Czech Technical University in Prague
Faculty of Electrical Engineering
Department of Power Engineering

Renewable energy sources

AE1M15PRE – Transmission and Distribution of Electricity

Distributed energy production

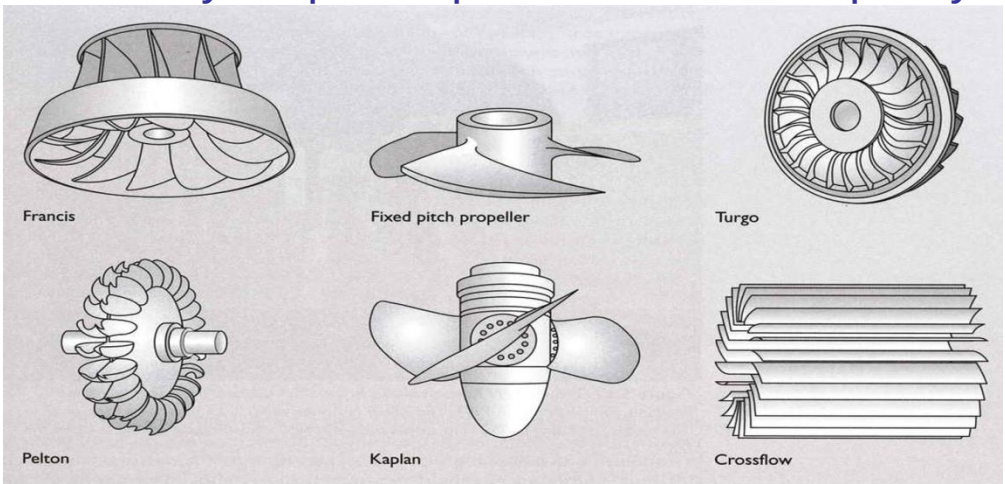
Distributed energy production:

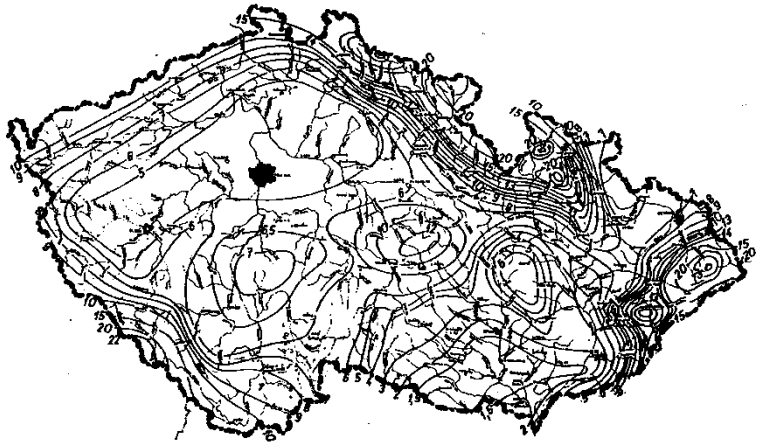
- **High number of sources** with low capacity
- **High price** per 1 kW installed capacity
- **Outage does not influence** quality of energy in grid
- Energy is produced at place of consumption, **lower transmission losses**

- Distributed energy production is connected to **renewable sources development**.
- Using renewable sources increase percent of **green energy production**:
  - Water flow energy
  - Solar energy
  - Energy from biomass
  - Wind energy
  - Geothermal energy
  - Tidal energy

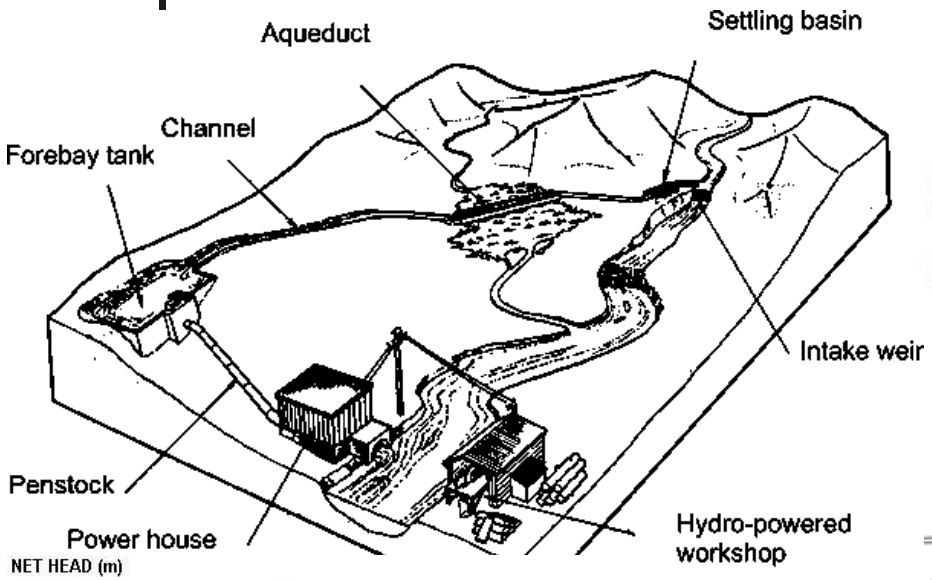
Small hydropower plant

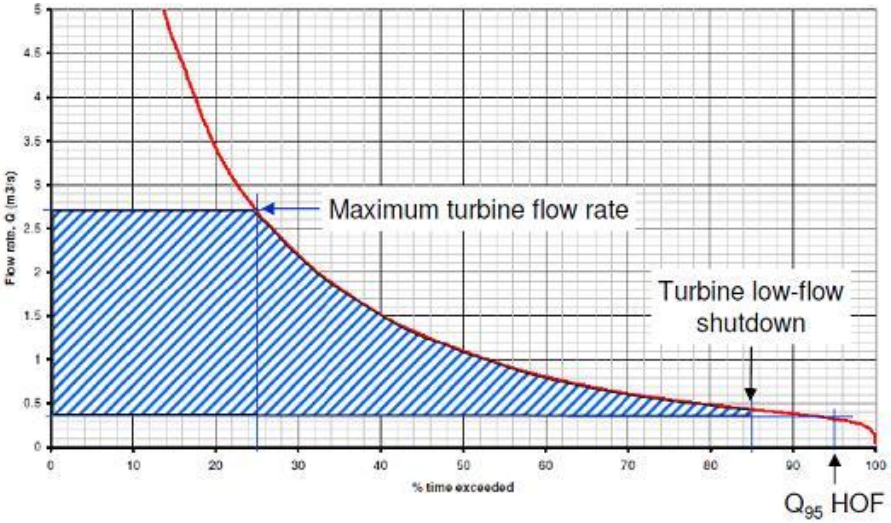
- No greenhouse gas emission
- Does not consume any fossil resources
- Flexible energy production control, accumulation of energy increases power system stability.
- High level of automatization allows water flow control and it has positive ecological effect
- Czech Republic is between 3 seas watershed
- Hydro power plants with 17% of total capacity cover only 4% of total production
- ¾ of hydro power potential is application with capacity up to 10 MW and 1570 GWh/year. Now about 500 GWh/year is used.
- Small hydro power plant – installed capacity up to 10 MW

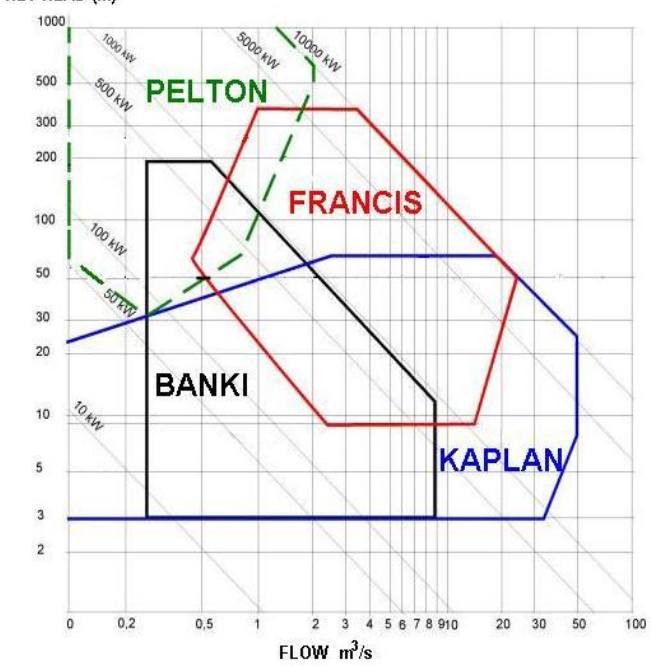


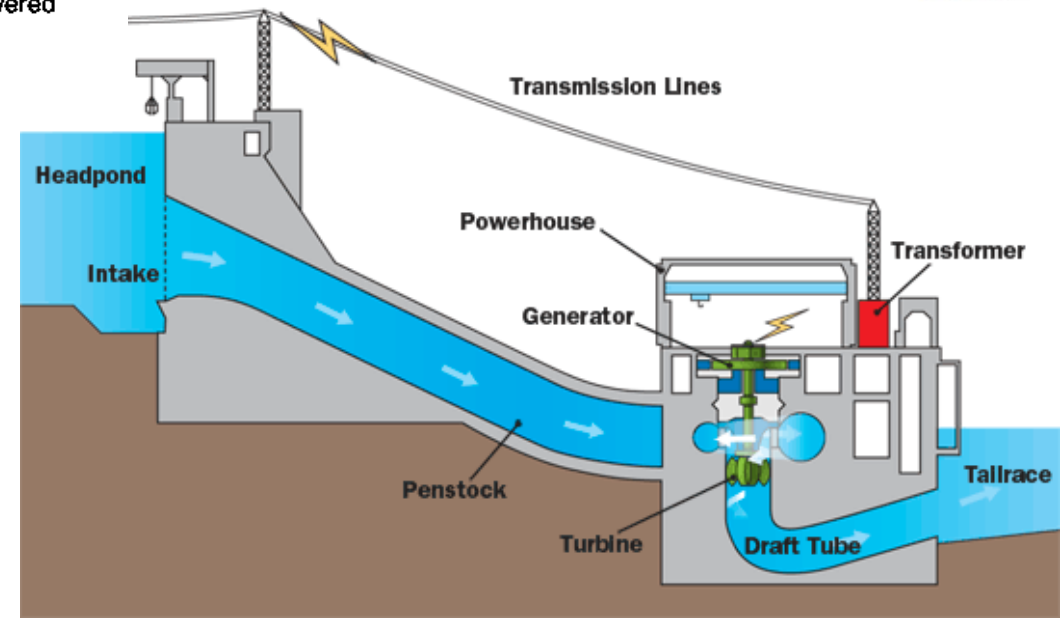


Hydro power plant



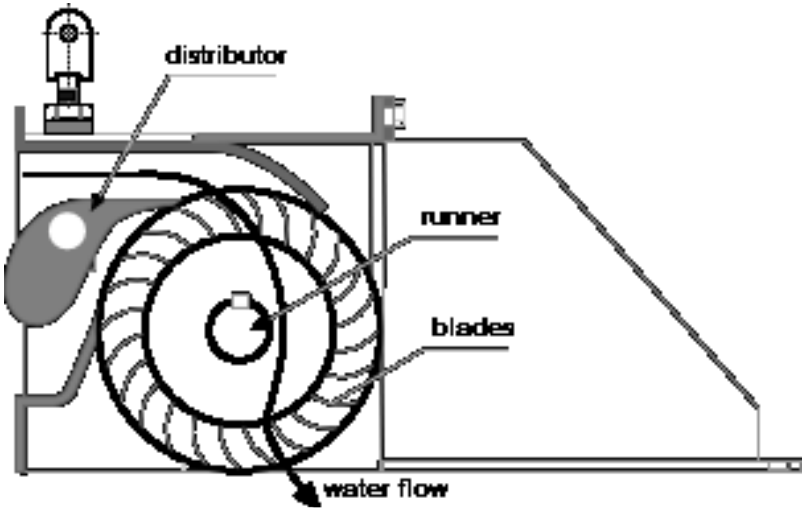


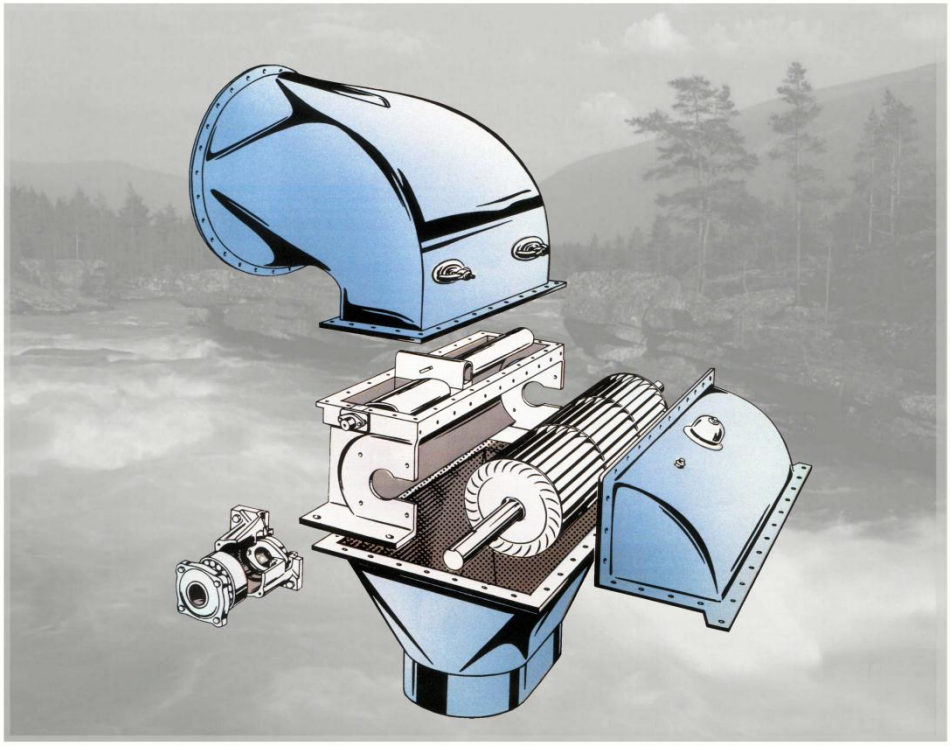




Banki turbine

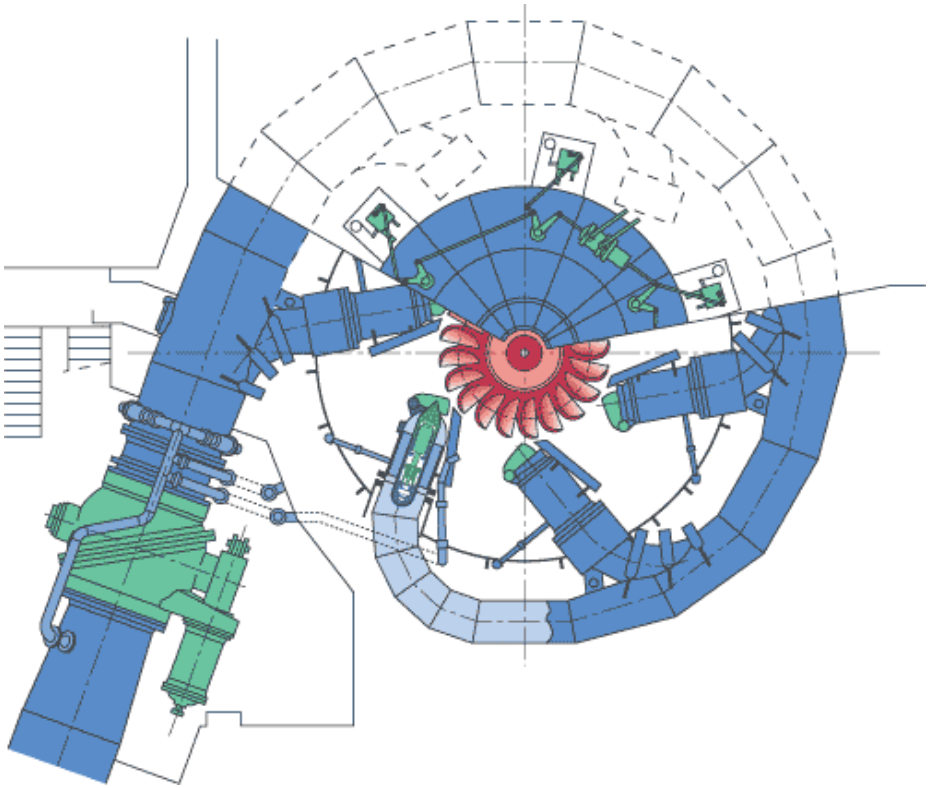
- Water fall from 1 up to 50 m
- Water flow from 50 l up to some m^3/s

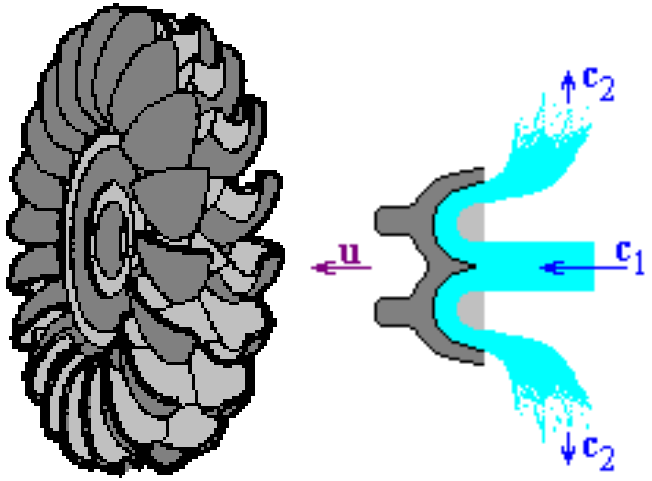




Pelton wheel (turbine)

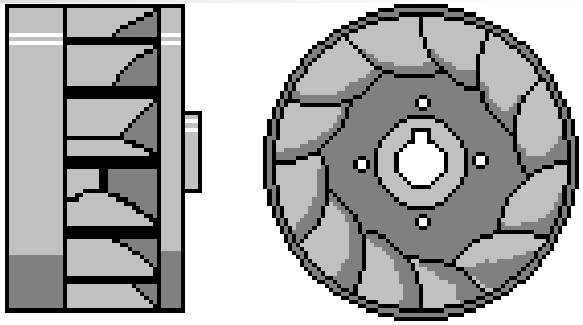
- Water fall higher than 30 m and flow up to 10 l/s
- Used at mountain rivers

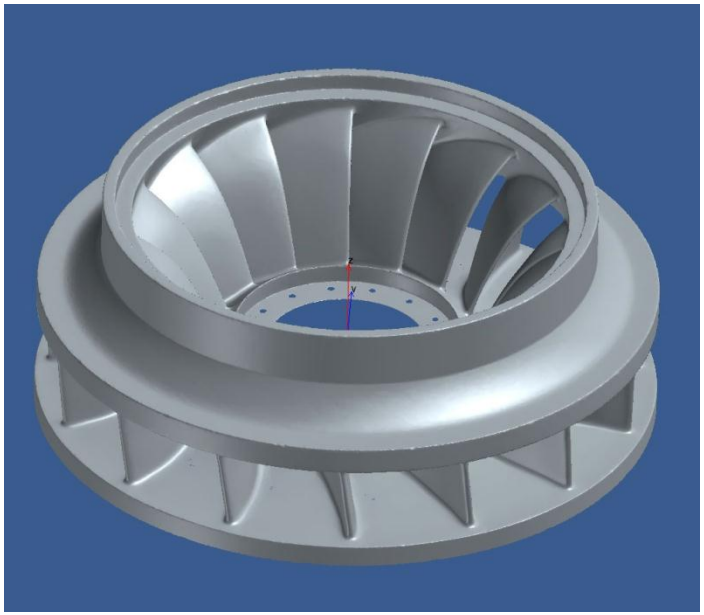


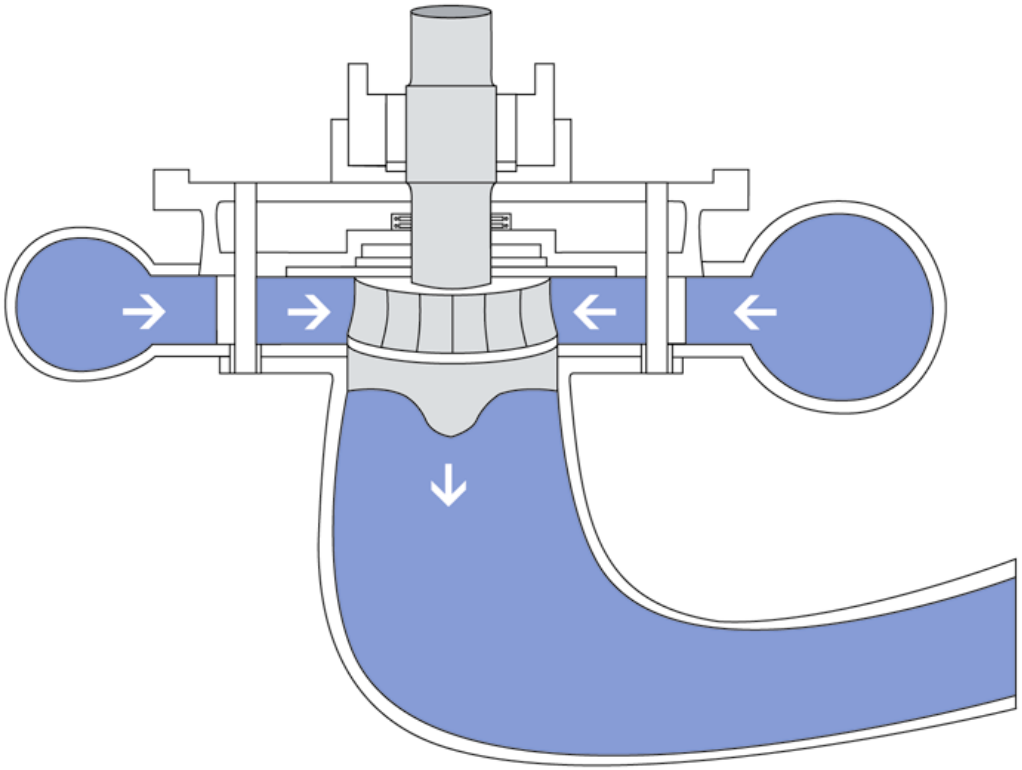


Francis turbine

- Used for low water fall up to 0,8 m and high water flow
- At pumped storage with water fall up to 500 m

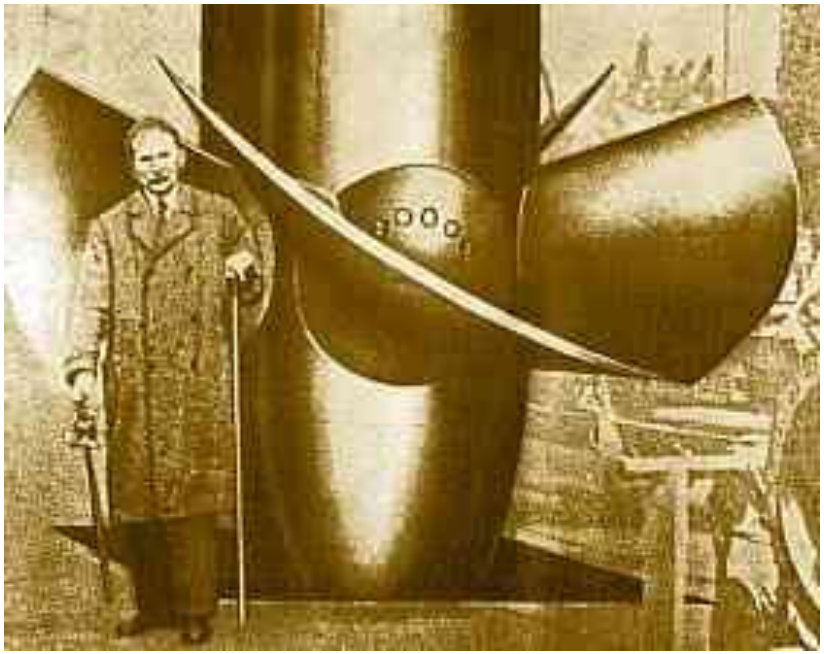


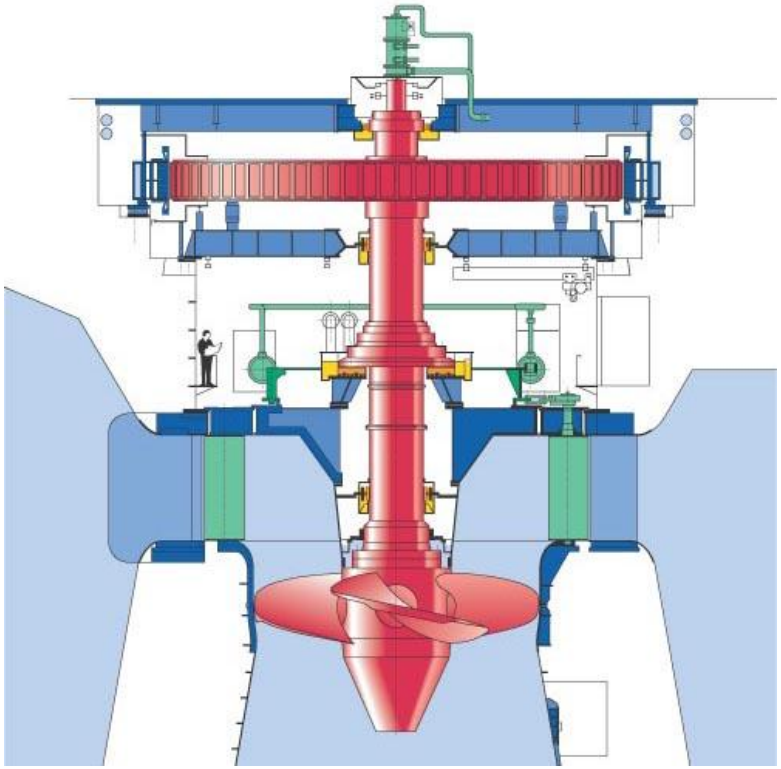




Kaplan turbine

- Used for water fall fro m1 up to 20 m, water flows from 0,1 up to some m^3/s (weir and small hydropower plant)

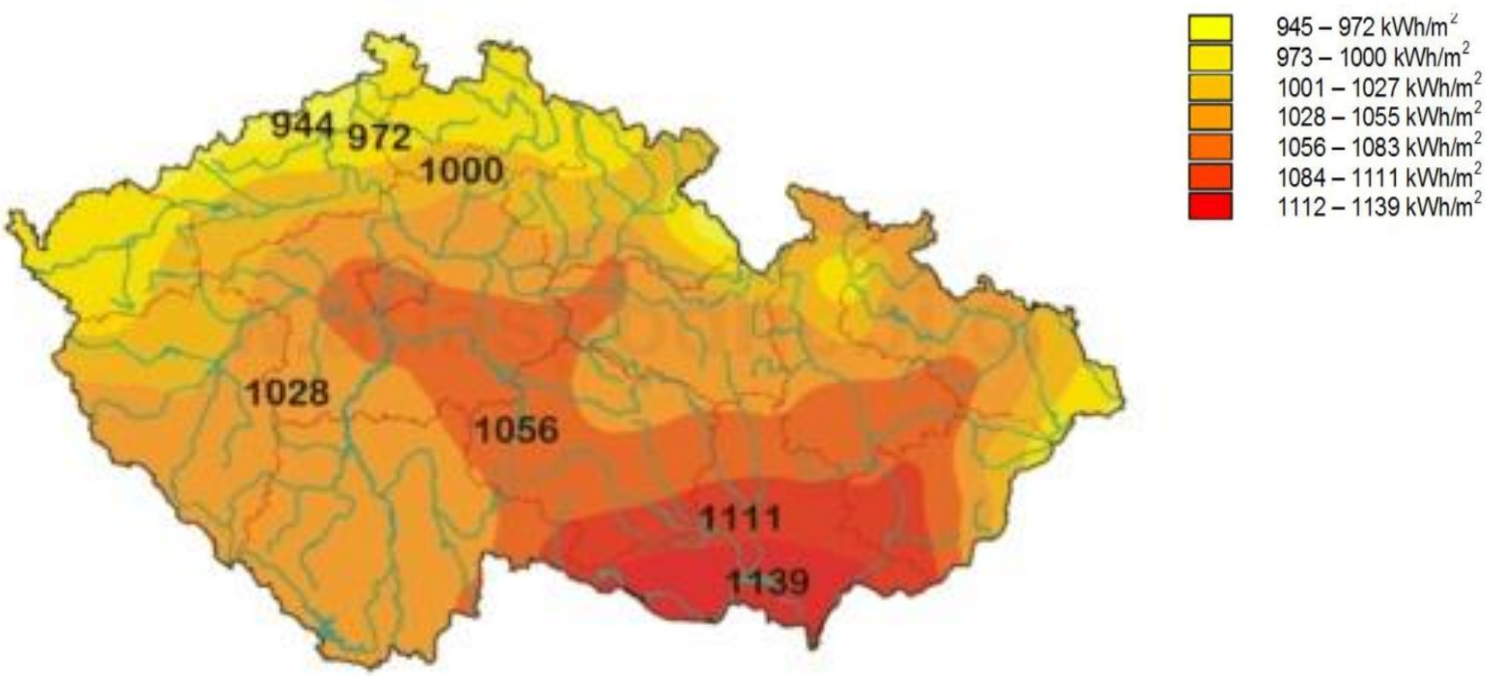




Solar energy

- In Czech Republic sun radiation bring 950 – 1340 kWh of energy per 1m²
- Annual sun hours are 1331 – 1844 hours

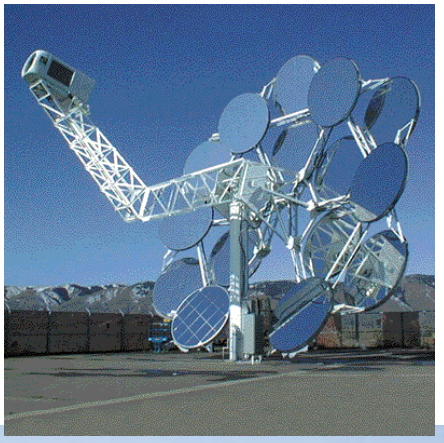
Solar radiation in Czech Republic – kWh/m²

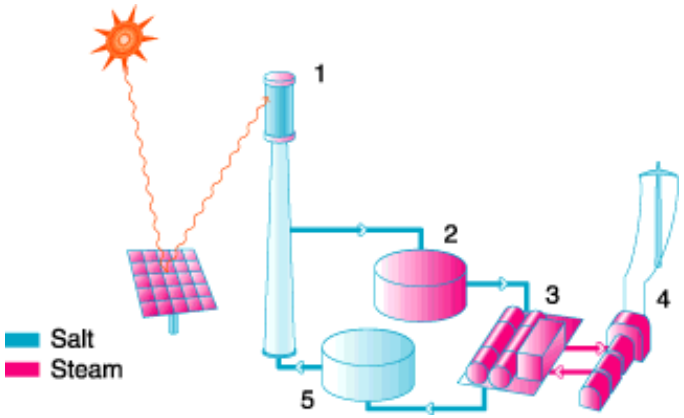


Solar power plants

Solar power plants:

- Photovoltaic panels
  - high price per 1kW
  - low efficiency)
- Power plant with solar collector:
  - uses high efficient PV cell
  - complicated constriction
- Solar tower power plant
  - Uses steam turbine
  - Store energy in salt



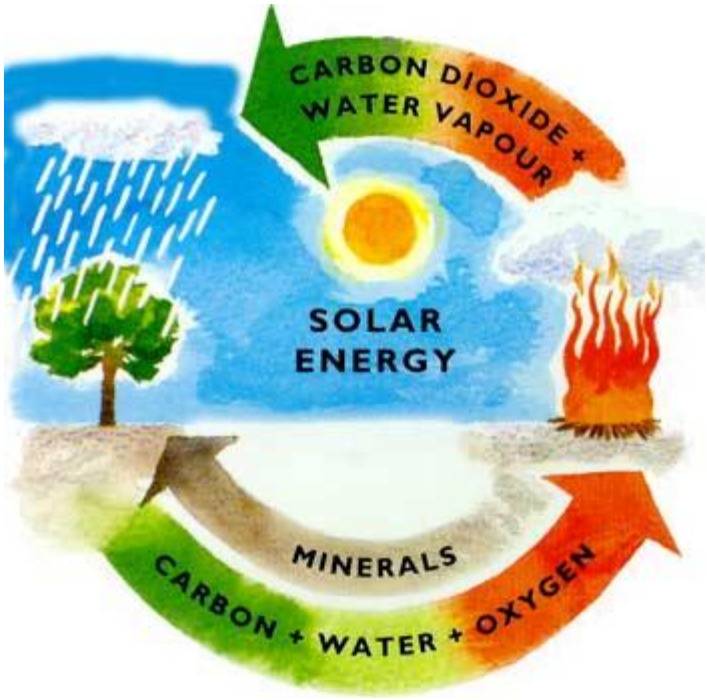


Solar power

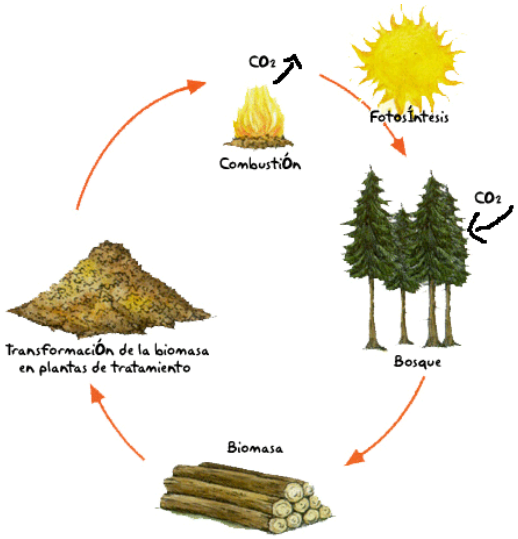
Solar power plants over 5 MWe in 2011

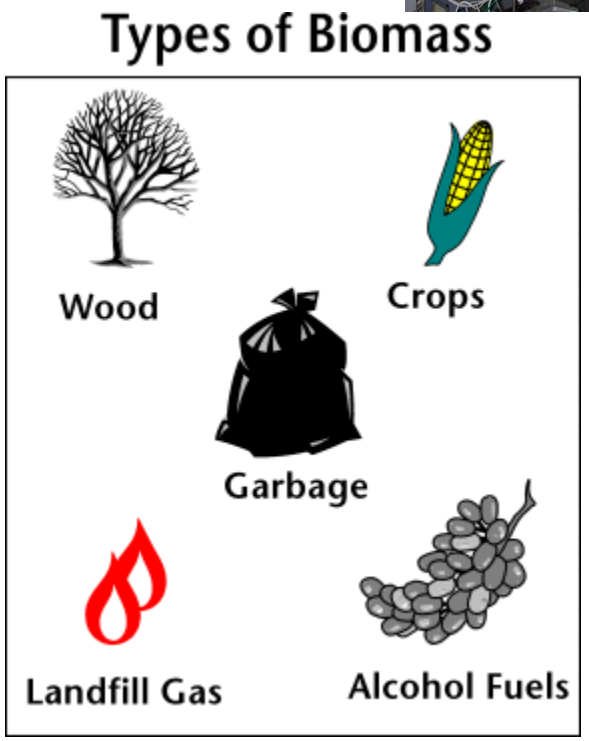
Biomasa

- Burning of biomass releases amount of greenhouse gases absorbed by the plant
- Low concentration of sulfur – no SO_2
- Amount of NO_X depends on temperature of burning
- Temperature lower than 500°C – release of unburned ash
- higher water content → lower calorific value
- Burning of biomass
  - solid
  - Liquid
  - gas
- Combined burning of biomass and fossil resources



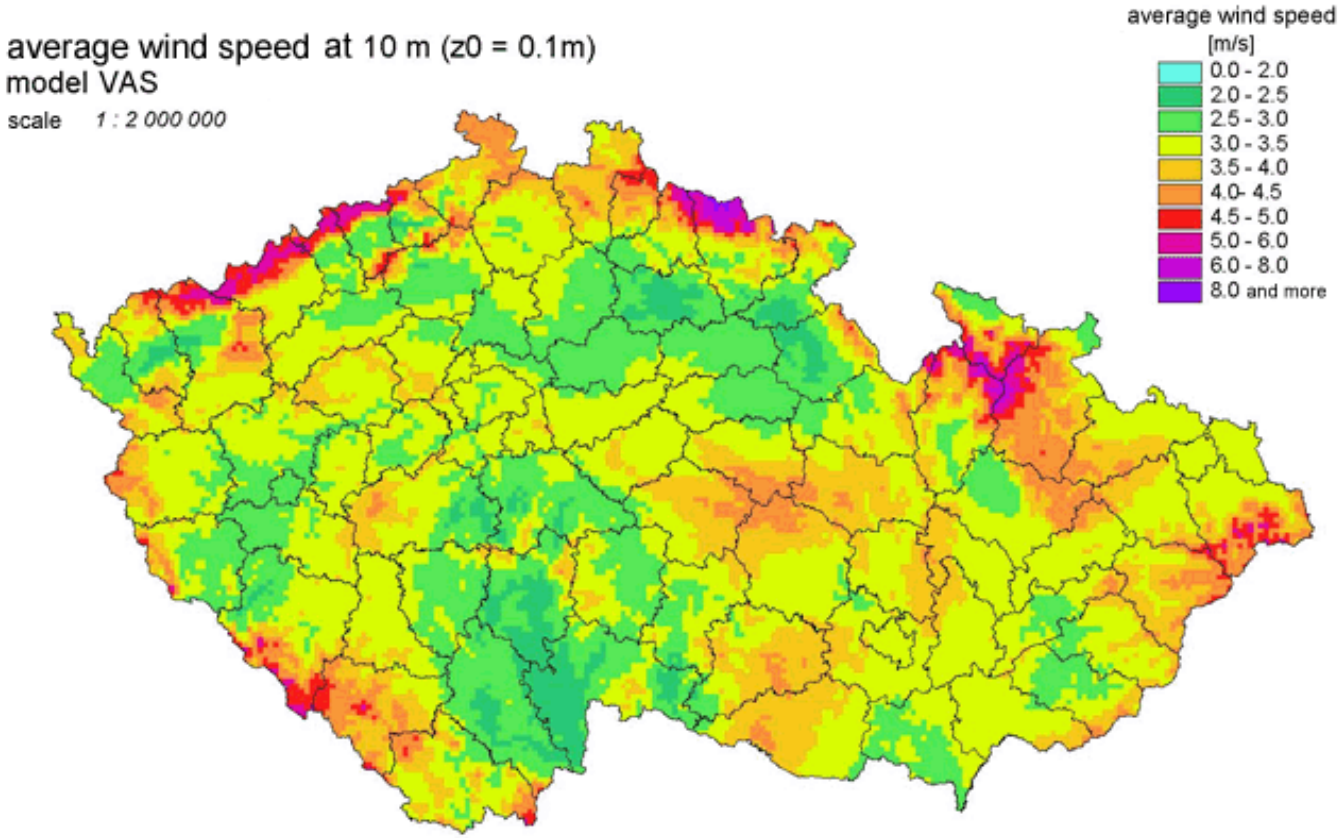
Biomass

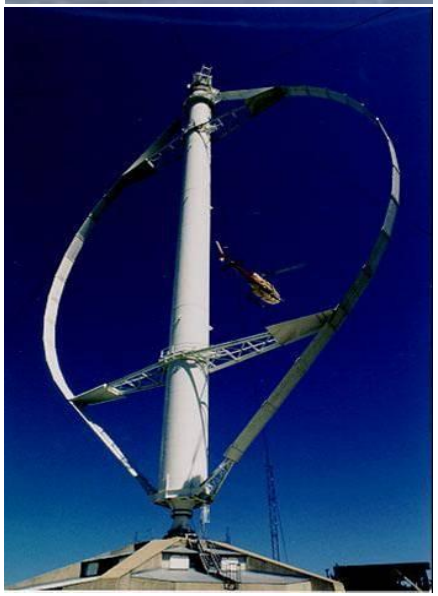

CO2
Fotosíntesis
Combustión
CO2
Transformación de la biomasa en plantas de tratamiento
Bosque
Biomasa


Types of Biomass
Wood
Crops
Garbage
Landfill Gas
Alcohol Fuels

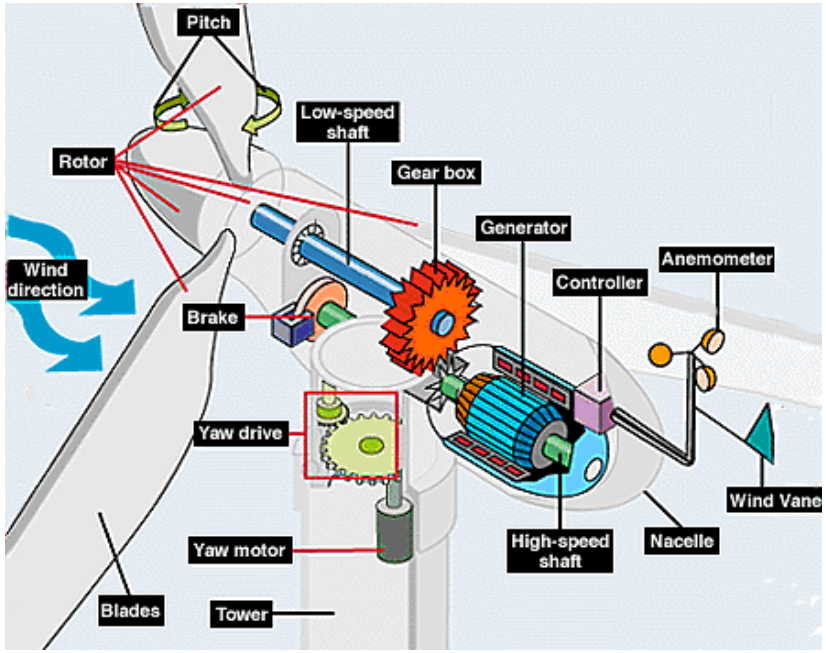
Wind power

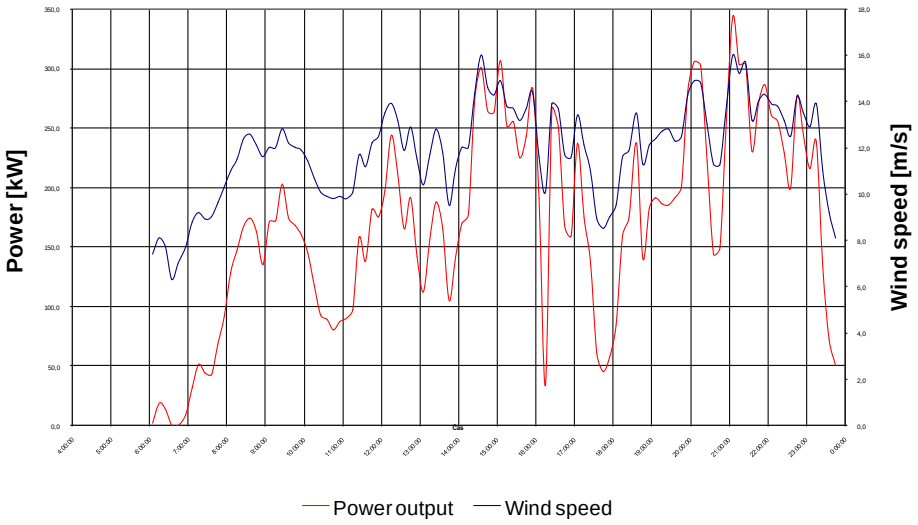
- Onshore power plants (close to consumers, lower efficiency)
- Offshore power plants (higher efficiency and constant wind)



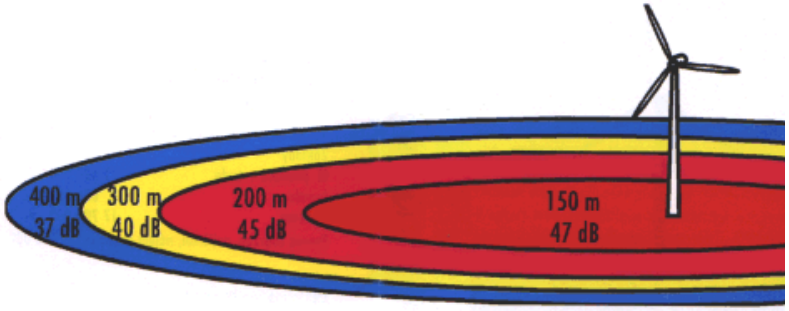


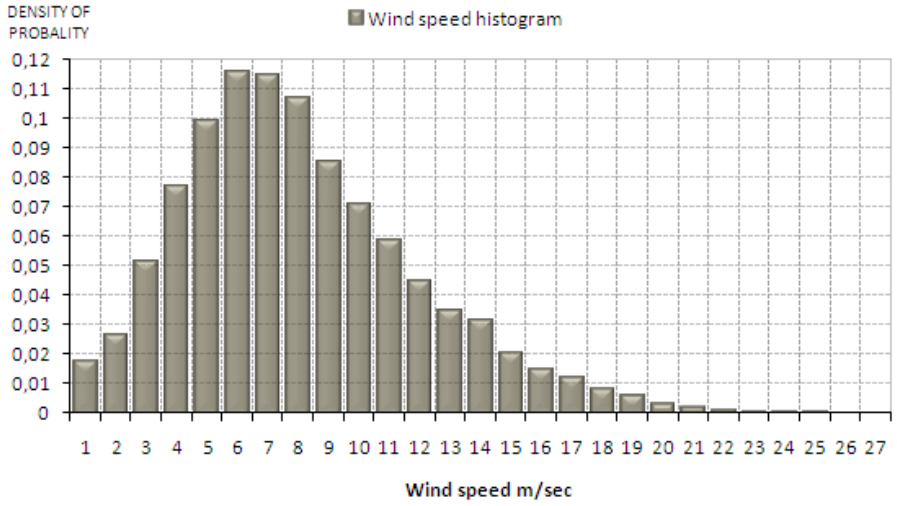
Wind power





$$P = k \cdot D^2 \cdot v^3$$

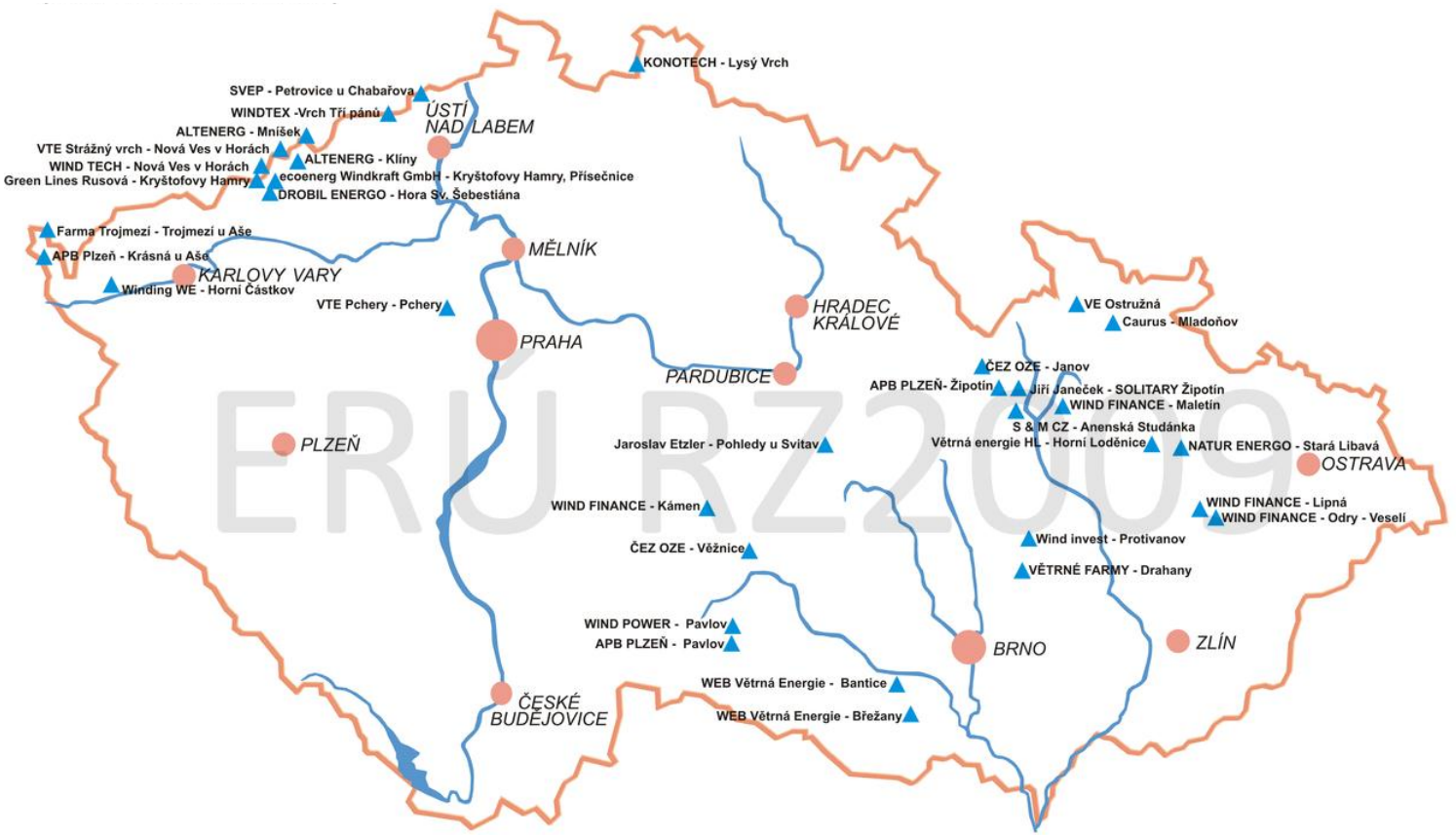




Wind power

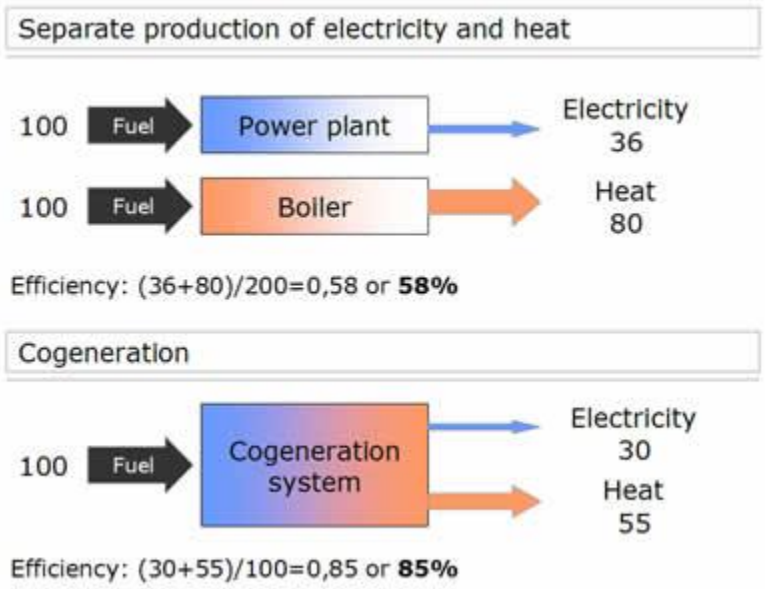
Wind power

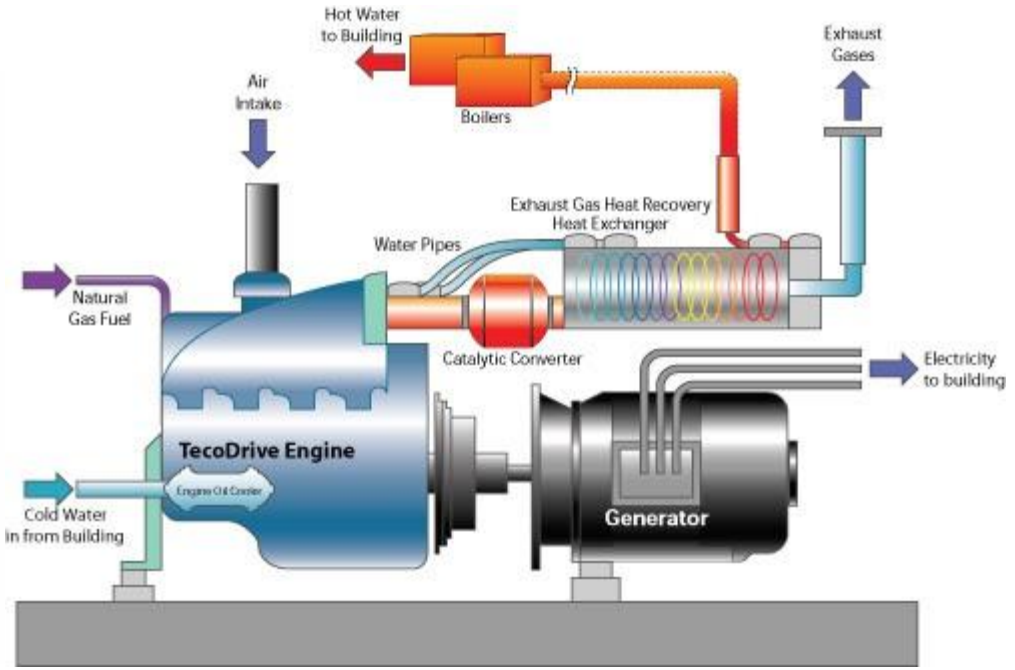
Wind power plants over 2 MWe in 2010



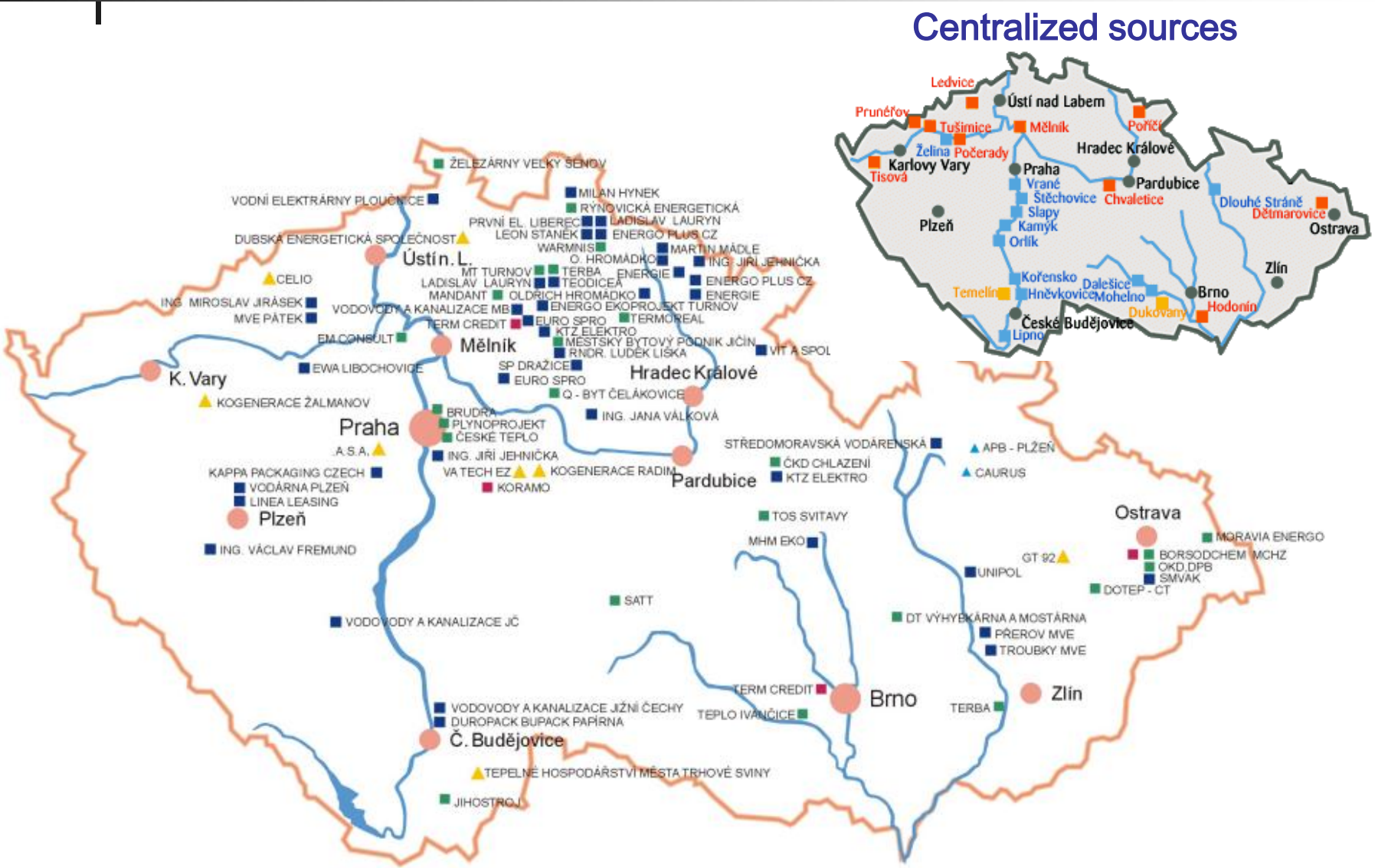
Cogeneration

- Combined electricity and heat production, 30-40% electricity and 60-70% heat
- Fuel:
  - Solid
  - Liquid
  - Gas



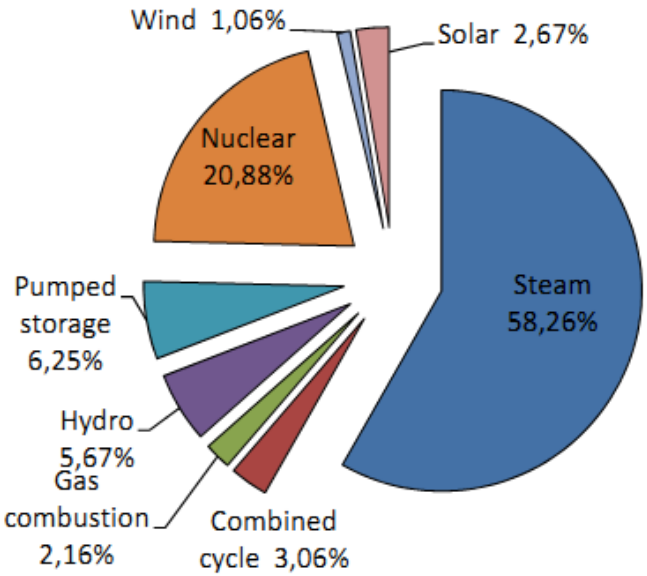


Distributed sources up to 1 MW

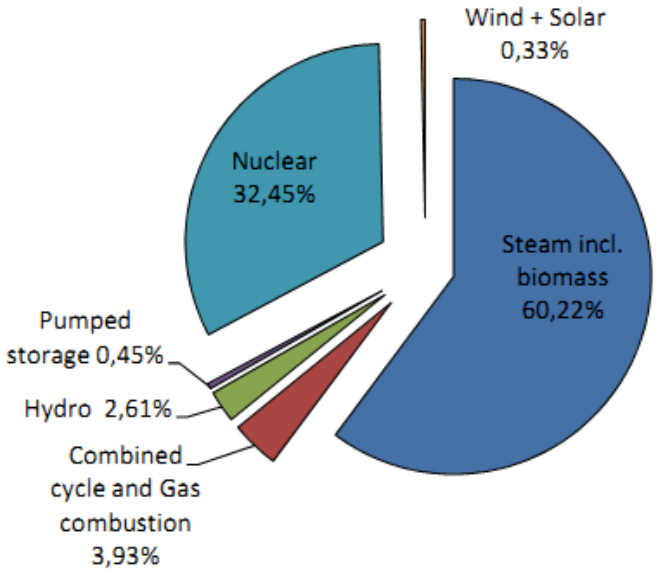


Installed capacity and energy production in CR

Power capacity 2010

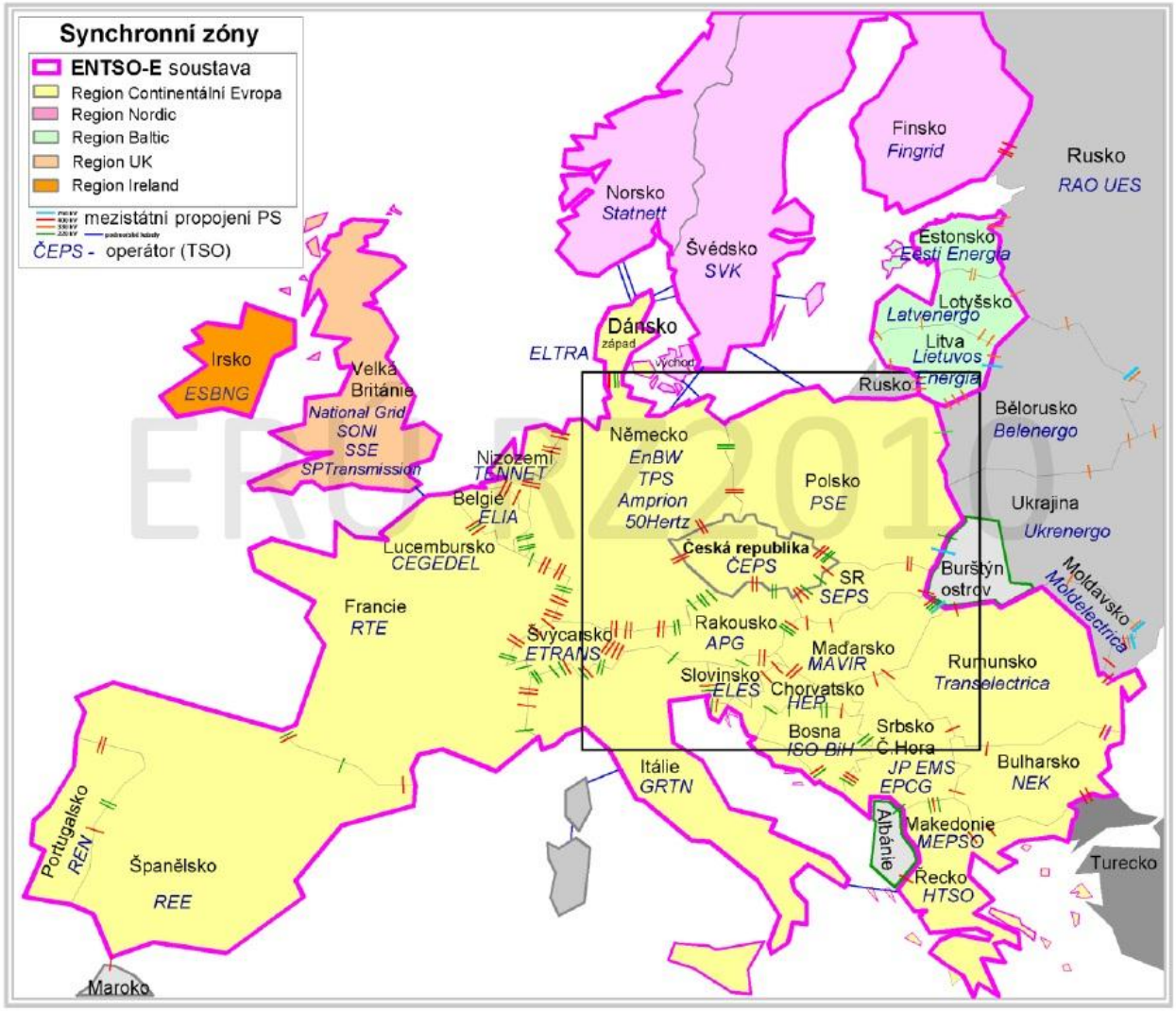


Power production 2010

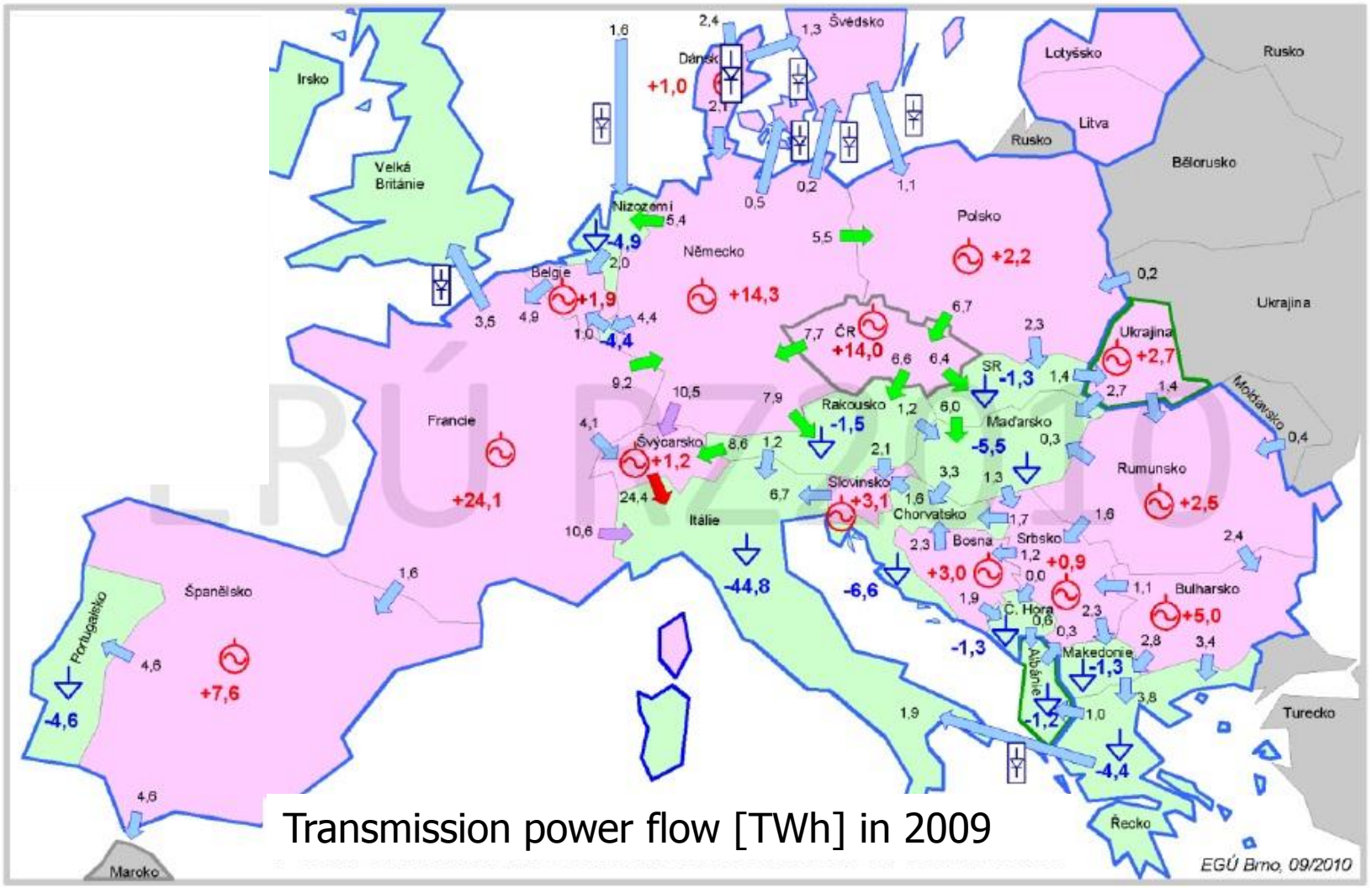


Power grid connection (UCTE)

Power grid connection (UCTE) in 2010

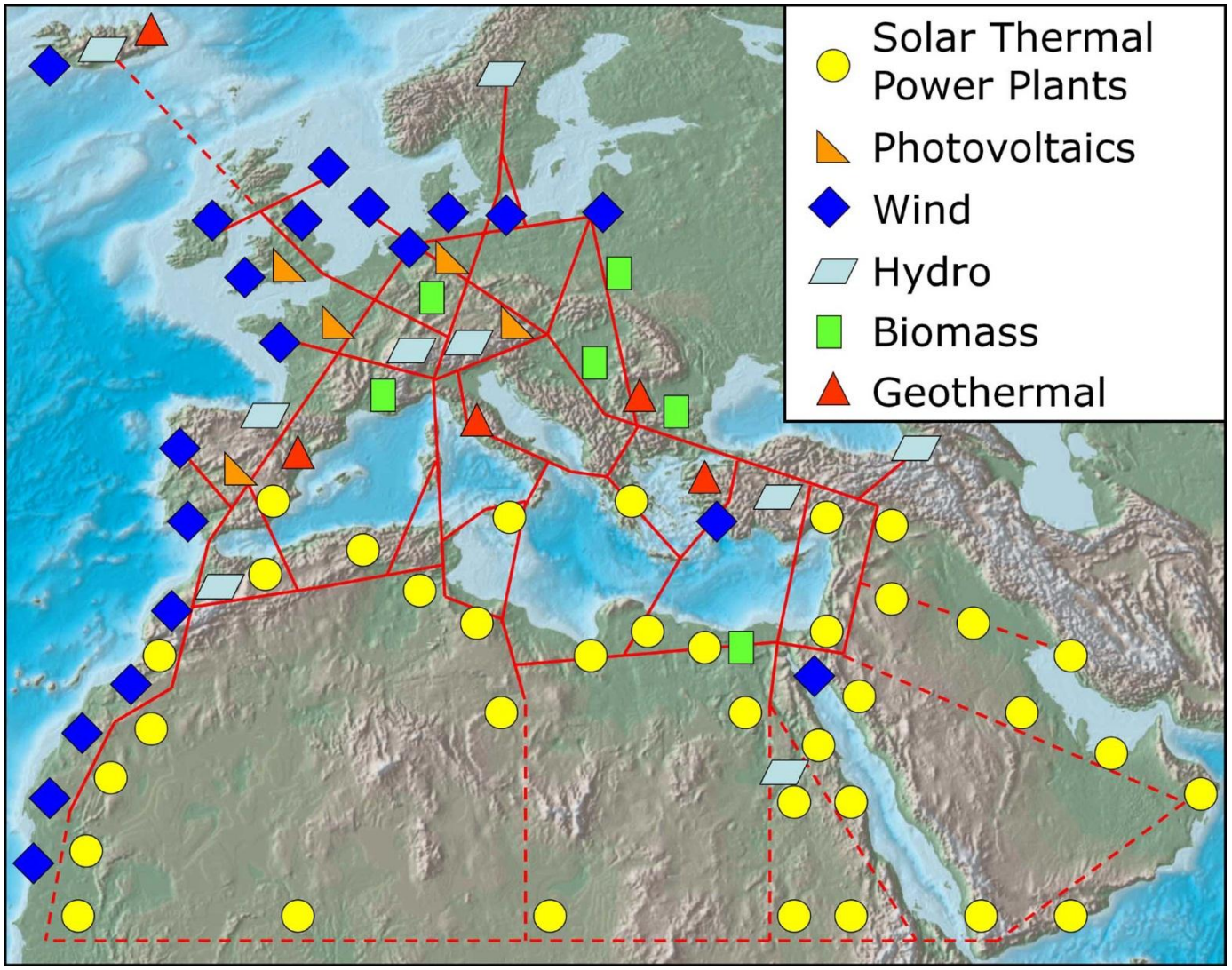


Power grid connection (UCTE) – power flow



Transmission power flow [TWh] in 2009

Super grid


Solar Thermal Power Plants
Photovoltaics
Wind
Hydro
Biomass
Geothermal