

# 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

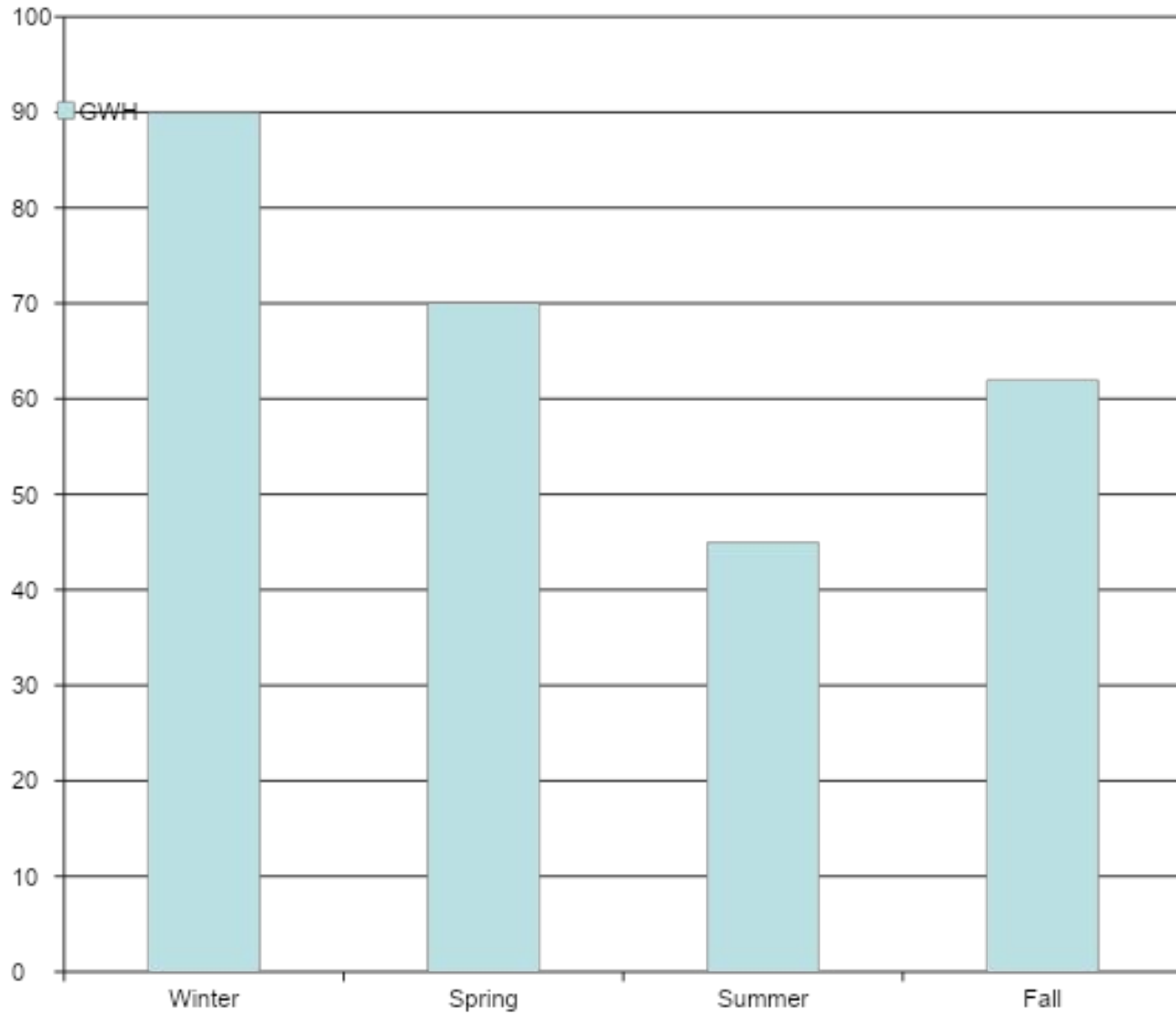
Seasonal

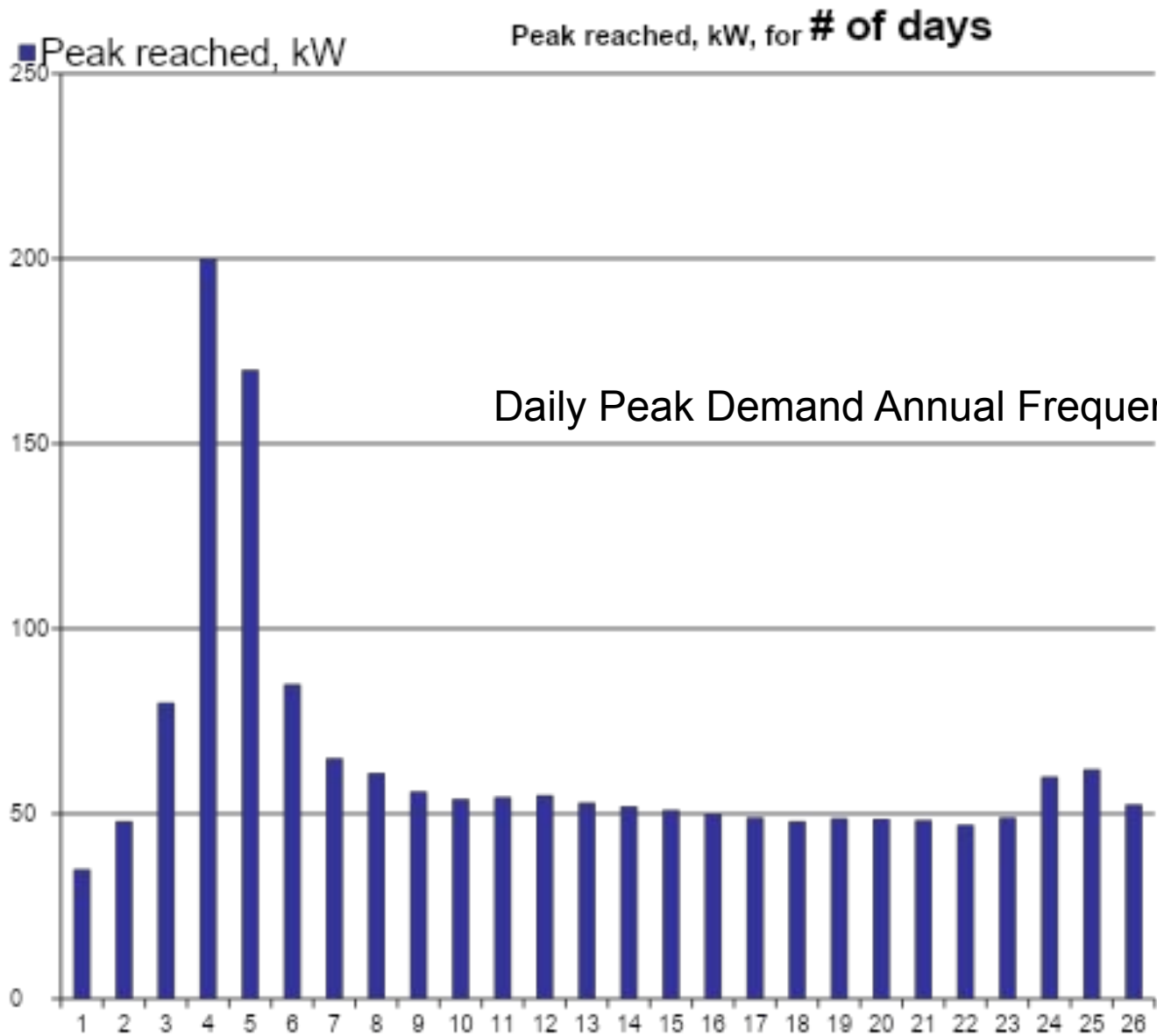
Per shift, other...?

- Plus a stochastic component.

# Seasonal

Seasonal Consumption

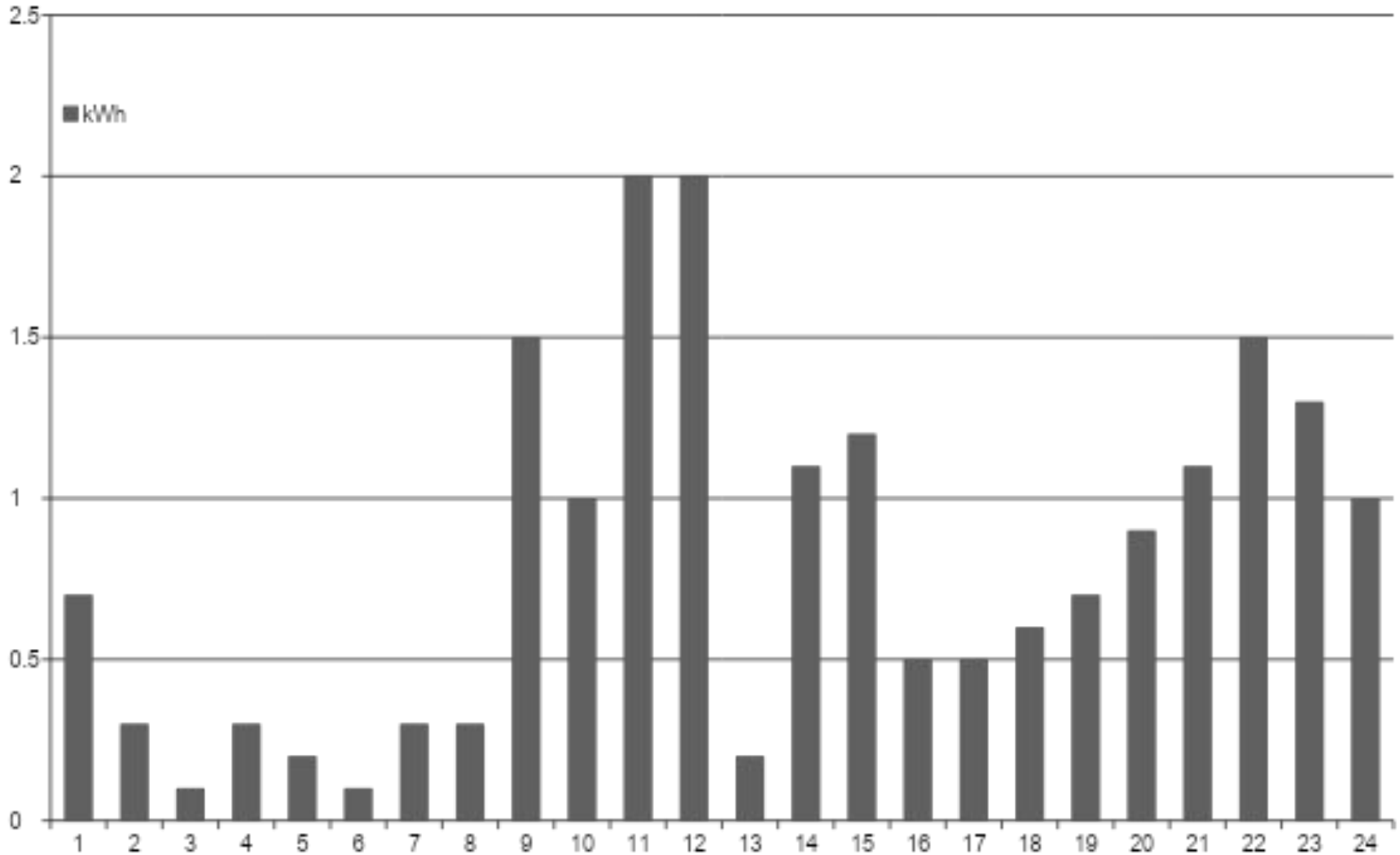






# Daily

Daily Consumption Pattern



# 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
<b>Three Gorges Dam (China)</b>	18.3 (22.5)	80 (368)	50%
<b>Itaipu Dam (Brazil, Peru)</b>	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<sup>2</sup> 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

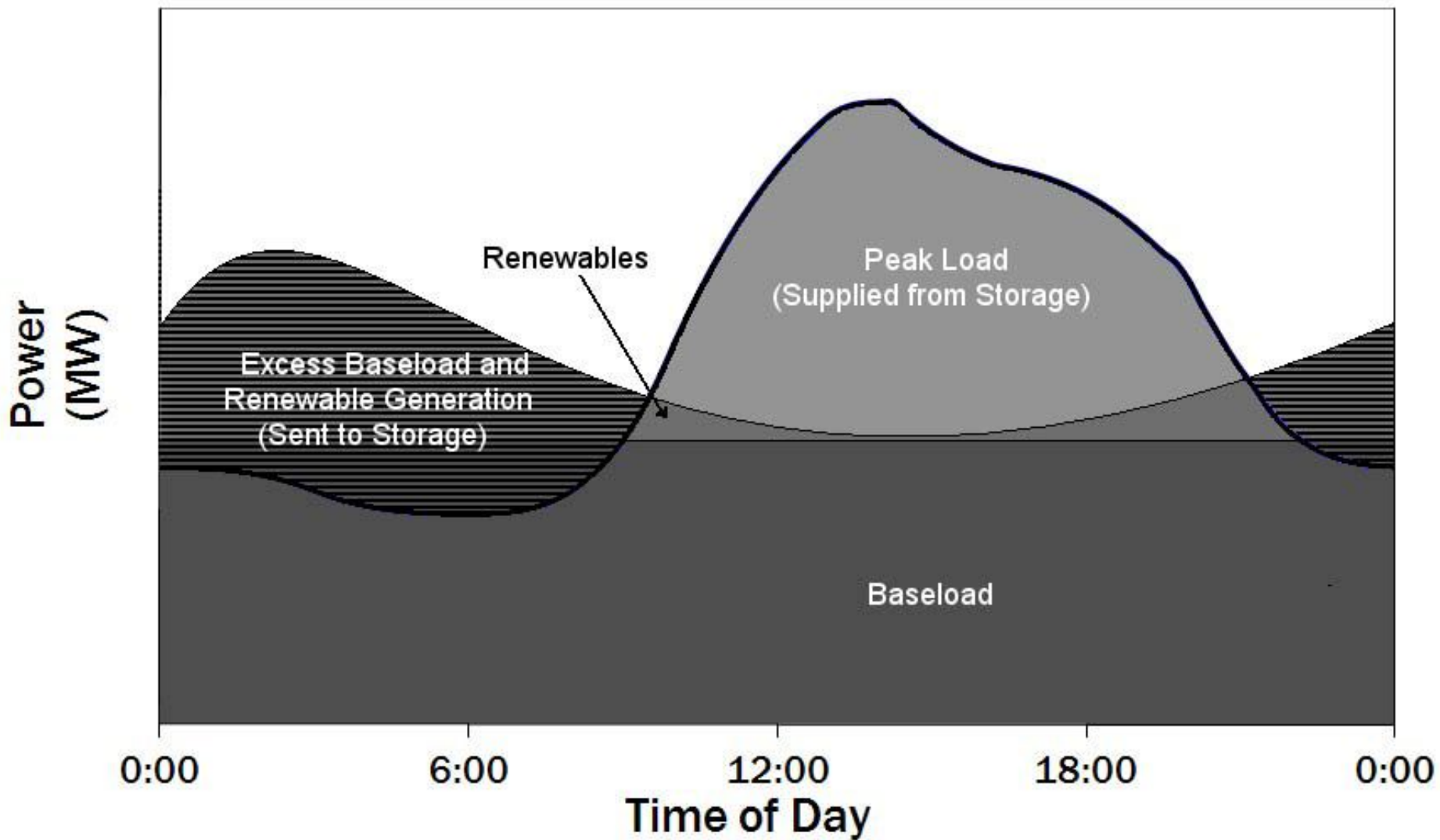


# Peak

- 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

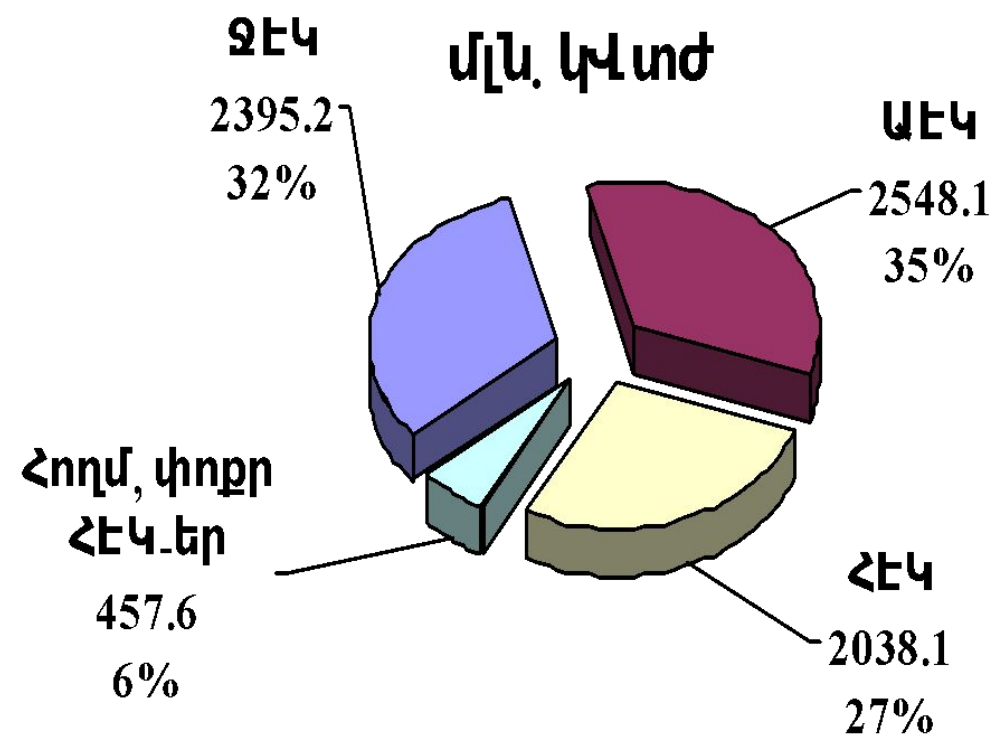
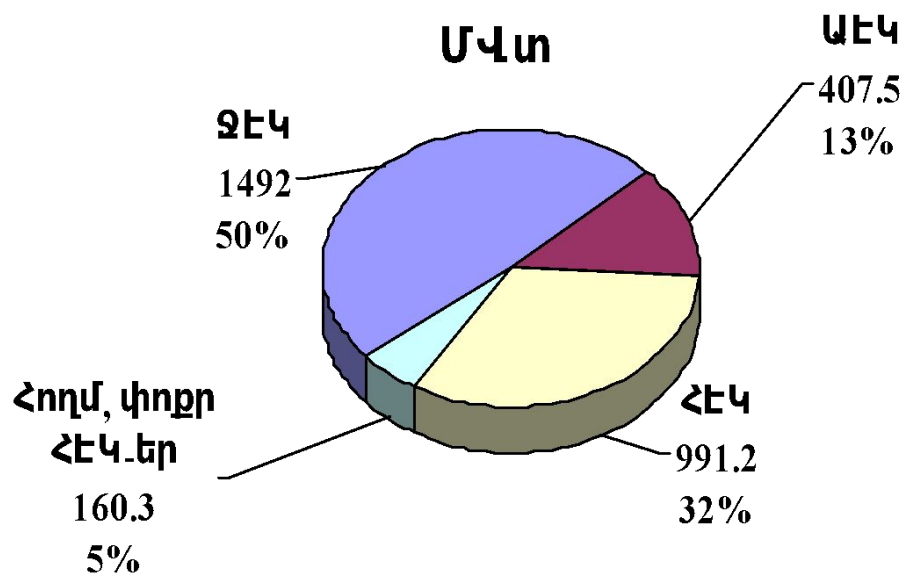
- Consumption never goes below certain amount
- Metsamor NPP is providing the base power.



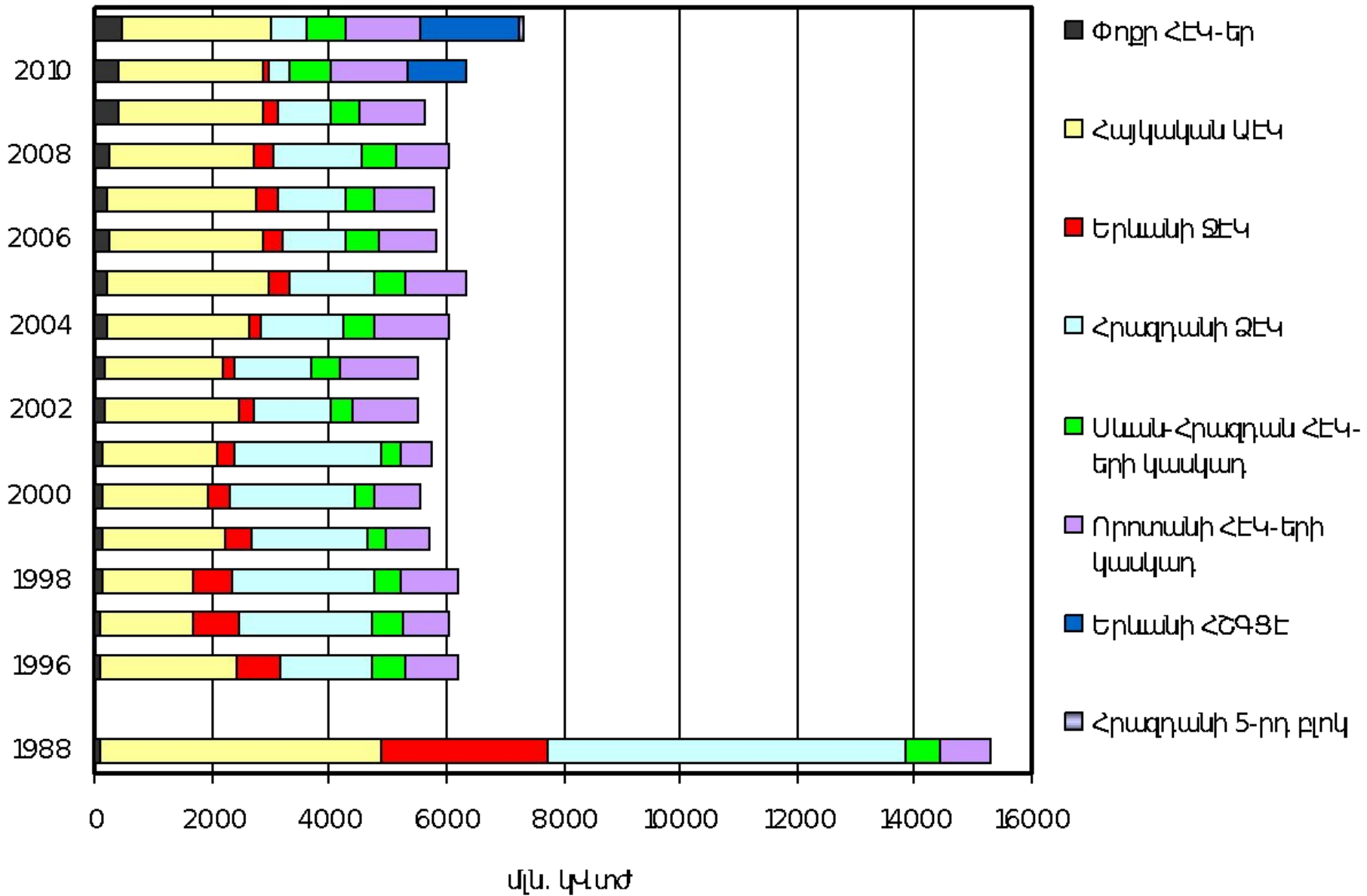


# 2011 Ա.-ի ՀՀ Կառավարության կողմից իրականացված աշխատանքների արդյունքները

## ՀՀ Կառավարության կողմից իրականացված աշխատանքների արդյունքները

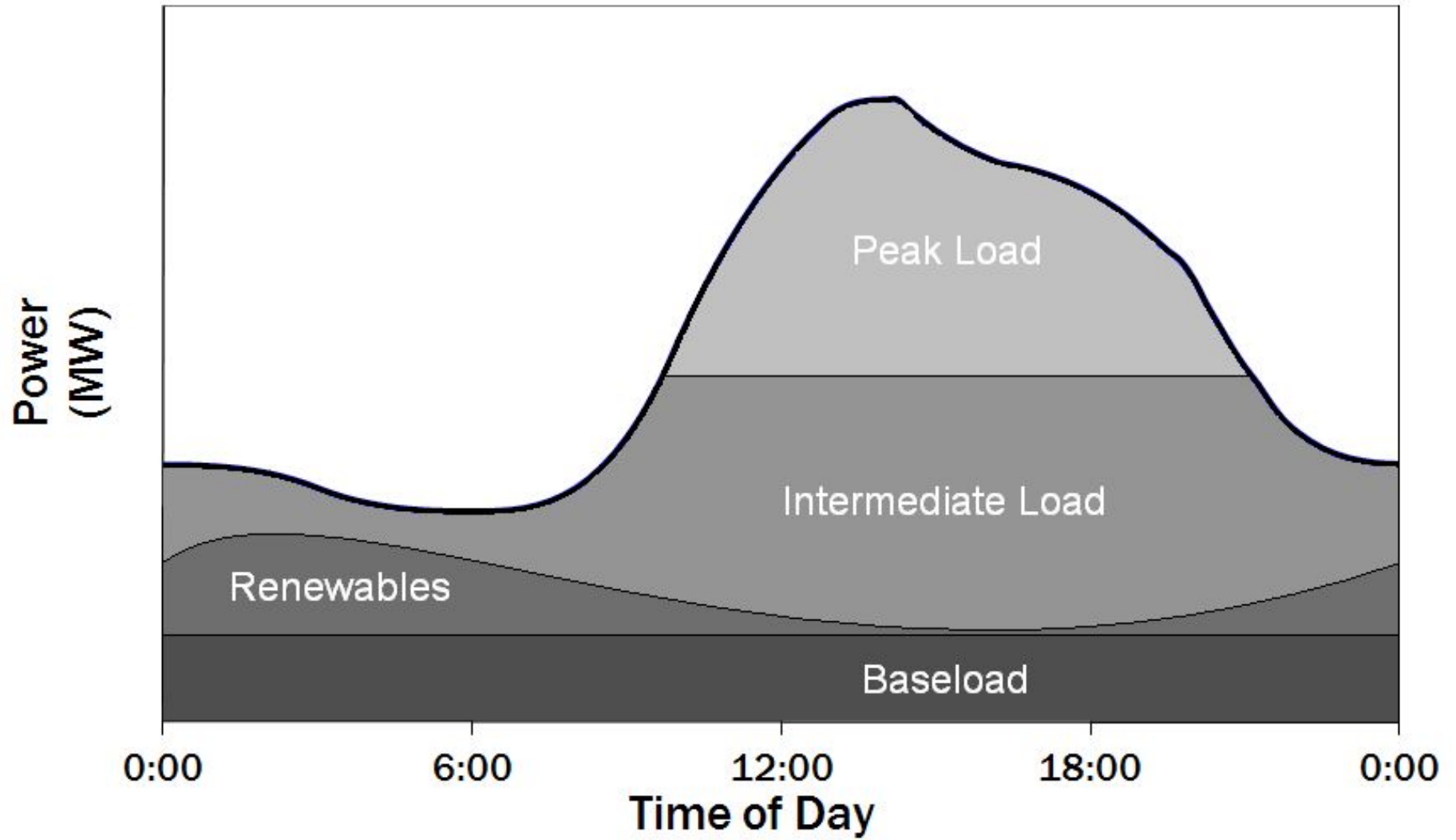


# Ֆինանսական համակարգի զարգացումը 1988-2010 թվականներին



# Average is in Between!

- Thus one needs:
- BASE, stable, 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%.

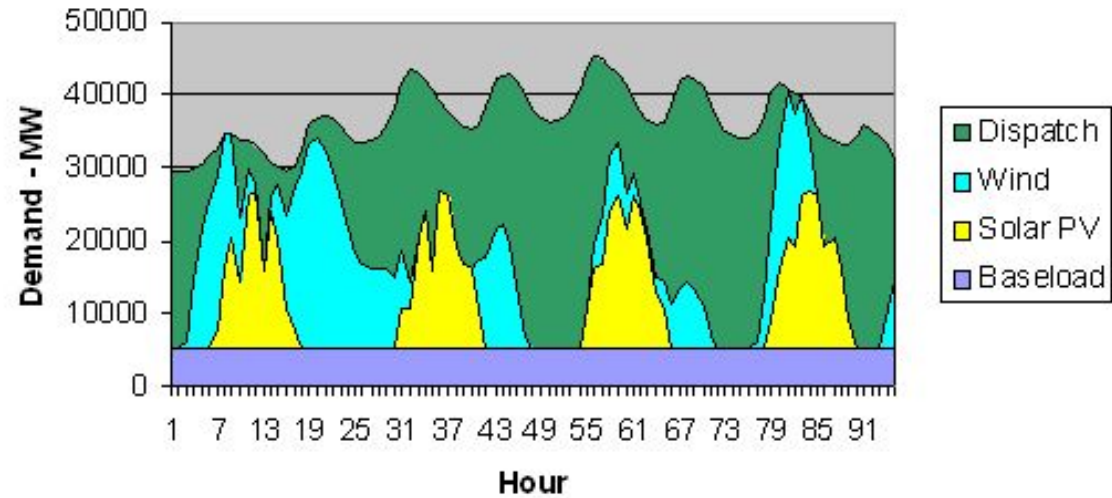


# Renewable

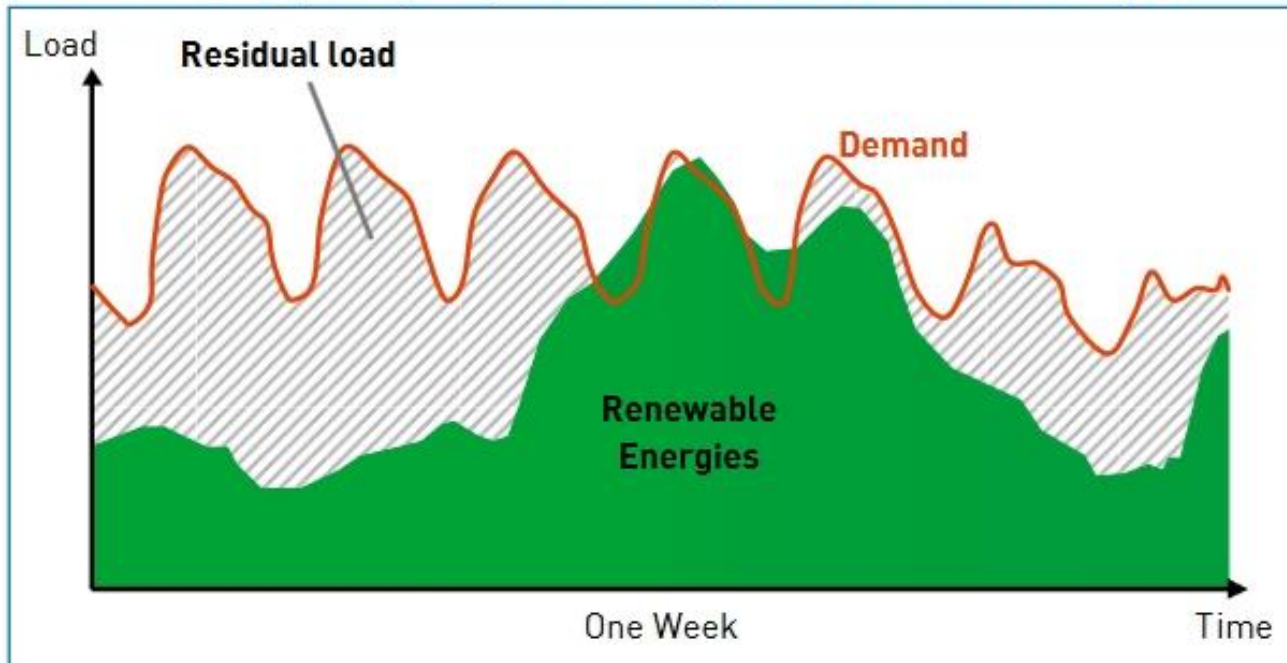
- Wind (CF < 35%)
- Solar (CF < 25%)



14% Baseload Scenario 19% Wind 17% Solar



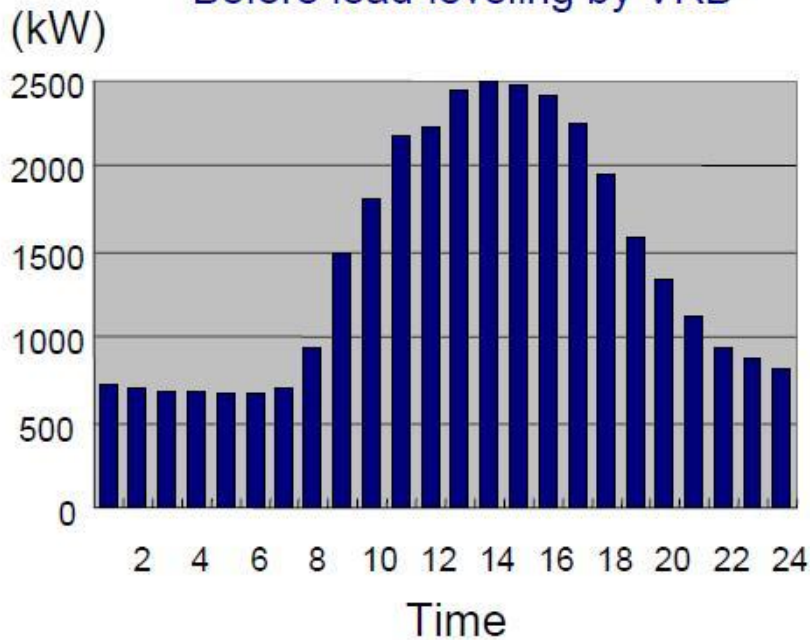
Residual load at a power plant park with a high share of renewable energies



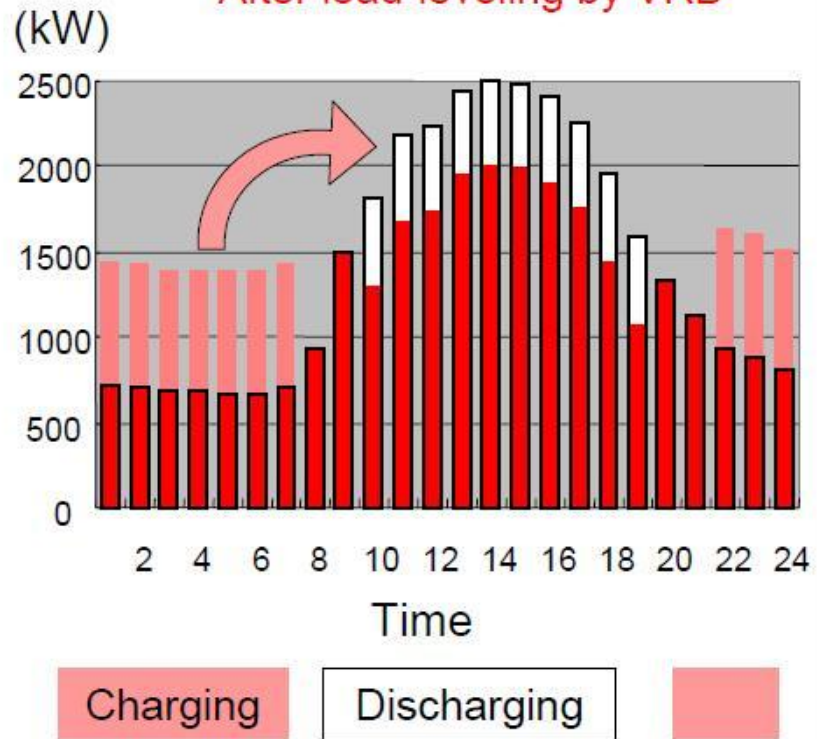
# Load leveling

- is a method for reducing large fluctuations in power demand

Before load-leveling by VRB



After load-leveling by VRB



# 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

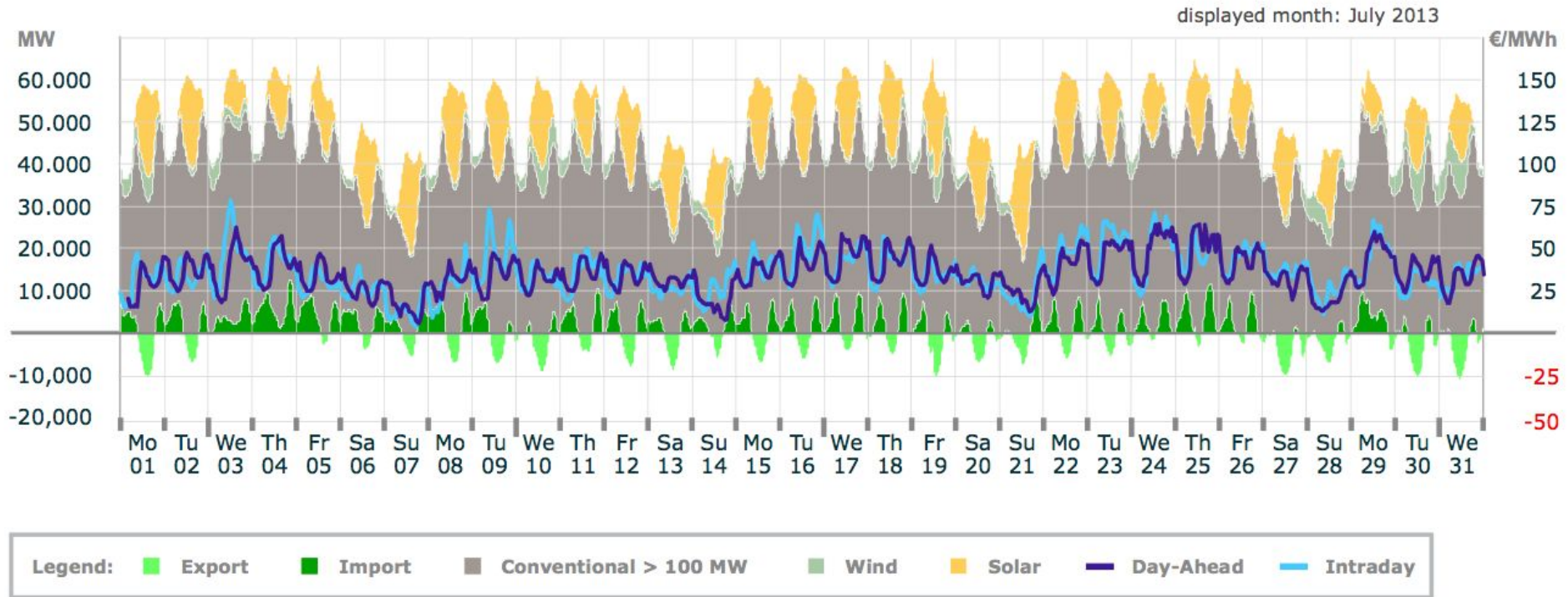
- **Supply Side Management**, the task is to organize capacities to meet the demand at PEAK TIMES.
- Need in energy generation market existence with advanced dispatching capability.
- Deciding the hours of generation, Chasing the load, Real-time pricing based on forecasts
- Renewable energy generation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

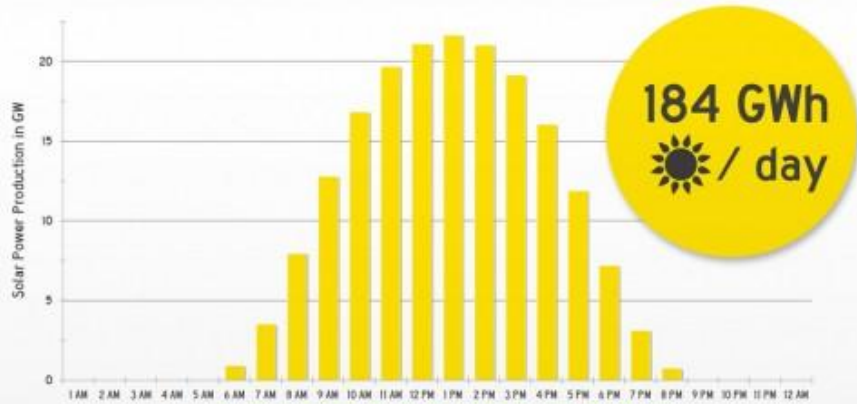
## Electricity Production and Spot-Prices: July 2013



# Dispatching



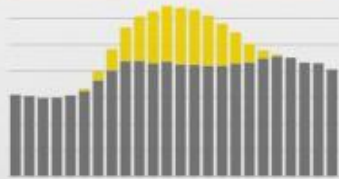
## Renewable Energy in Germany Solar Power Production on the 23th July 2012



How much is 184 GWh?

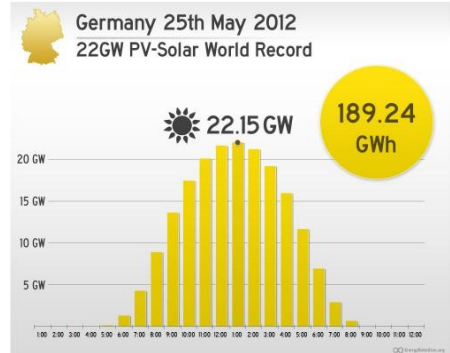
Enough to supply 16% of the total power demand of Germany

Cover the daily power consumption of 46% of all german households

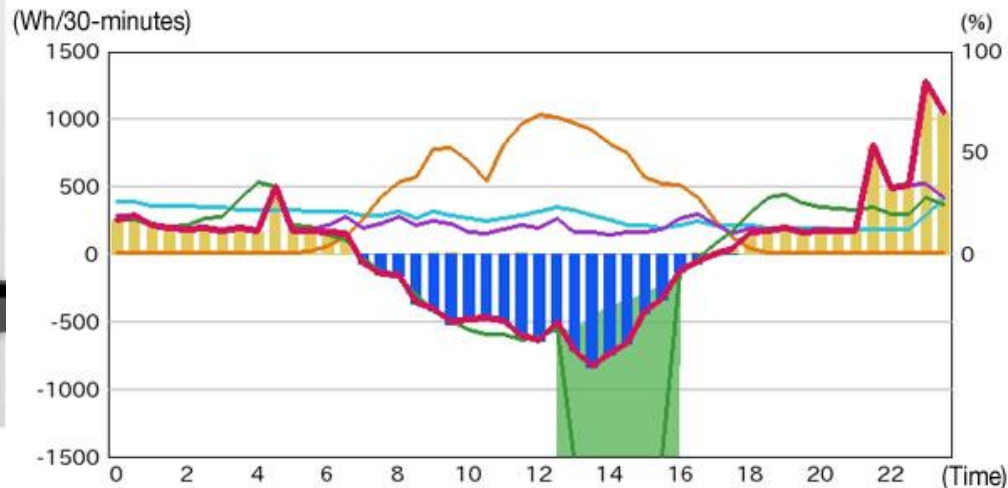


or...

To fully charge 4.6 million Tesla Model S, allowing them to drive 920,000,000 km (approx. 8 roundtrips to Mars)



## Smart Life Graph: August 2013



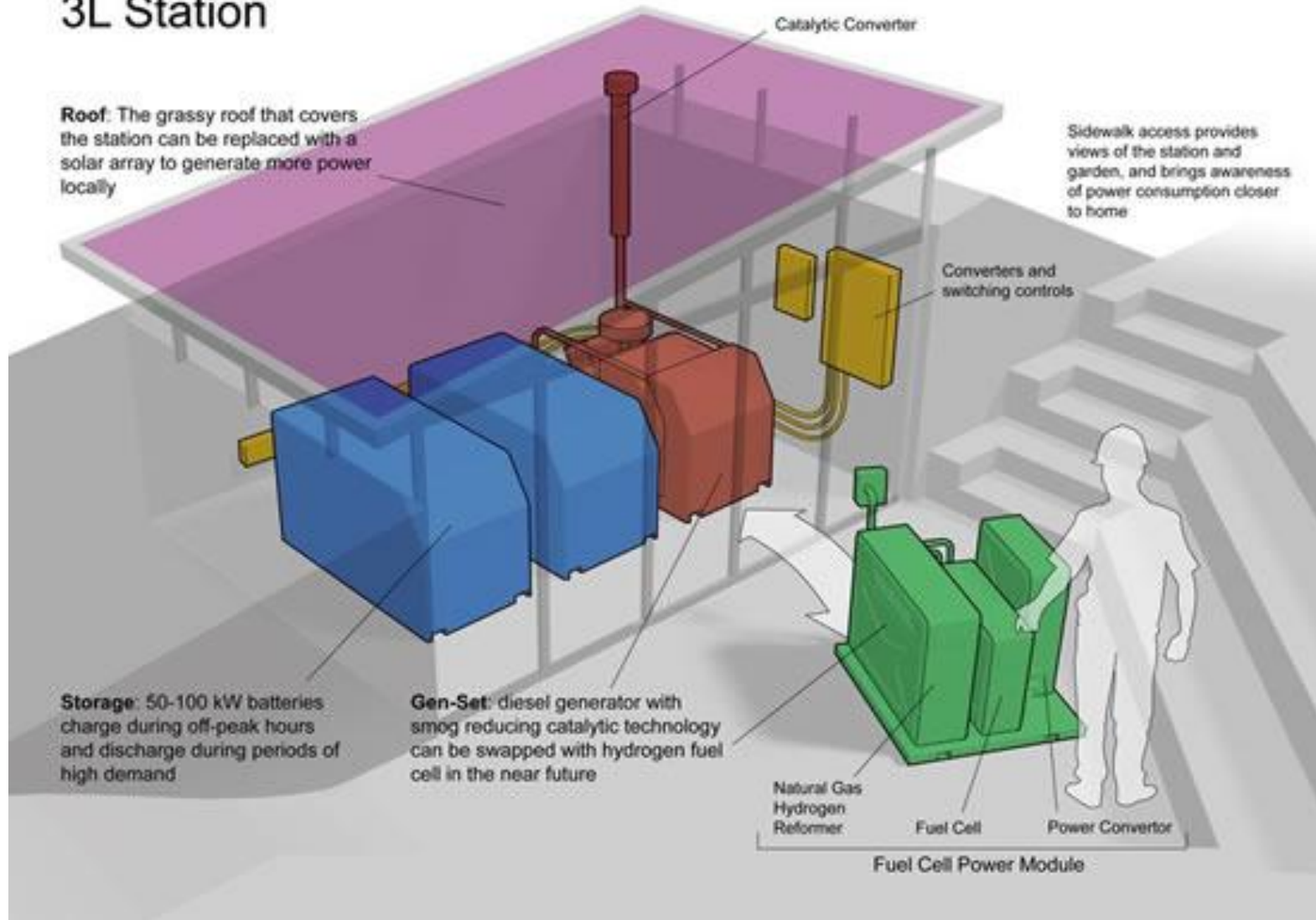


# Storage

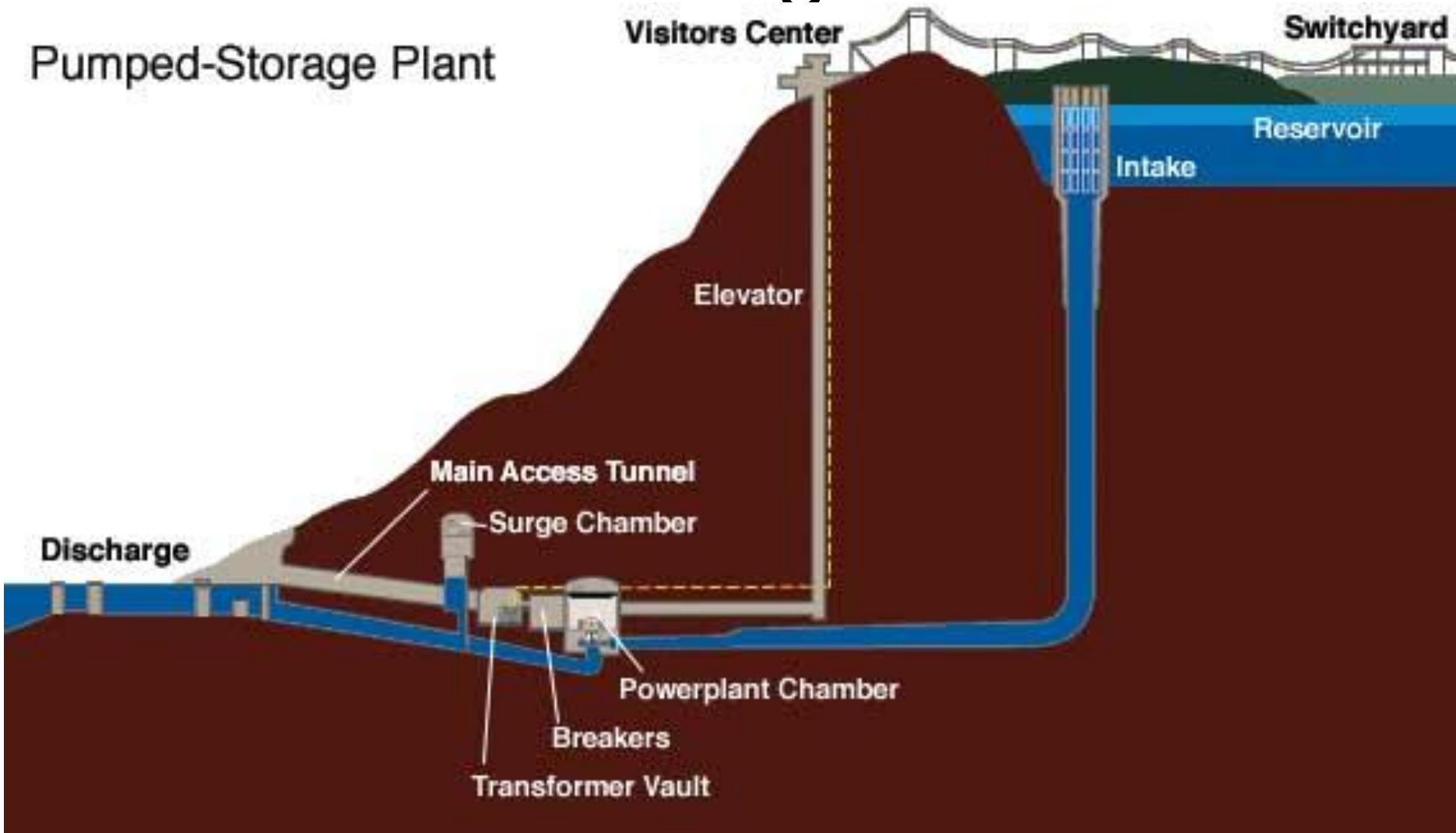
- Hydro-Pump
- Natural gas
  - Thermal
- Hydrogen

# Storage

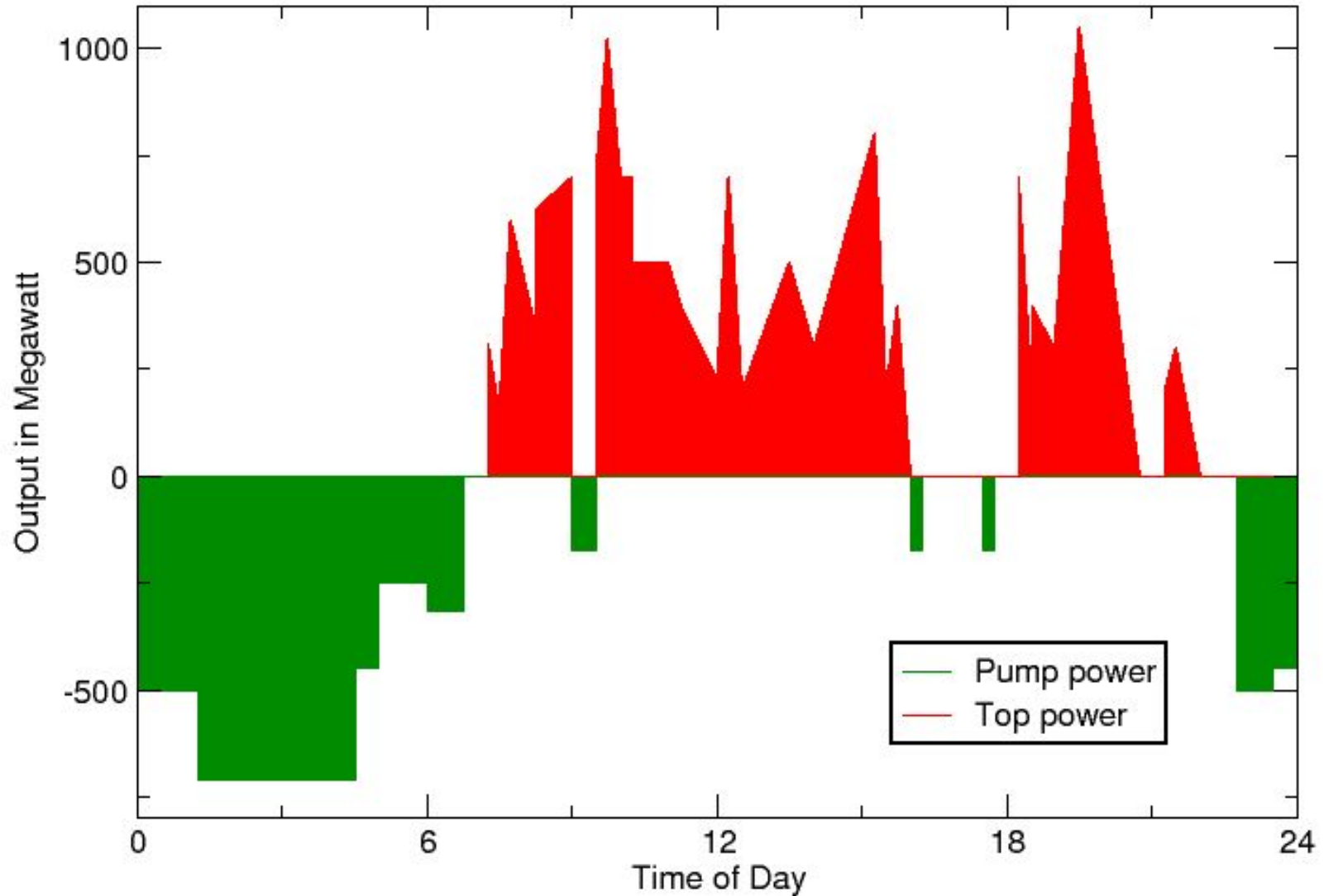
## 3L Station



# 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<sup>3</sup> 2 069/1 765

### Abovian Underground

Gas Storage facility 129 mln.m<sup>3</sup>

# Load levelling – EV fleet



# Homework

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