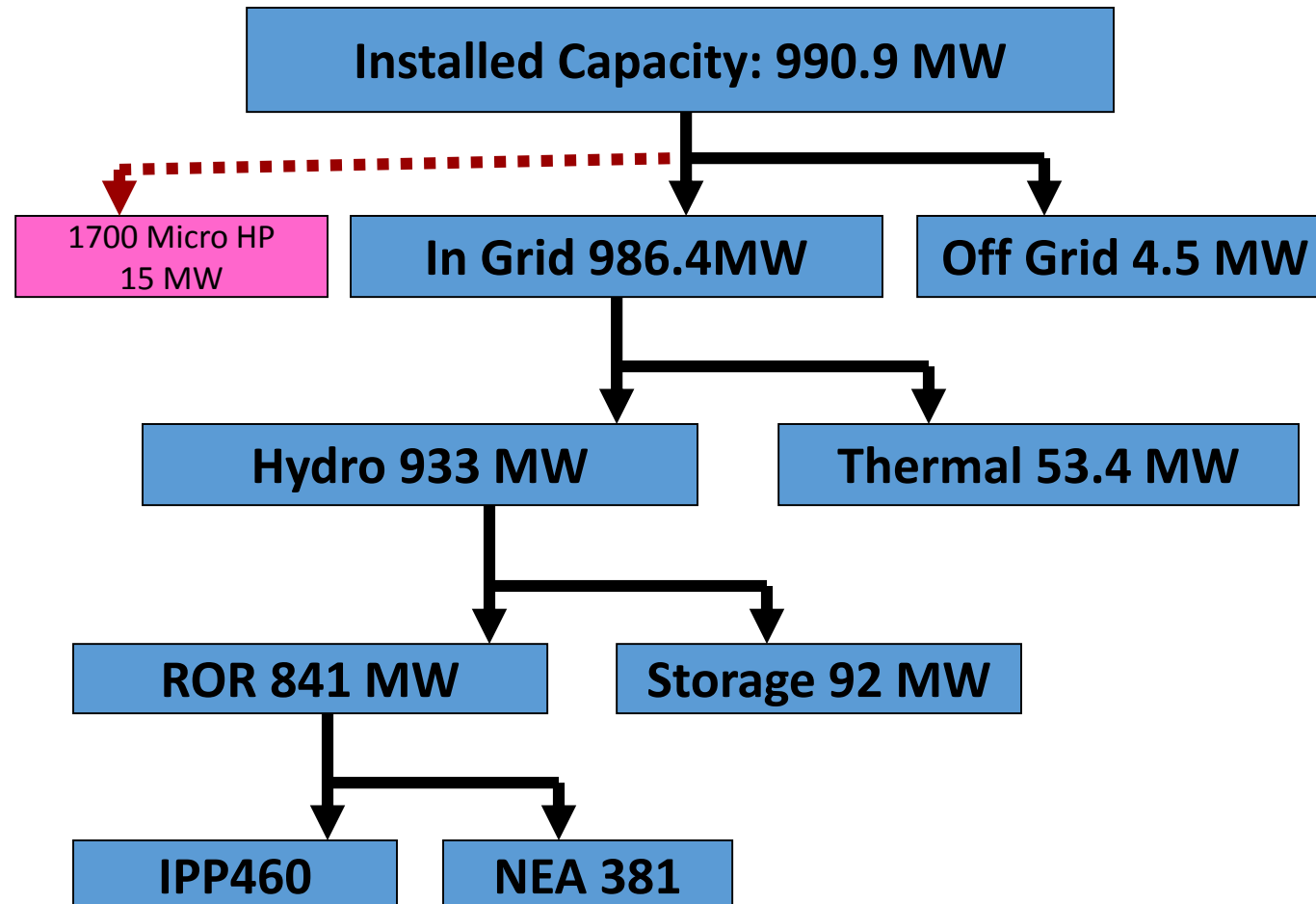
Series 1



INPS: TYPICAL SEASONAL SUPPLY CURVE



INPS: TOTAL INSTALLED CAPACITY



This 990 MW installed capacity might fetch only 350 to 400 MW during Winter.

INPS: TYPICAL SYSTEMIC PROBLEM

- Very poor demand load factor asking high installed capacity.
- Overall installed capacity lower than demand 990 MW Vs. 1508 MW.
- Single source (hydro) dominance (above 95%), majority ROR
- The single source has high seasonality with less than 30% availability compared to installed capacity in winter and dry season.
- If we have installed capacity equal to peak demand then huge surplus during off peak hours of the day in rainy season but severe capacity and energy deficit in winter.
- Solution to this problem is:
 - Some Energy Storage Technology that can store off peak surplus of rainy season on seasonal basis for Winter deficit
 - An Energy mix that can address daily TOD demand variation as well as seasonal demand and supply variations.
 - Abundance of hydro-potential and lack of fossil sources indicates hydro based energy mix of ROR, PROR and **Seasonal Storage and** in right proportion.
 - Hydro product line of this mix to suit all season demands. “or”
 - Grid connectivity with neighboring countries
- Absence of such a mix means never ending seasonal surplus and deficits in supply.
- PROR can only address daily TOD variation but Seasonal Storage hydro is the answer to Nepal’s Typical Seasonal Energy problem.

SHIFTING PREFERENCE FOR PRIMARY SUPPLY SOURCE IN THE GRID

- Traditionally, hydro, coal, diesel based generation etc. has been source of primary supply in the grid.
- But technical and financial viability of renewable sources in recent years has shifted this preference for developers and financiers.
- Lowering costs, shorter time for installation and relief from geological and other risks have attracted the developers and financiers towards renewables.
- This trend may force the hydro and other sources to go on back foot or they should explore ways for survival.
- This is a threat for the countries having hydro potential in abundance.
- To cope with this situation, we should identify the impediments of renewable supply sources and then develop hydro products to complement these impediments.
- One major impediment of renewables is they are intermittent in nature and hence can be integrated in grid only up to limited capacity for grid stability.
- Hydropower can facilitate more and more integration of renewables in the grid by complementing the impediments.
- Doing so hydropower can go hand in hand with renewables.

HYDRO PRODUCTS FOR INTEGRATION OF MORE RENEWABLES

Following are some of the products that are essential for grid stability by renewables can't offer them and hence are integrated in limited capacity:

- Real Time Frequency Regulation Service
 - Real Time Voltage Regulation or Reactive Power Supply Service
 - Loss Compensation Service
 - Peak Demand Supply Service
 - Black Start Service
 - Energy Storage Service
-
- If these services are offered by appropriate hydro products, hydro will complement renewables.
 - Among hydro also, storage hydro can offer all above products. That is why development of Storage Hydro is answer to many problems.

NEW HYDROPOWER PRODUCTS

- **Real Time Frequency Regulation Service**

- Power output of renewables susceptible to factors of weather
- Primary supply contribution by renewables changes in real time
- Instead of offering frequency regulation in real time they are source of frequency variation
- It is usual that demand fluctuates in real time causing frequency variations.
- But renewables cannot change their generation to regulate frequency to address real time fluctuation in demand
- That is why renewables are integrated up to only 10% of peak supply.
- If hydro offer this frequency regulation in real time , more and more renewables can be integrated in grid.
- So this frequency regulation service can be marketed as separate product.
- Storage hydro are best to offer this service or produce this product.

New Hydropower Products

- **Real Time Voltage Regulation or Reactive Power Supply Service**

- Renewable sources like photovoltaic solar power do not supply reactive power for voltage balance in the grid.
- Insufficient availability of reactive power is threat for system stability.
- So if we wish to integrate more and more photovoltaic solar power in the grid then we need some other spinning source to supply reactive power in the grid on behalf of renewable.
- Hydro and especially storage hydro is a preferred source of voltage regulation.

NEW HYDROPOWER PRODUCTS

- **Peak Demand Supply Service**

- Power systems do not have a consistent load throughout the day.
- Depending on various system specific factors, every power system has daily maximum demand during certain hours of the day and usually it is during evening hours.
- System is exposed to sharp and substantial demand rise during peak hours which rise is different than normal demand fluctuations.
- Most renewable sources connected to grid cannot regulate their generation output according to system demand in real time.
- To integrate more and more renewables in the grid, some other source that not only can address the normal frequency variations due to real time load or supply fluctuations but also substantial shoot in the demand during peak hours is needed.
- Hydropower, especially storage or pumped storage is most suitable product for this service.
- But if the system has energy deficit as in our case in Winter, then pumped storage is not the answer. Seasonal Storage is the key.

NEW HYDROPOWER PRODUCTS

- **Loss Compensation Service**

- Bulk consumers purchase power either through bilateral PPA or from market.
- Generator delivers sale quantum "X" at its delivery point to transmission provider. Transmission provider takes this power up to off take point of purchaser.
- But there are losses say "y" in transmission system. If the purchaser off takes same quantum "x" then system will be unbalanced by "y".
- This unbalance "y" is attributed to transmission system so transmission provider should take the responsibility of system balance.
- For that transmission provider will purchase power equivalent to real time losses from another spinning source and inject in the grid.
- Storage hydro is the best spinning source for this purpose.

NEW HYDROPOWER PRODUCTS

- **Black Start Service**

- System restoration after collapse is a difficult and time taking process.
- One of the reliable generating unit has to be started first and should supply to some load.
- Then step by step other units of system are synchronized and load is gradually increased corresponding to these synchronized units.
- Voltage and frequency balance at this stage is very critical.
- Starting of this first unit is called Black Start and this generating unit has to be robust to absorb voltage frequency fluctuations.
- Renewable sources cannot offer this flexibility. Hydro generating units are best for this service.
- This “Black Start Service” product can be marketed at premium price.

NEW HYDROPOWER PRODUCTS

- **Energy Storage Service**

- Generation output of many renewables is contingent to weather factors but demand does not change in the same direction and same quantum.
- If we integrate more and more renewables in the grid then during certain hours of the day when weather conditions are favorable for generation, the generation may surpass the demand. Ultimately we will have to switch off the generation.
- But if we have some means to store this available surplus generation as capital stock of energy we can market it later when there is demand in the system.
- Grid connected batteries have been developed to be charged by this surplus generation and supply in the system when so required.
- But batteries developed so far can only address short term fluctuation in the system.
- Hydropower units can quickly regulate their generation and are most suitable to offer this storage service. They can offer daily, weekly or seasonal storage service.
- So by developing PROR, Seasonal Storage or Pumped Storage Hydropower Projects; we can offer “Energy Storage Service” as another product in the hydro product line.
- Hydropower projects with this storage facility can sign “Energy Storage Service Agreement” with ROR hydro or renewable generators.
- Alternatively this agreement can be signed with system operator also.

SUMMARY

- INPS is facing and will continue to face seasonal energy deficit problem due to typical nature of its supply source
- This problem can be eliminated by development of Seasonal Energy Storage hydropower projects.
- Seasonal storage hydropower projects can also complement the impediments of renewables to integrate them in grid.
- Seasonal storage hydropower projects are appropriate technology for Nepal for energy storage.
- Traditionally hydropower is the main source of primary supply in the grid.
- They were supplying a single composite product where in other services like frequency regulation, reactive support, peak demand supply, loss compensation, black start came free with primary supply.
- But now is the time for hydropower developers to segregate these products and market them

CONCLUSION

A Visionary Sector Planner and Forward Looking Sector Regulator can help develop and market new hydropower products to solve the typical energy problem of Nepal and make hydro complimentary to other renewable sources.