Capacity and Demand

IE350

A problem

- AUA average power consumption rate is:
  75 kW.
- Large Auditorium Lighting ONLY takes:
  120 kW.
- Size a gas driven generator.

Solution

- Answer:
  75 kW?
  120 kW?
  195 kW?
  Or?
- Answer: Solve an optimization problem.

Capacity & Demand

- Investment is needed to add the physical Stock of Capital.

  Capital Stock =

  = Installed Capacity =

  = Size = Power, In …

Capacity & Demand

- Power shortage means:

Peak demand > Installed capacity

- Energy shortage means:

Not enough fuel to generate power.

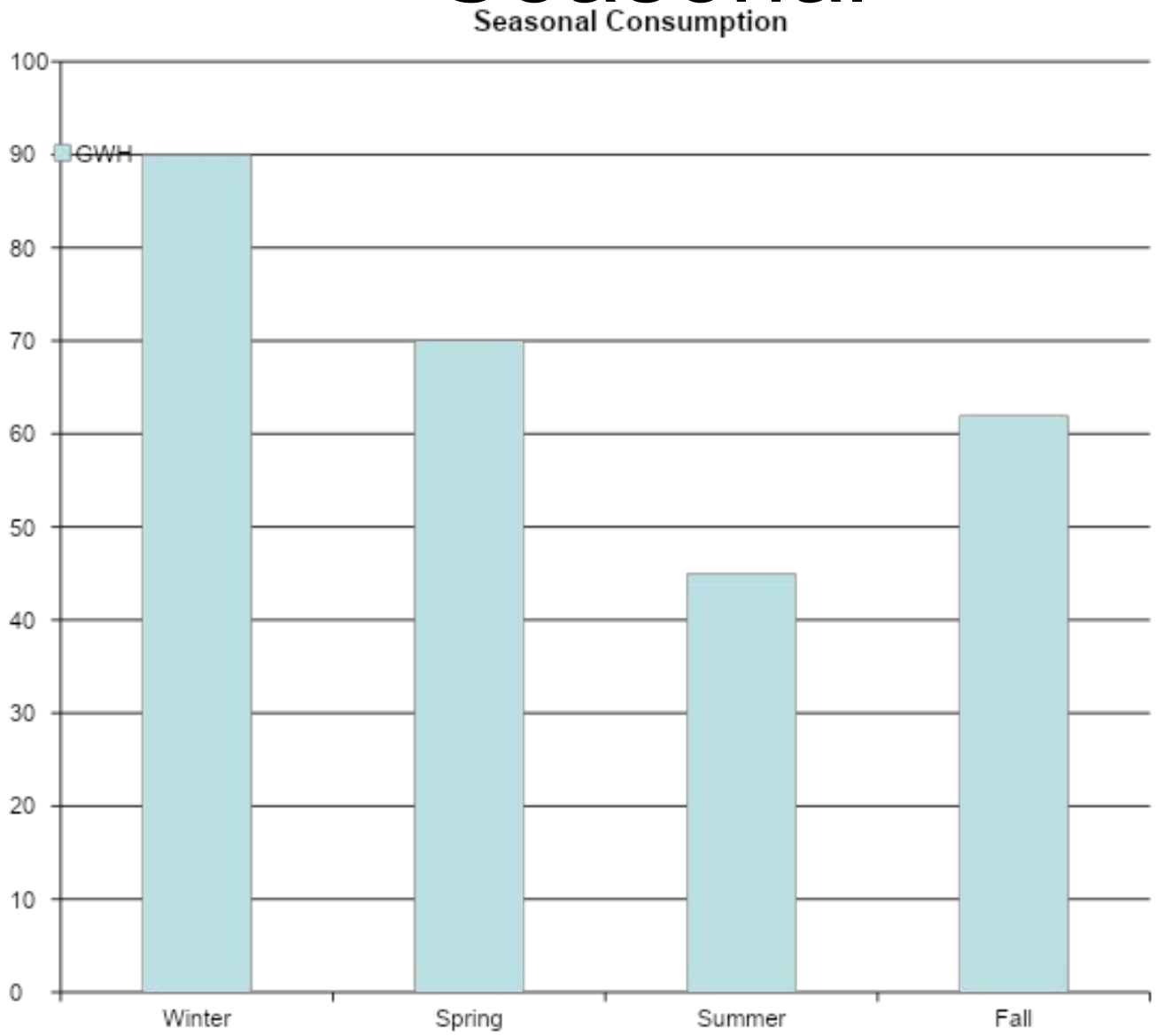
Load curves

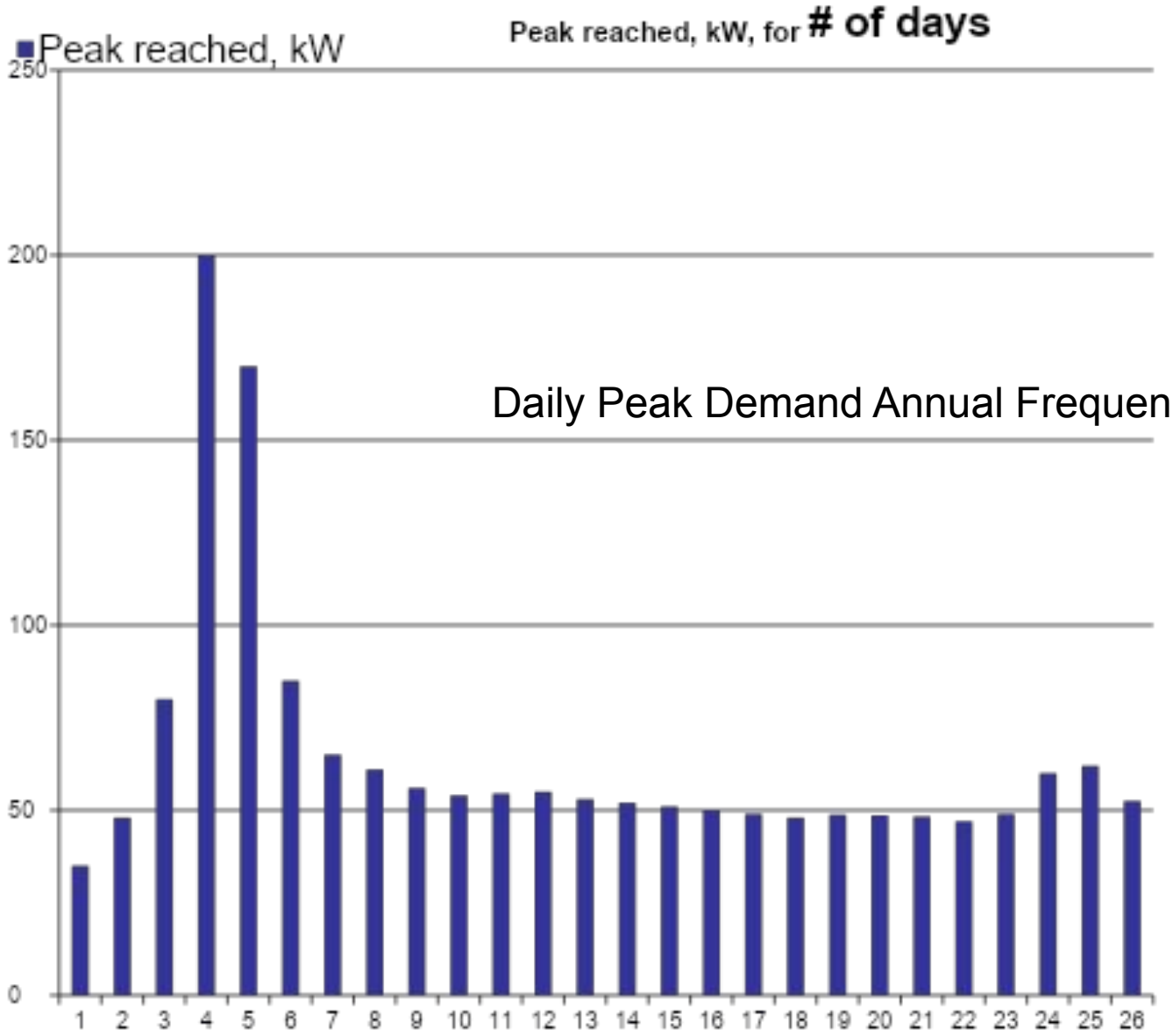
- Electric power demand = load
- Load curves, regular (periodic):

Daily
Weekly
Seasonal
Per shift, other…?

- Plus a stochastic component.

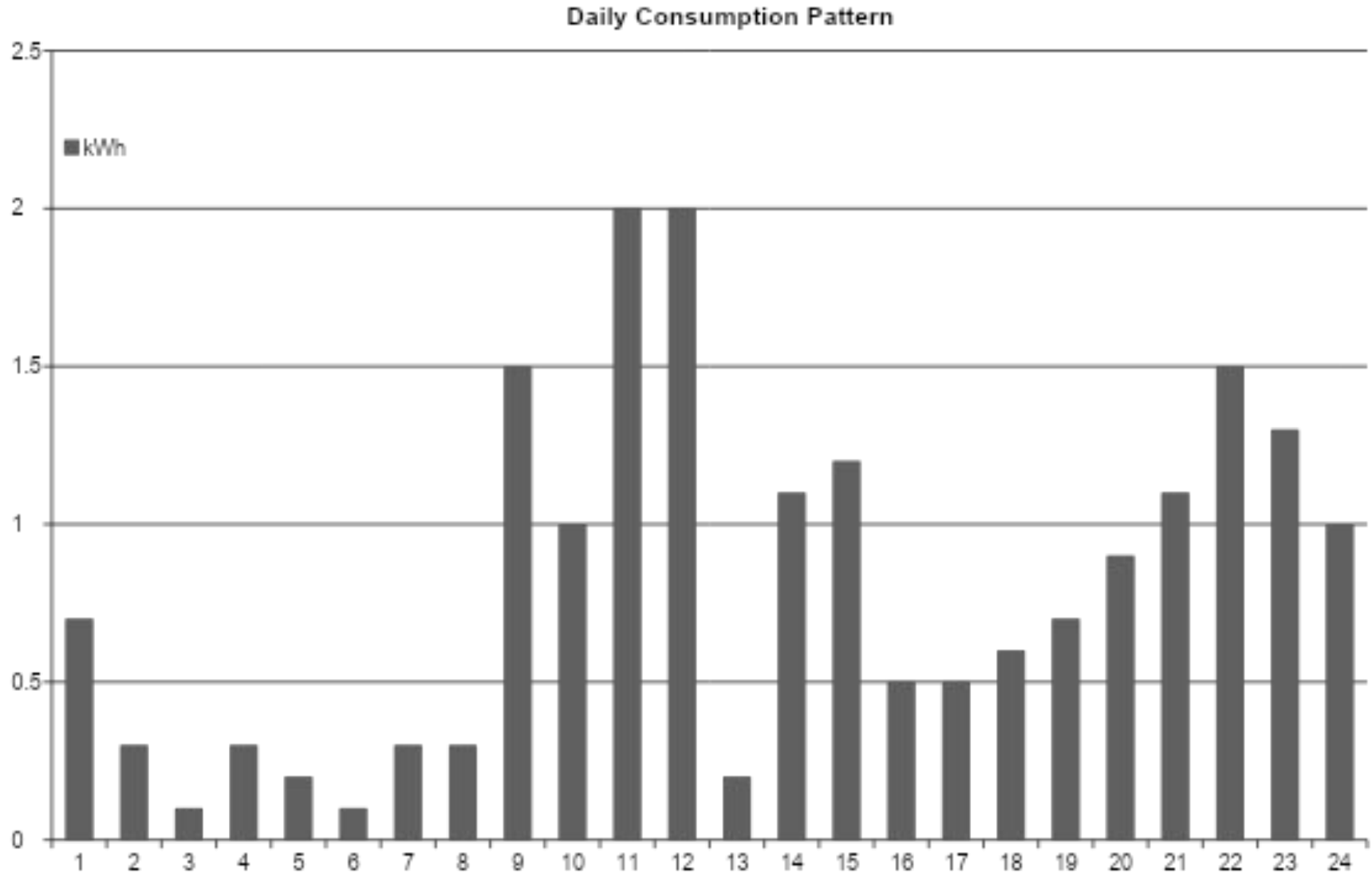
Seasonal


Seasonal Consumption
100
90
80
70
60
50
40
30
20
10
0
GWH
Winter
Spring
Summer
Fall



Daily Peak Demand Annual Frequency Histogram

Daily


Daily Consumption Pattern
kWh
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

Capacity factor (CF)

$$CF = \frac{\text{Actual Generated Energy}}{\text{Energy Generated @ 100\%}}$$

Is it constant?

It is different for different types of powerplants.

Hydropower

Powerplant	Capacity, GW	Production, TWh/year	Capacity Factor	
Three Gorges Dam (China)	18.3 (22.5)	80 (368)	50%	
Itaipu Dam (Brazil, Peru)	14	91.6	74.6%	

Comparison

Type	Capacity factor, %	Category
Hydro	20-80% (100%)	Seasonal
Wind	25-35%	Intermittent
PV	20%	Intermittent
Solar thermal	15%	Intermittent
Nuclear	90%	Base
Geothermal	90%	Base
Fossil	90%	Base-Peak

PV capacity factor

- 1kW of PV produces always annual amount kWhs equal to the monitoring amount:
- … e.g. in Yerevan we have 1720kWh/m^2 annually.
- 1720/8760 = 19.63% - capacity factor for PV.
- For 3 kW system we would get 5160 kWh

Energy Shortage: Two Approaches

1. Construction of new capacities - supply side.
2. Conservation, Load leveling – demand side.

Peak vs. Average vs. Base

- AUA peak is:
  75 kW?
  120 kW?
  195 kW?
  Or?
- Average is another number…

Countrywise

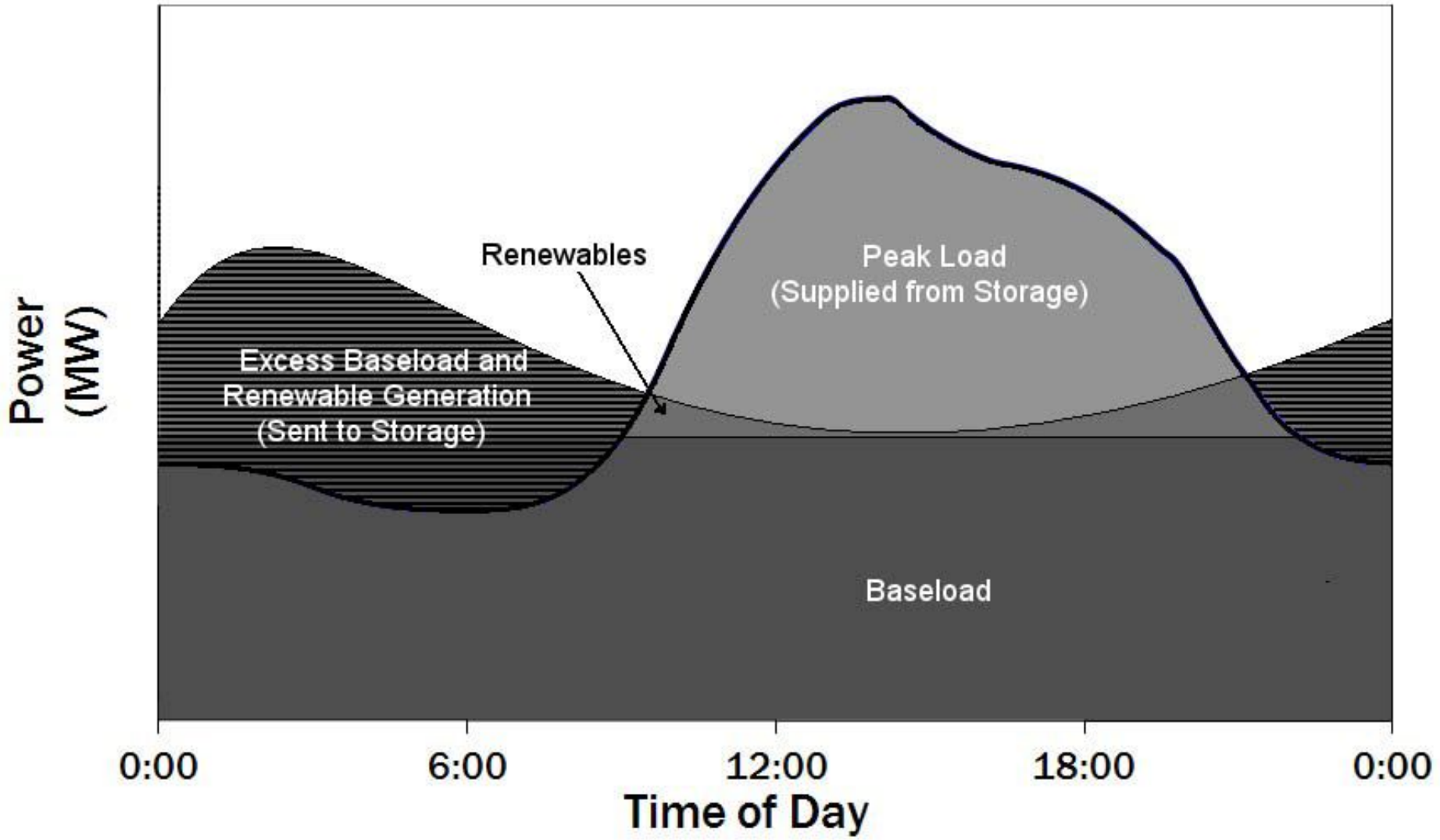
- Peak
- Average
- Base

Peak

- All powerplants, all generation capacities are operating.
- We are going to extreme measures: ALLOWING TO LOWER SEVAN LEVEL!
- We are buying power from other countries
- And the power is not enough:
  in some places power is cut.

Base

- Consumption never goes below certain amount
- Metsamor NPP is providing the base power.


Power
(MW)
Renewables
Peak Load
(Supplied from Storage)
Excess Baseload and
Renewable Generation
(Sent to Storage)
Baseload
0:00
6:00
12:00
18:00
0:00
Time of Day

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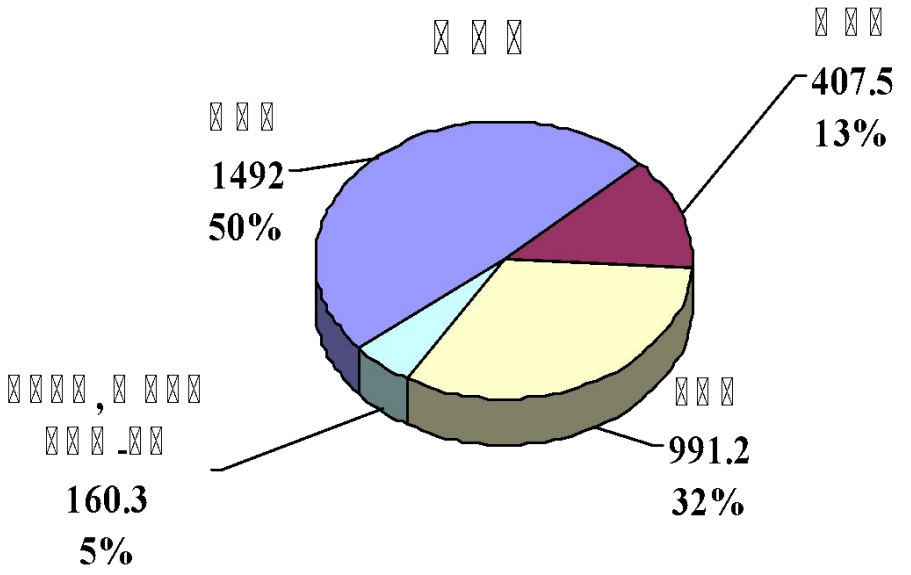

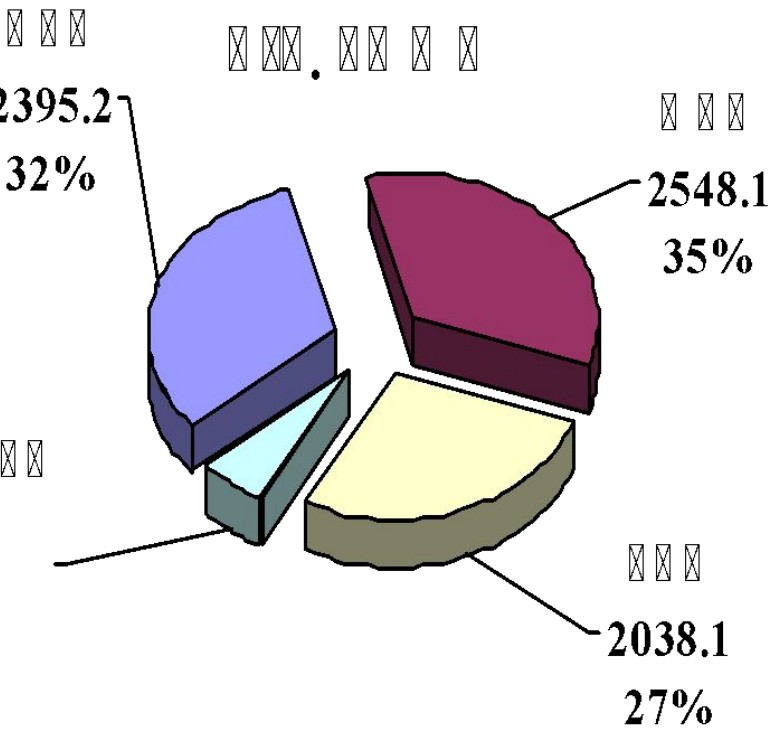

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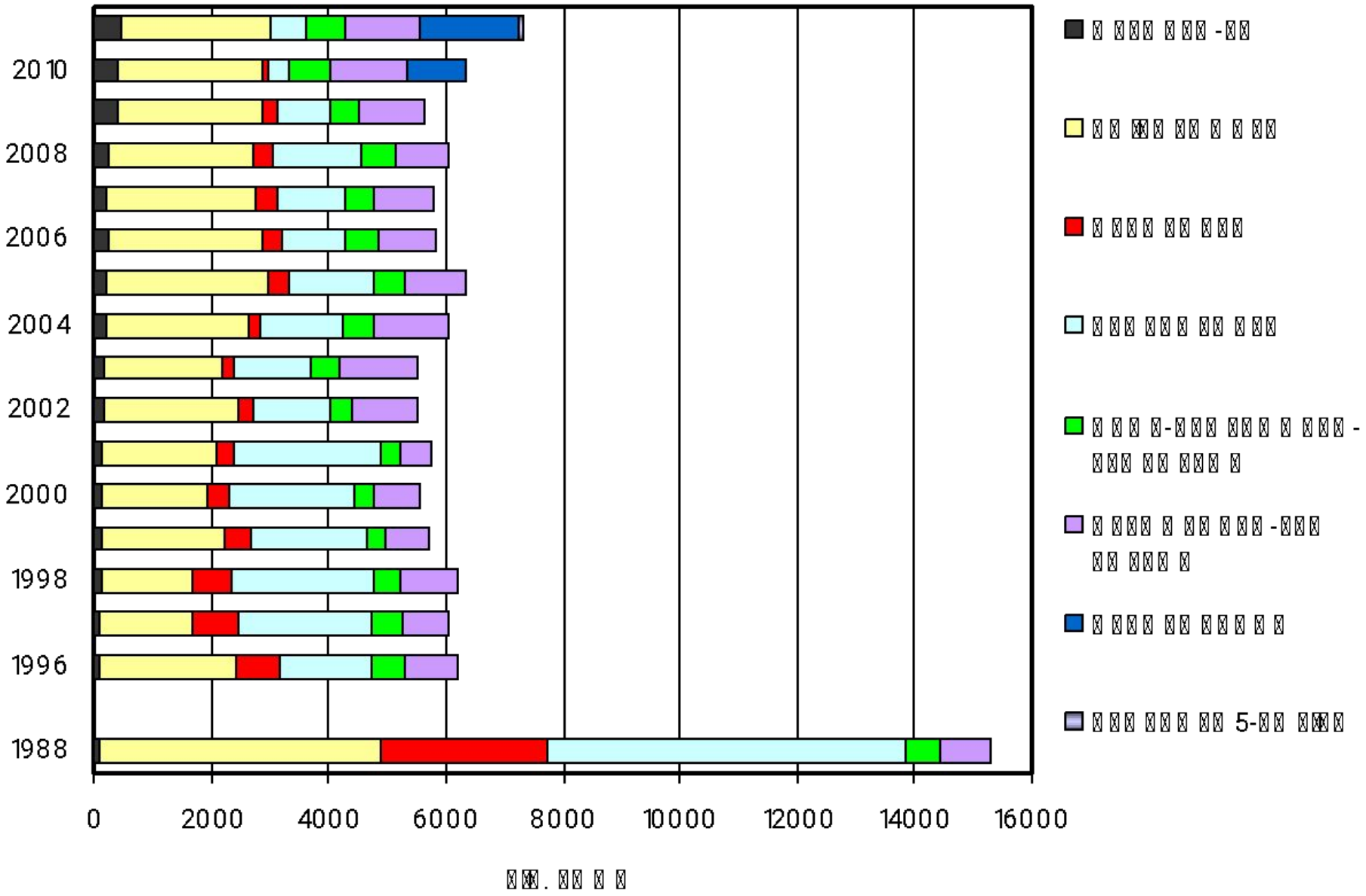
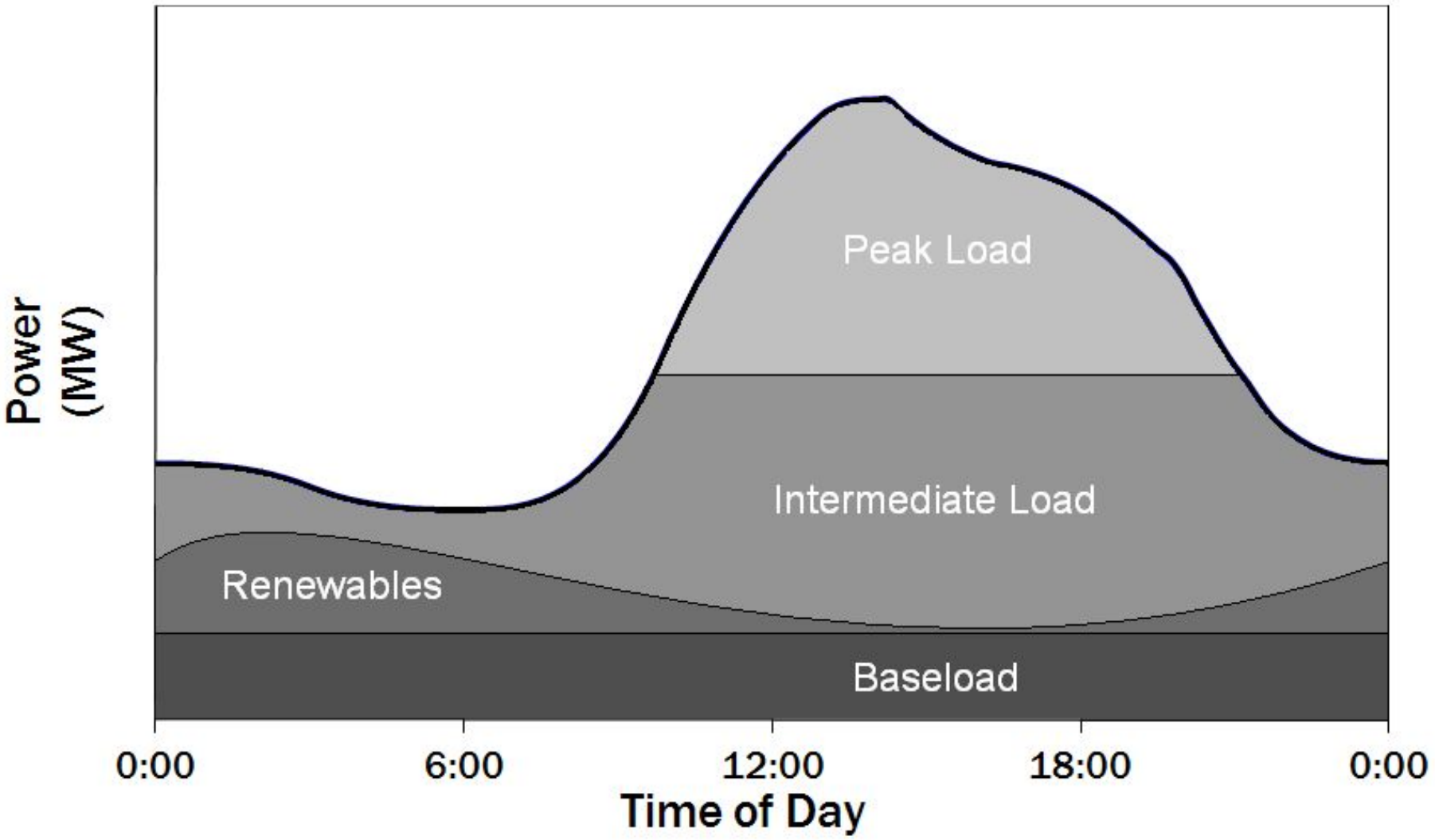


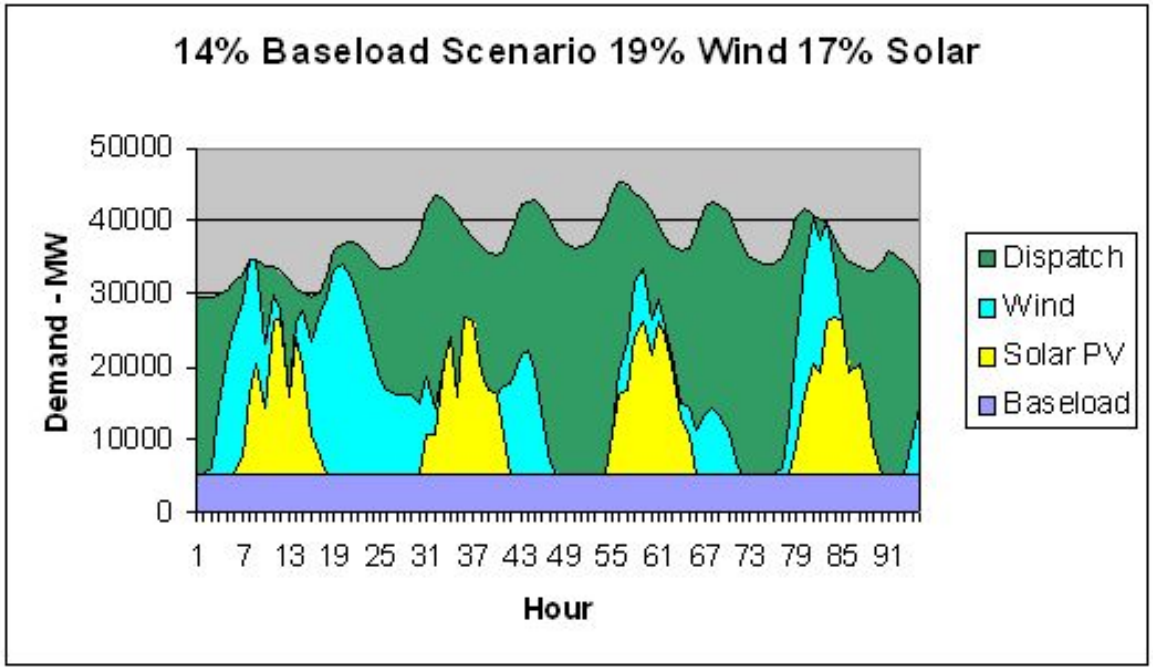
Average is in Between!

- Thus one needs:
- BASE, stabile, powerplants, e.g. Nuclear, Coal. CF > 90%;
- PEAKING, a powerplant that has relatively small capital (fixed) cost, although the operational (variable) cost is high. Gas-turbine. CF ~ 5%
- INTERMEDIATE, that can output variable power. Combined cycle natural gas. CF ~ 30% ÷ 80%.

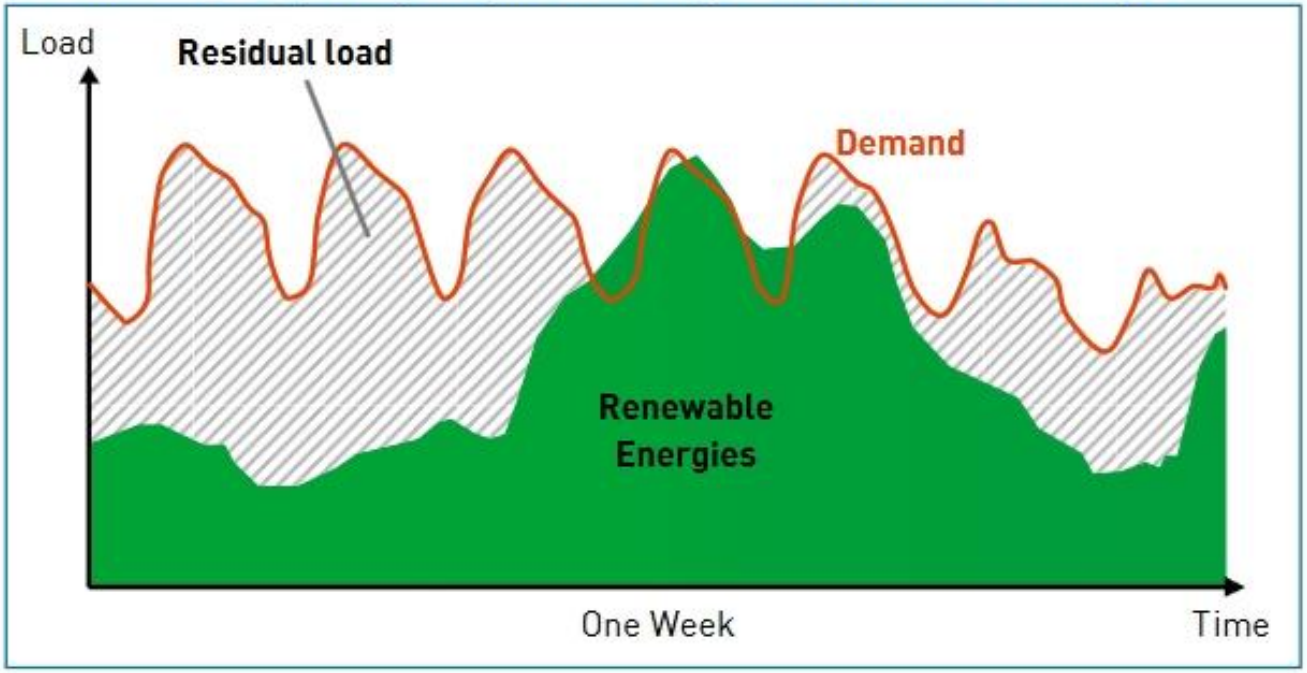

Power
(MW)
Peak Load
Intermediate Load
Renewables
Baseload
0:00
6:00
12:00
18:00
0:00
Time of Day

Renewable

- Wind (CF <35%)
- Solar (CF <25%)

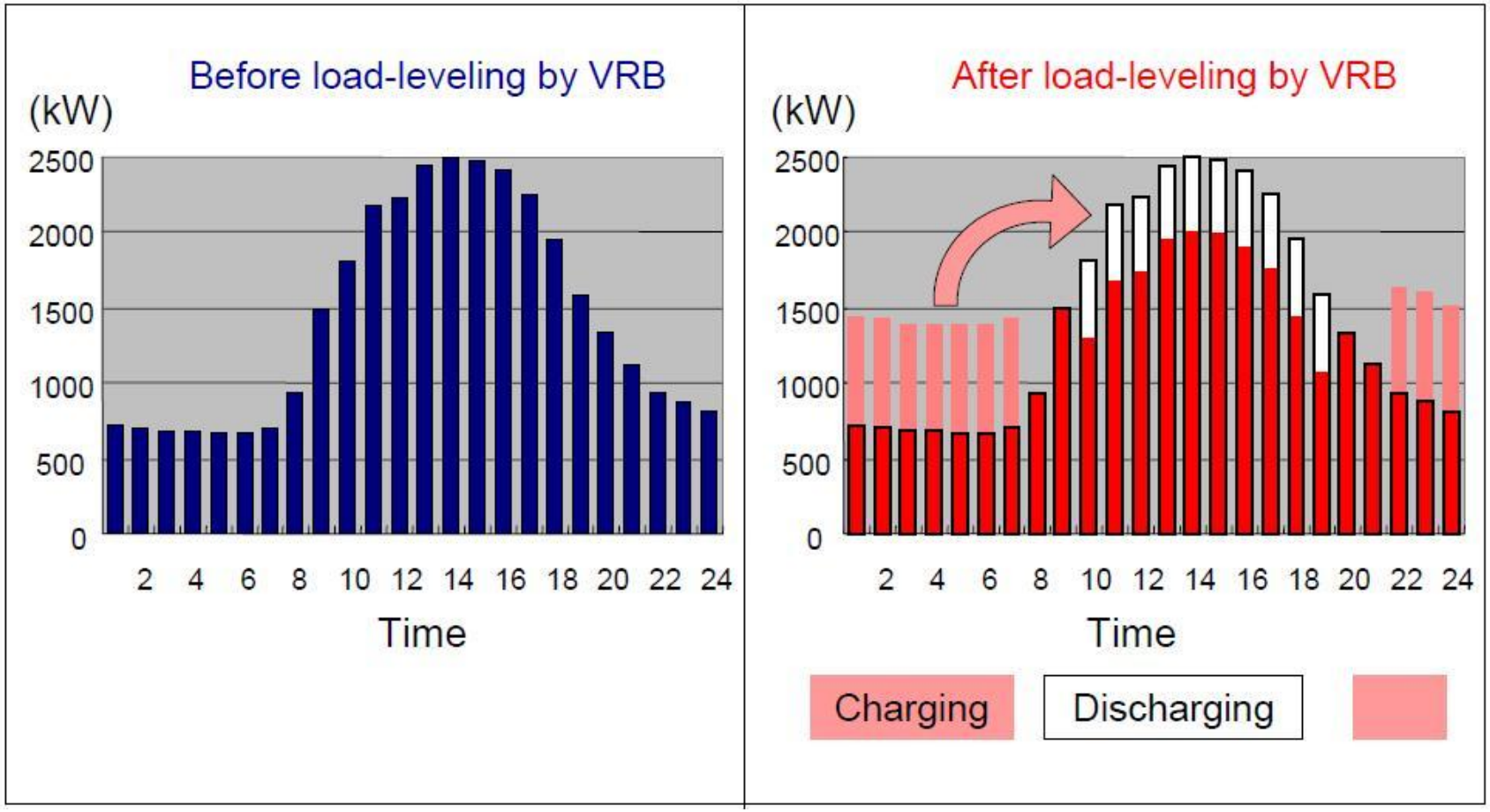


Residual load at a power plant park with a high share of renewable energies



Load leveling

- is a method for reducing large fluctuations in power demand



Load Leveling - DSM

- **Demand Side Management**, the task is to decrease the demand at PEAK TIMES.
- Tariff regulations:
  - tariffs' non-linear dependency on power consumed.
  - time dependency of tariffs
- Deciding the hours of **operation**, Chasing the load, Real-time pricing based on forecasts
- Overall Energy Efficiency measures – wide use of LEDs, ventilation and insulation, etc.

Elasticity

$$E(d) = \frac{\%\ \text{Demand Change}}{\%\ \text{of Price Change}}$$

Load Leveling - SSM

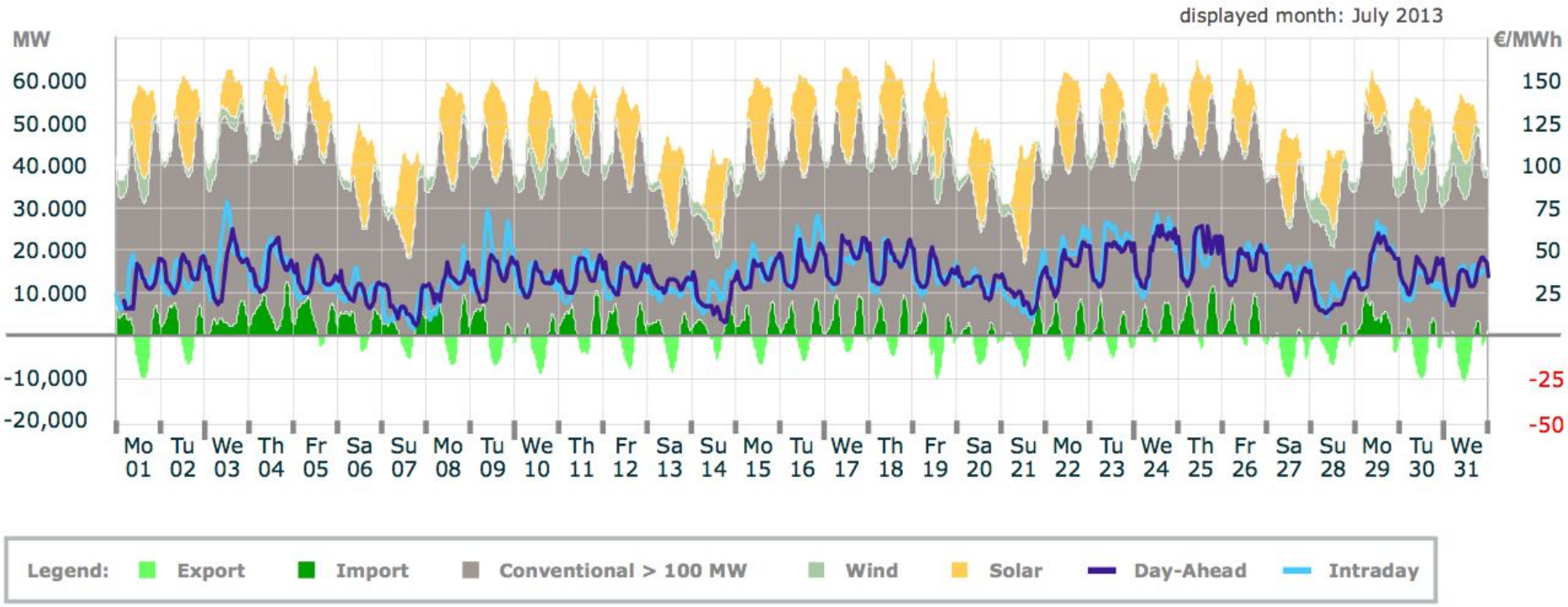
- **Supply Side Management**, the task is to organize capacities to meet the demand at PEAK TIMES.
- Need in energy generation market existence with advanced dispatching capability.
- Deciding the hours of generation, Chasing the load, Real-time pricing based on forecasts
- Renewable energy generation encouragement policies.

European policy

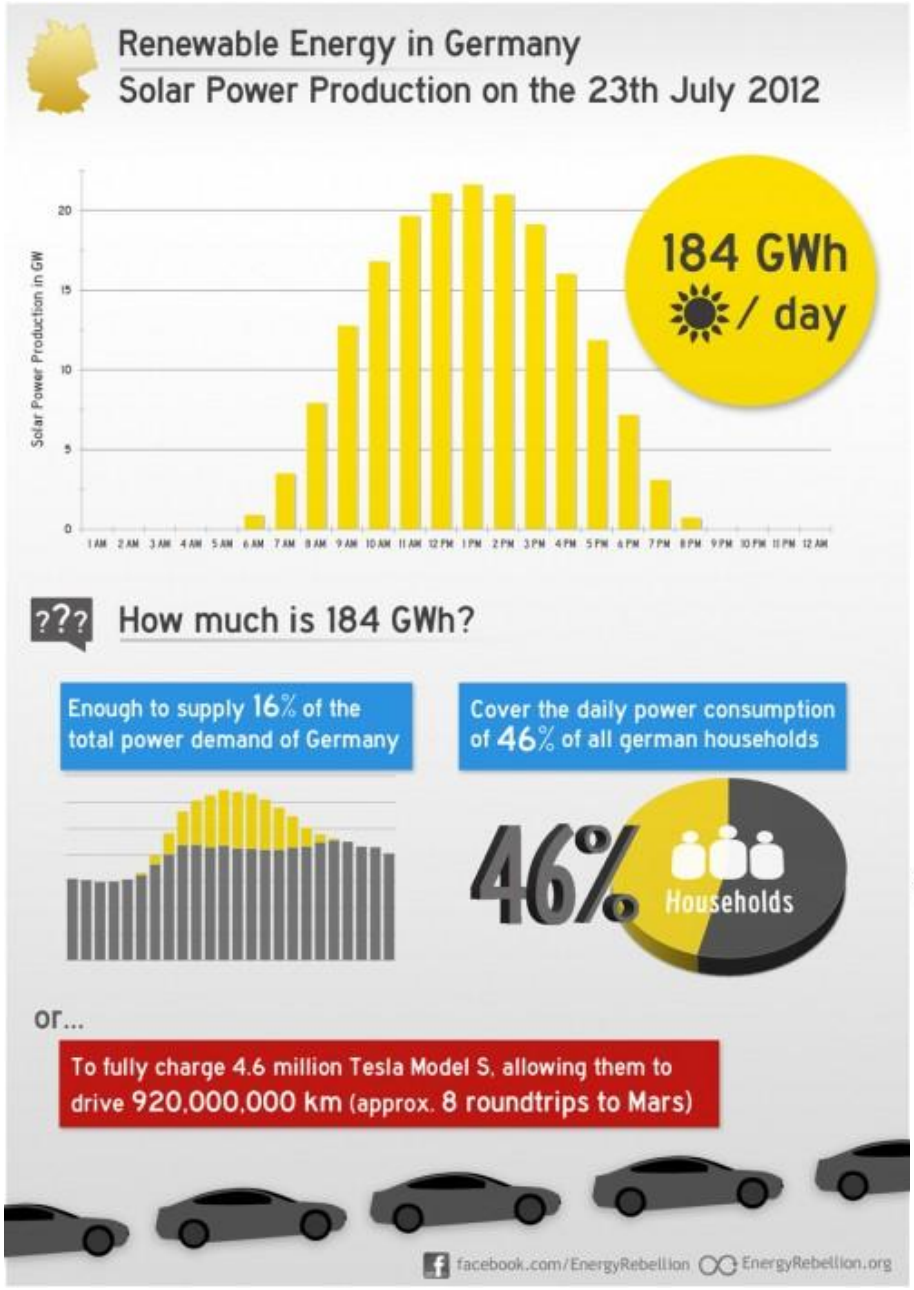
- In 2007, the EU was importing 82% of its oil and 57% of its gas, which then made it the world's leading importer of these fuels.
- Only 3% of the uranium used in European nuclear reactors has been mined in Europe. Russia, Canada, Australia, Niger and Kazakhstan were the five largest suppliers of nuclear materials to the EU, supplying more than 75% of the total needs in 2009.
- In 2015, the EU imports 53% of the energy it consumes. In January 2014, the EU agreed to a 40% emissions reduction by 2030, compared to 1990 levels, and a 27% renewable energy target.

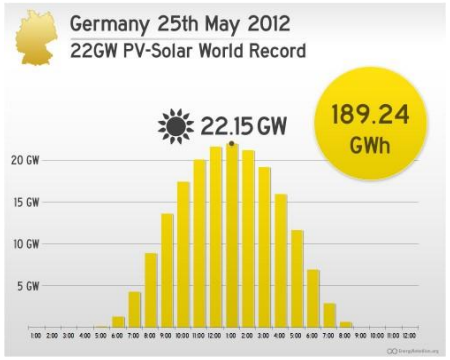
Energy Market

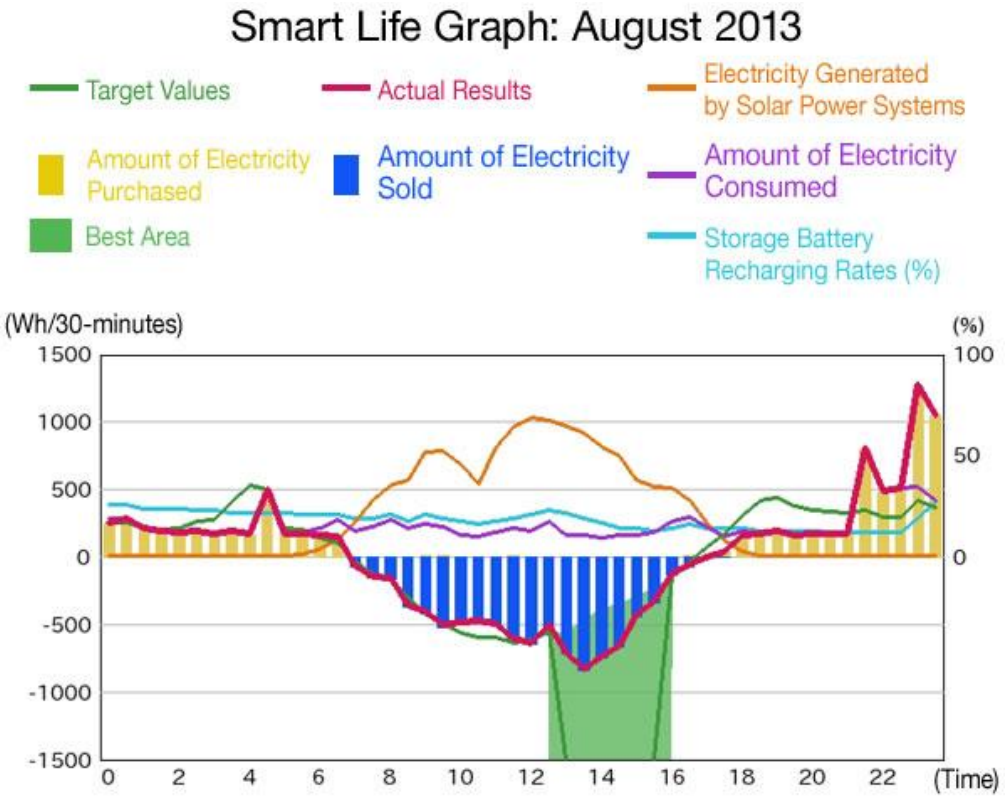
Electricity Production and Spot-Prices: July 2013



Dispatching



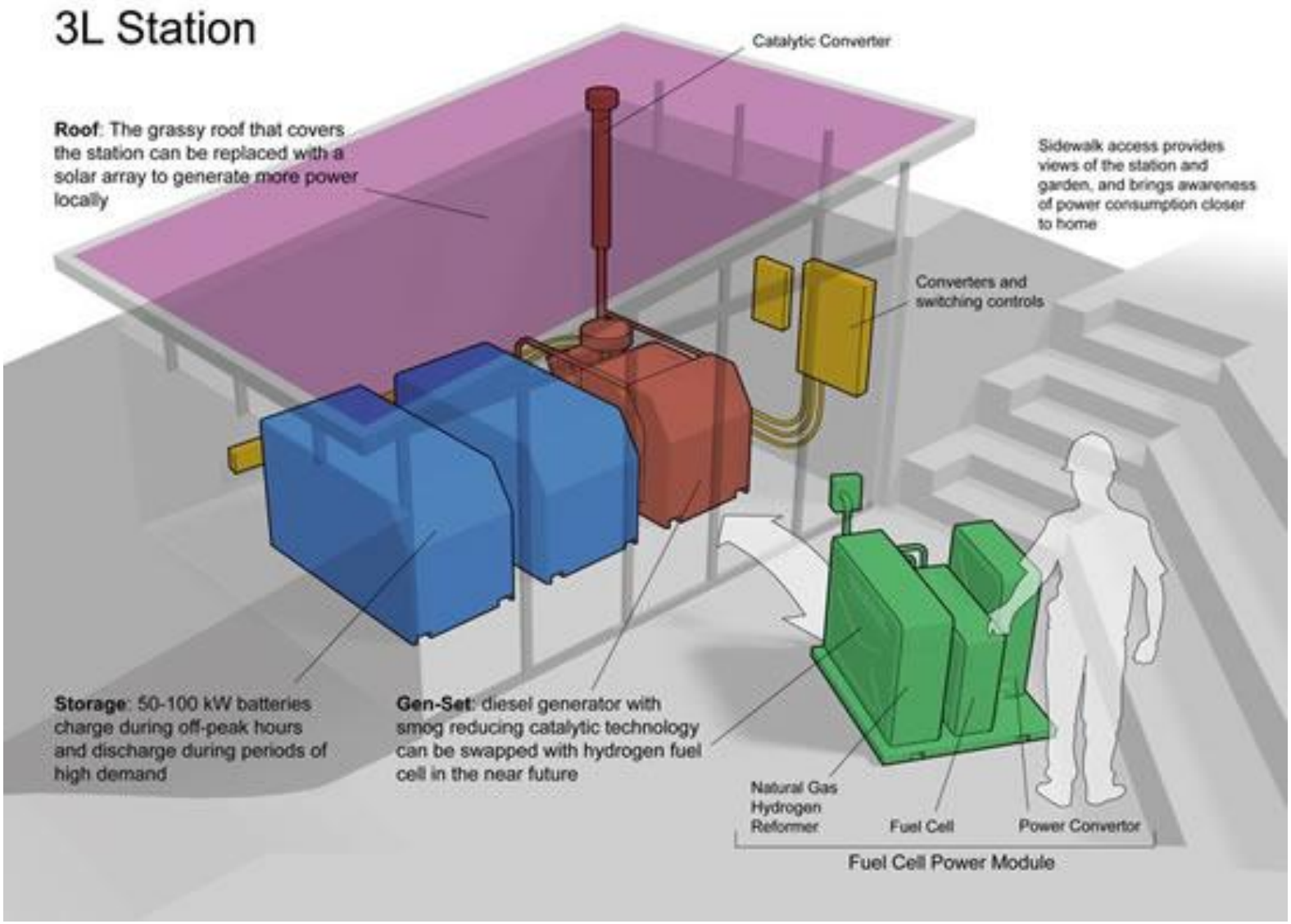




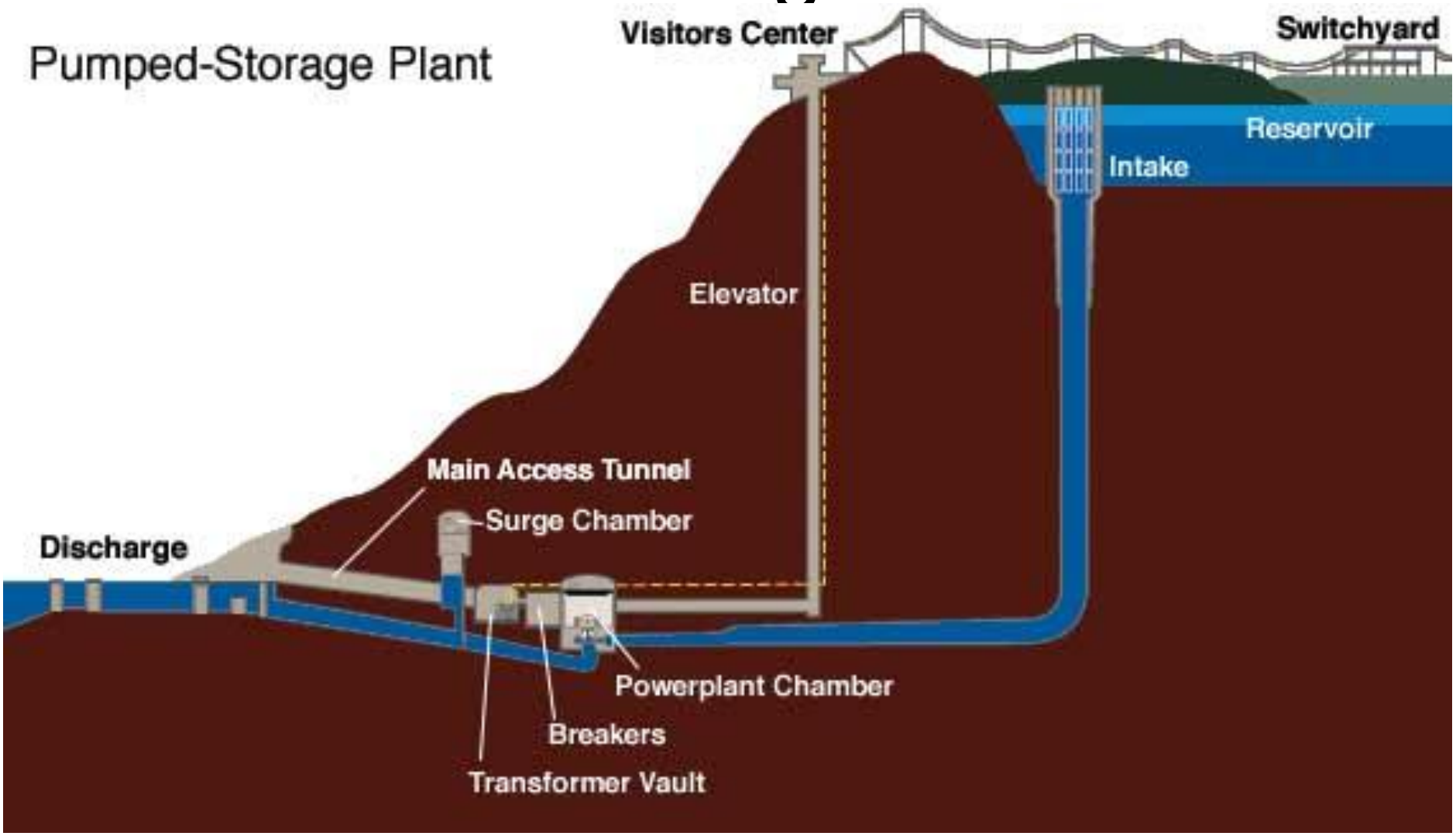
Storage

- Hydro-Pump
- Natural gas
- Thermal
- Hydrogen

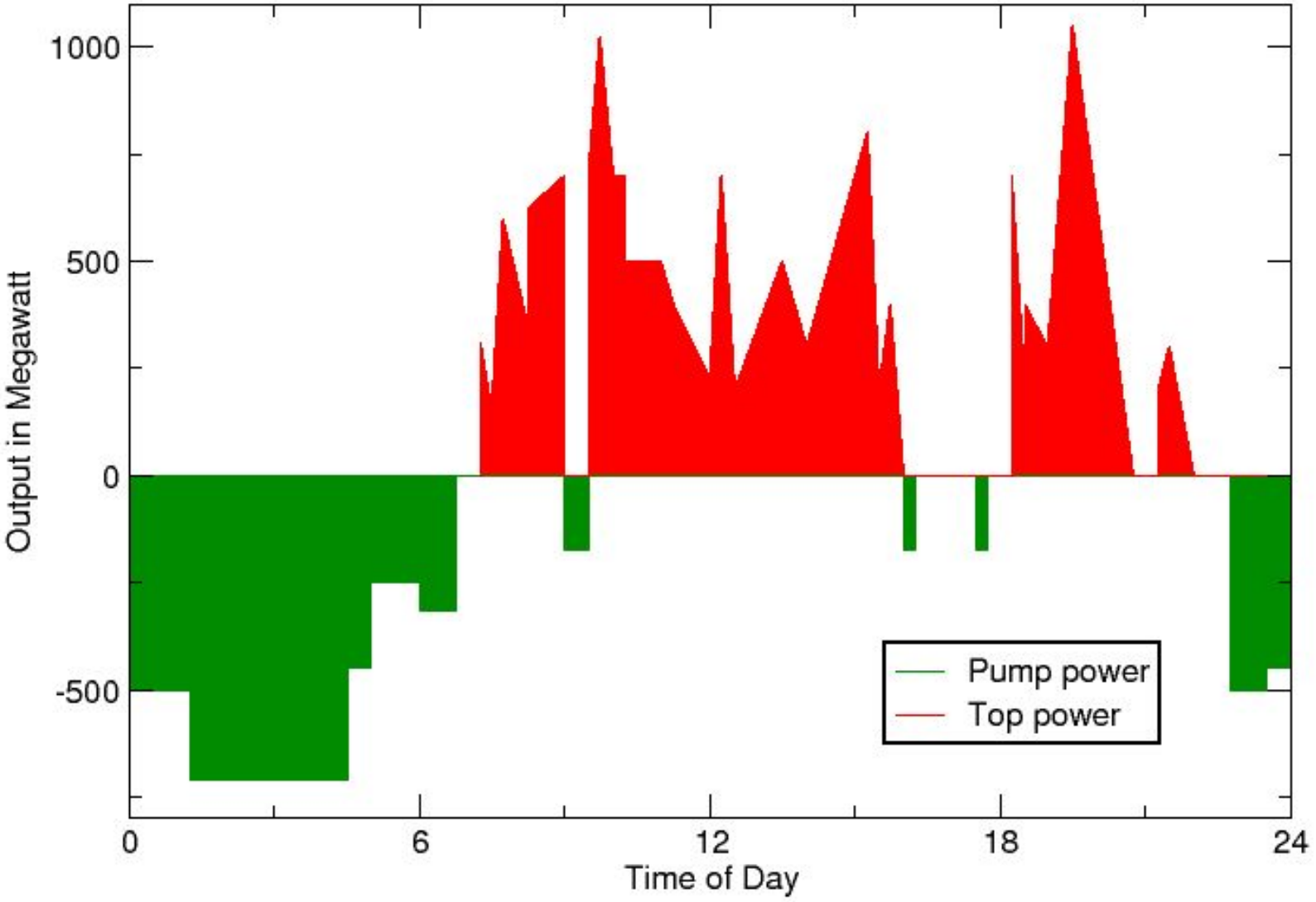
Storage


3L Station
Catalytic Converter
Roof: The grassy roof that covers the station can be replaced with a solar array to generate more power locally
Sidewalk access provides views of the station and garden, and brings awareness of power consumption closer to home
Converters and switching controls
Storage: 50-100 kW batteries charge during off-peak hours and discharge during periods of high demand
Gen-Set: diesel generator with smog reducing catalytic technology can be swapped with hydrogen fuel cell in the near future
Natural Gas Hydrogen Reformer
Fuel Cell
Power Convertor
Fuel Cell Power Module

Load levelling – pumped hydro storage



Load levelling – pumped hydro



Gas Supply System
Main Indicators *(as of 31.12.2011)*

- RA gasification level~94%
- Length of the main pipelines 14 050 km
- Number of gasified communities 576
- Number of consumers (01.03.2012) 627 065

  potential consumers 80 444
- Import, mln. m^3 2 069/1 765

Abovian Underground

Gas Storage facility 129 mln.m^3

Load levelling – EV fleet

Homework

- Problem #1, page 94 of the Shaten WB.