

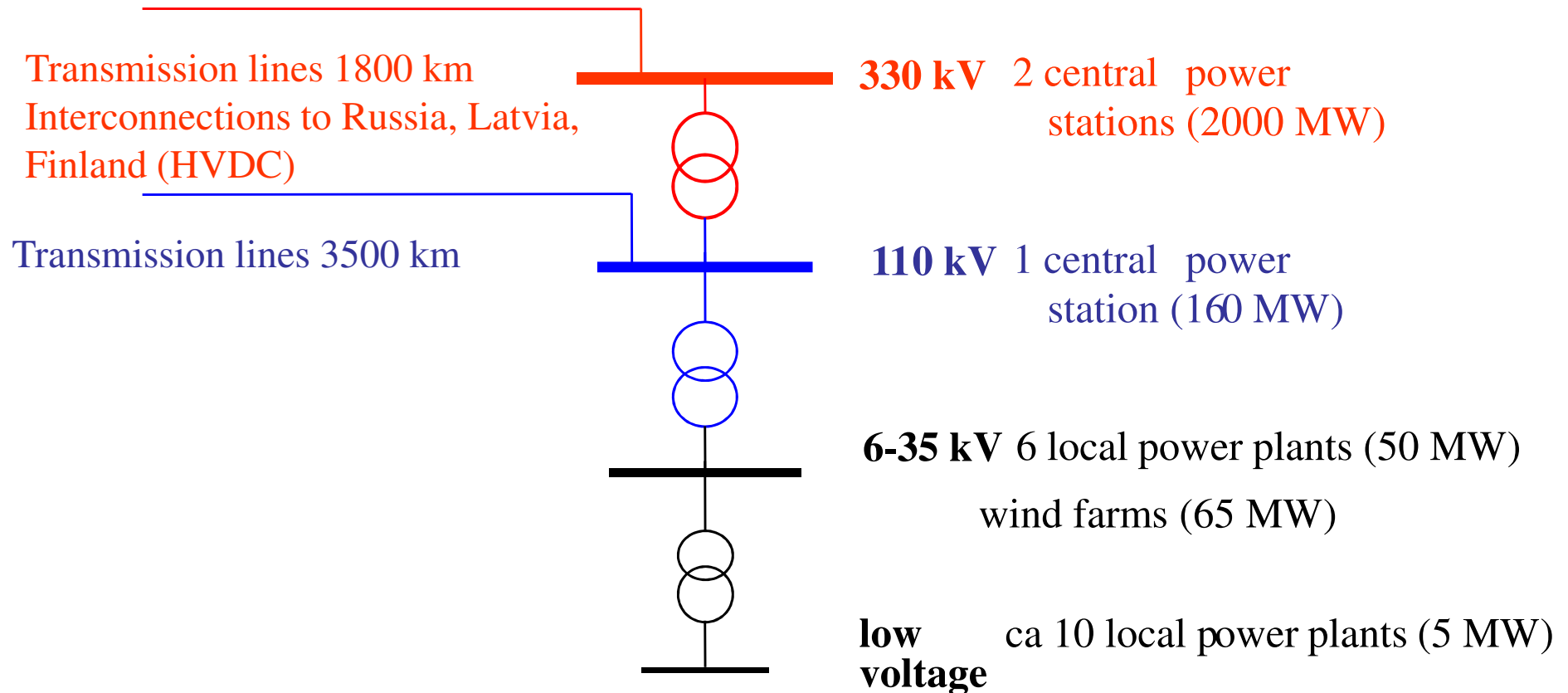
# Possibilities of Accomodation of Nuclear Energy into Estonian Power System

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# Estonian Transmission System

- The Estonian energy system is connected to neighbouring countries (Latvia, Russia) via five 330 kV transmission lines.
- From the year 2006 the Estonian network has been connected to the Finland network via 350 MW DC submarine cable (Estlink).
- For the year 2013 the second connection between Estonia and Finland, Estlink-2, is planned
- The Estonian transmission network is relatively powerful and allows the country to import or export 400 ... 1400 MW power.

# Structure of the power system of Estonia



Power demand: peak-load 1600 MW, low-load 400 MW;  
annual net consumption 7,2 TWh (2007)

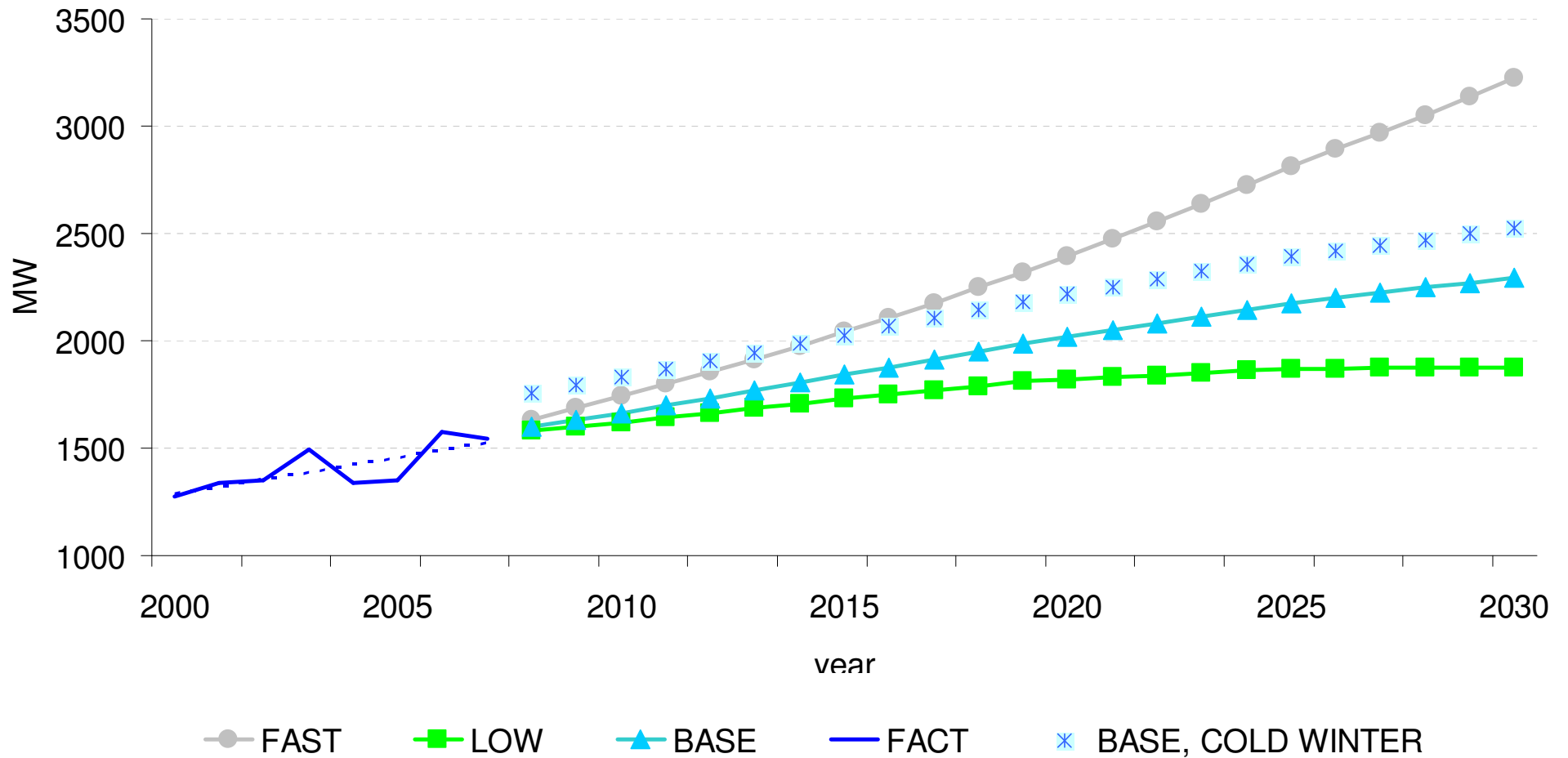
# Estonian Transmission System, a Part of IPS/UPS of Russia



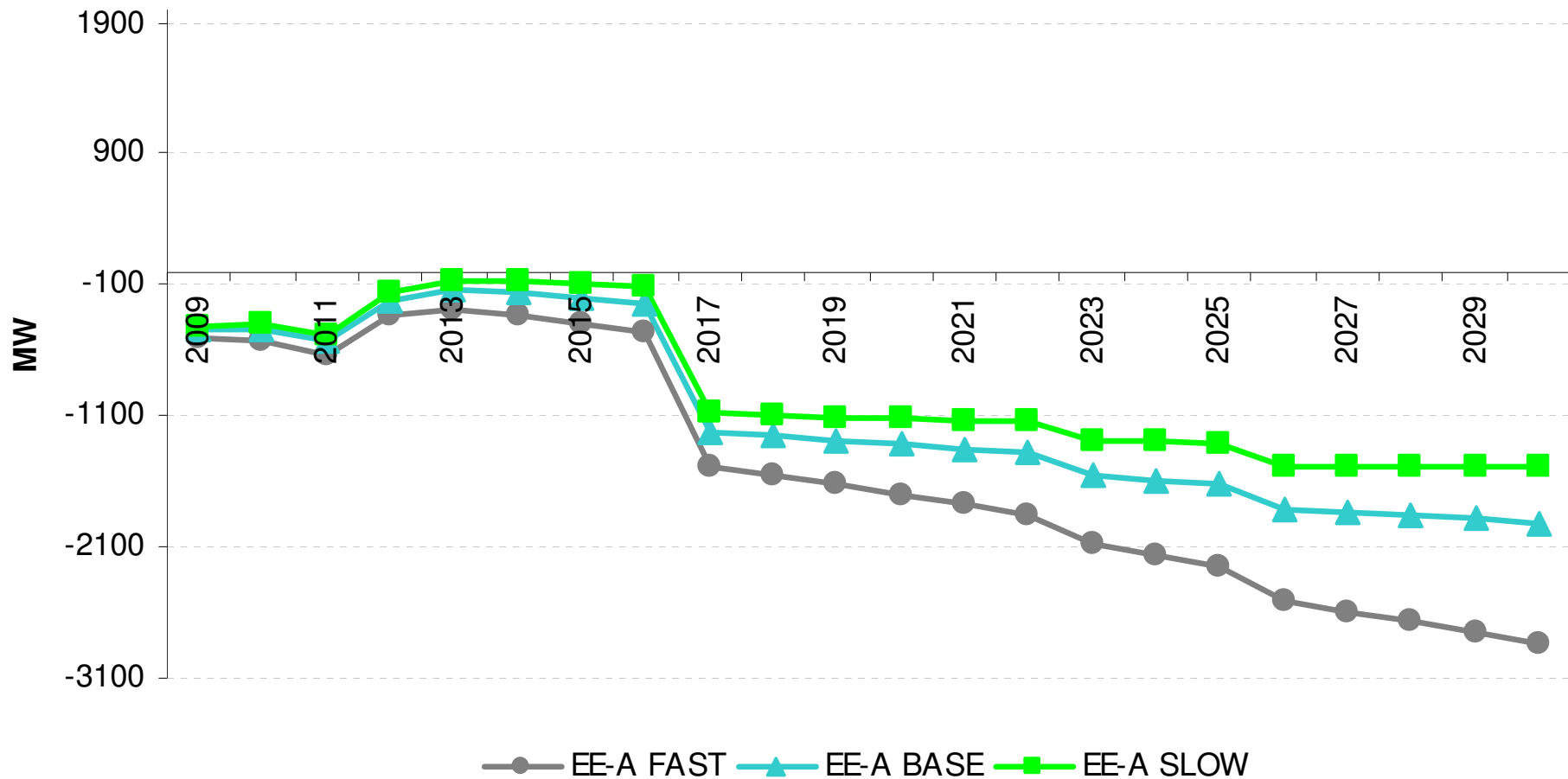
# Power consumption and generation in Estonia

- Considering the economic growth targets, a reduction of electricity demand cannot be envisaged.
- Existing generating units are old and cannot most of them cannot operate without additional investments in flue gas cleaning devices.
- Today domestic consumption and modest exports of electricity are adequately covered, but severe restrictions are expected after 2010.

# Load growth scenarios



# Adequacy of generation (conservative scenario) under different load growth scenarios



# Nuclear power in Estonia?

(+)

- Huge need for investments in power generation
- CO<sub>2</sub> - free
- Experiences of accommodation of nuclear power in neighboring grids

(-)

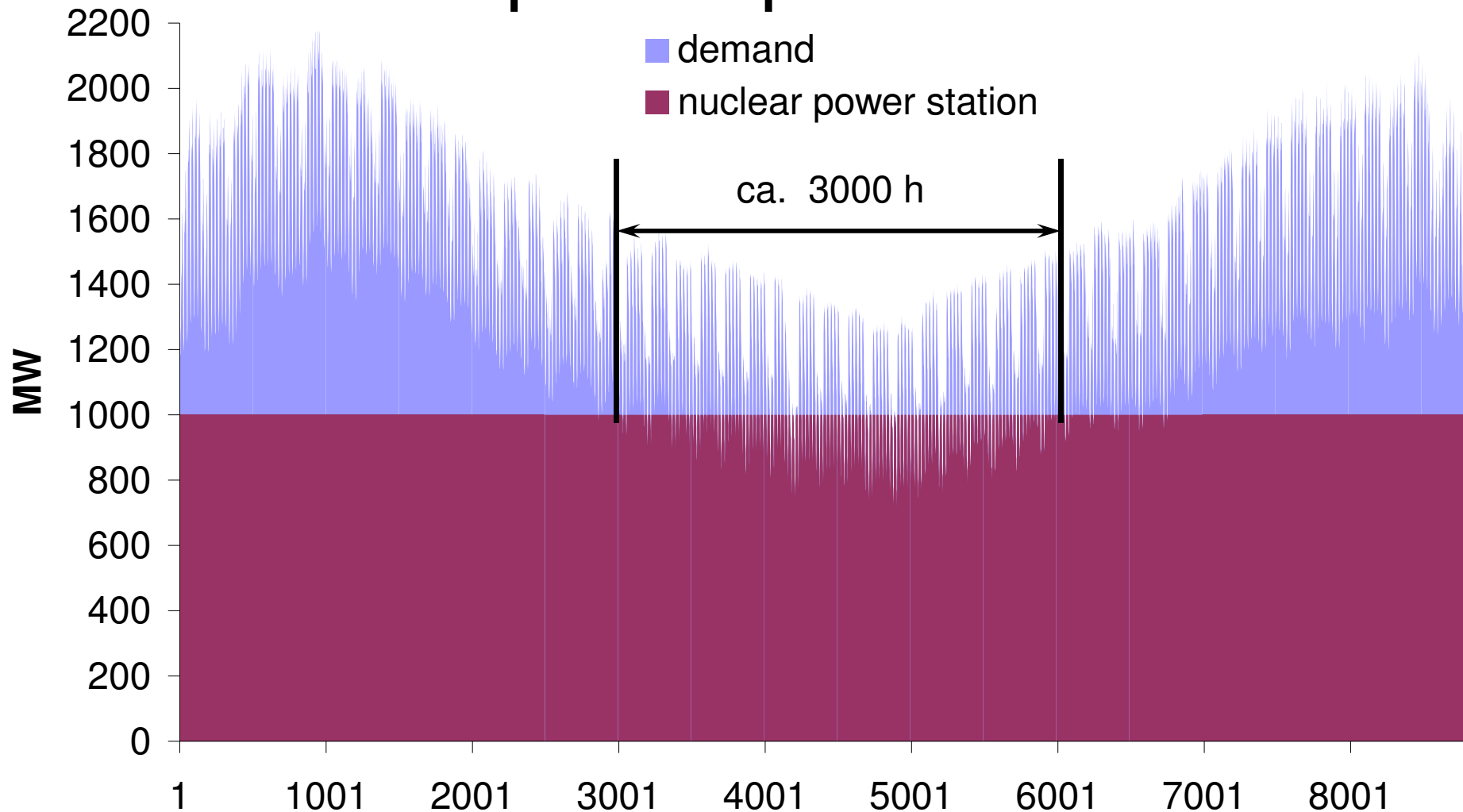
- Small consumption, no fast start-up units (hydro) in the system
- Larger units are more economical, but create additional problems in a small system
- Huge interest in connecting fluctuating (wind) generation into the system

# Balancing of the system

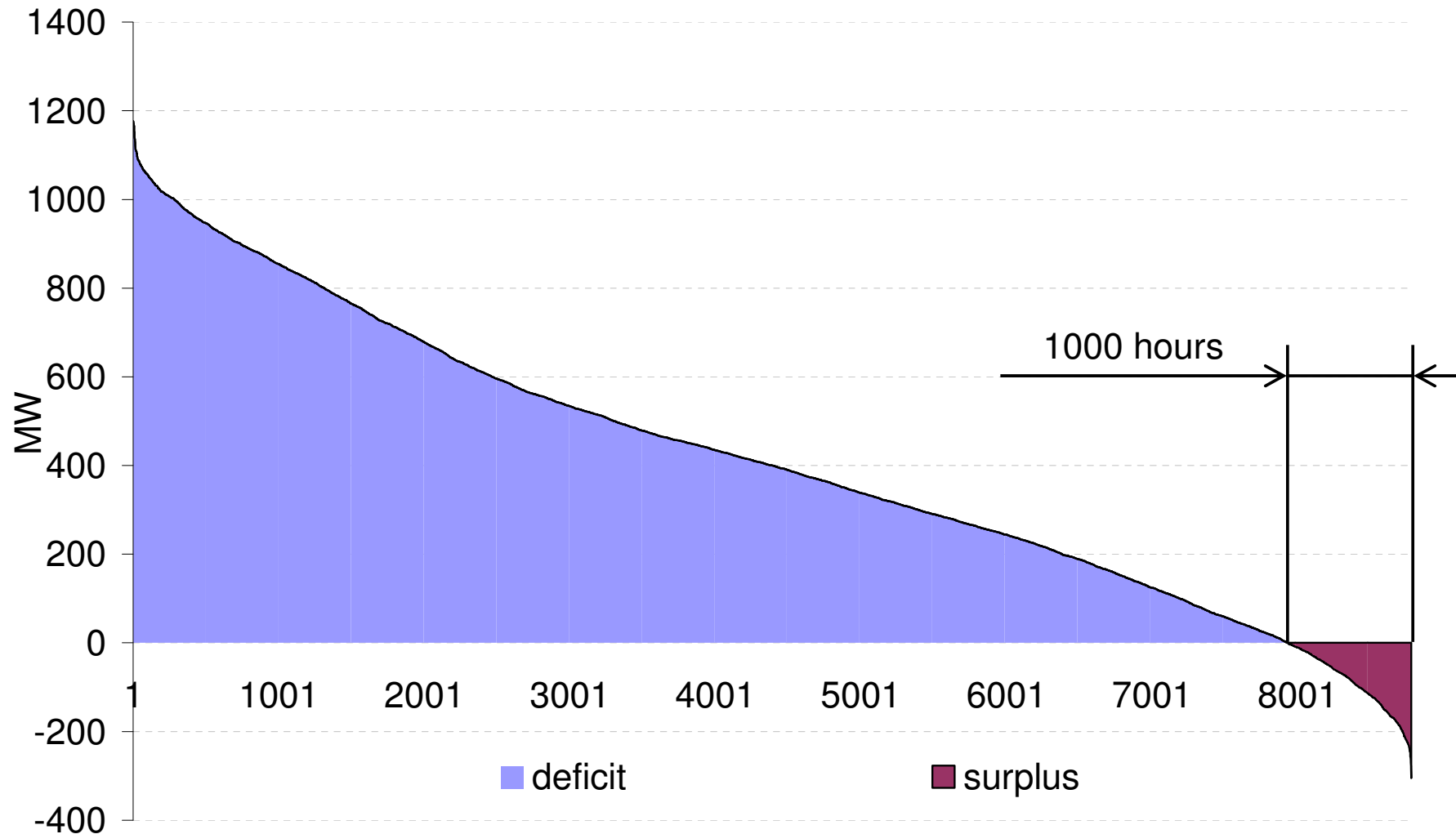
- As nuclear plants have relatively high capital costs but low marginal operating costs, they run most economically at very high load factors
- Lower capital costs per/kW can be expected for larger units, on the other hand, considering the relatively low demand in Estonia, large nuclear unit size can create additional problems with balancing during low-load period
- Balancing during low-load can be achieved through load-following of the units, smaller units or using two generators per one reactor
- Losses in profitability due to lower market prices during that period can be expected.

# Need for additional capacity to cover domestic demand in 2025.

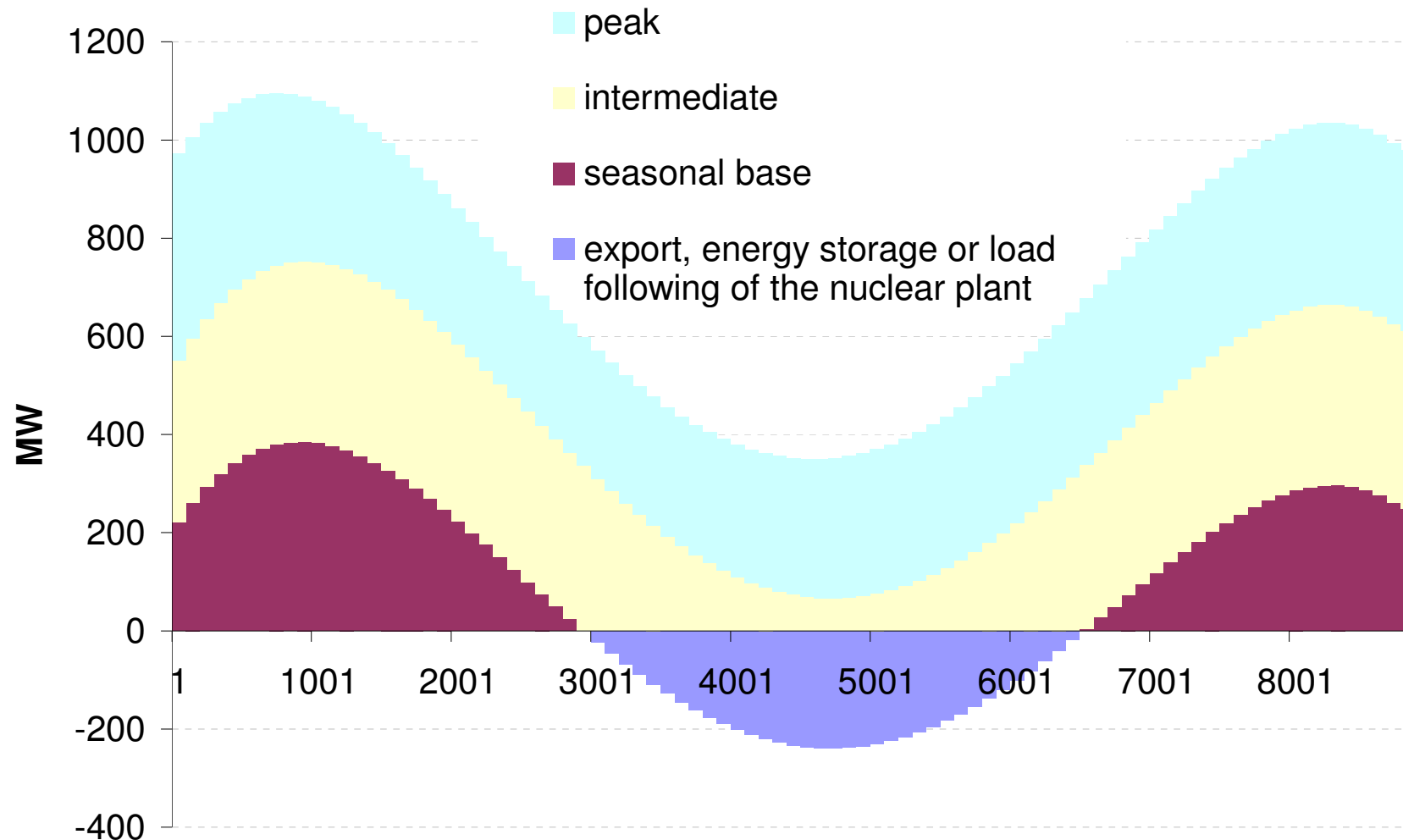
## Nuclear power plant 1000 MW



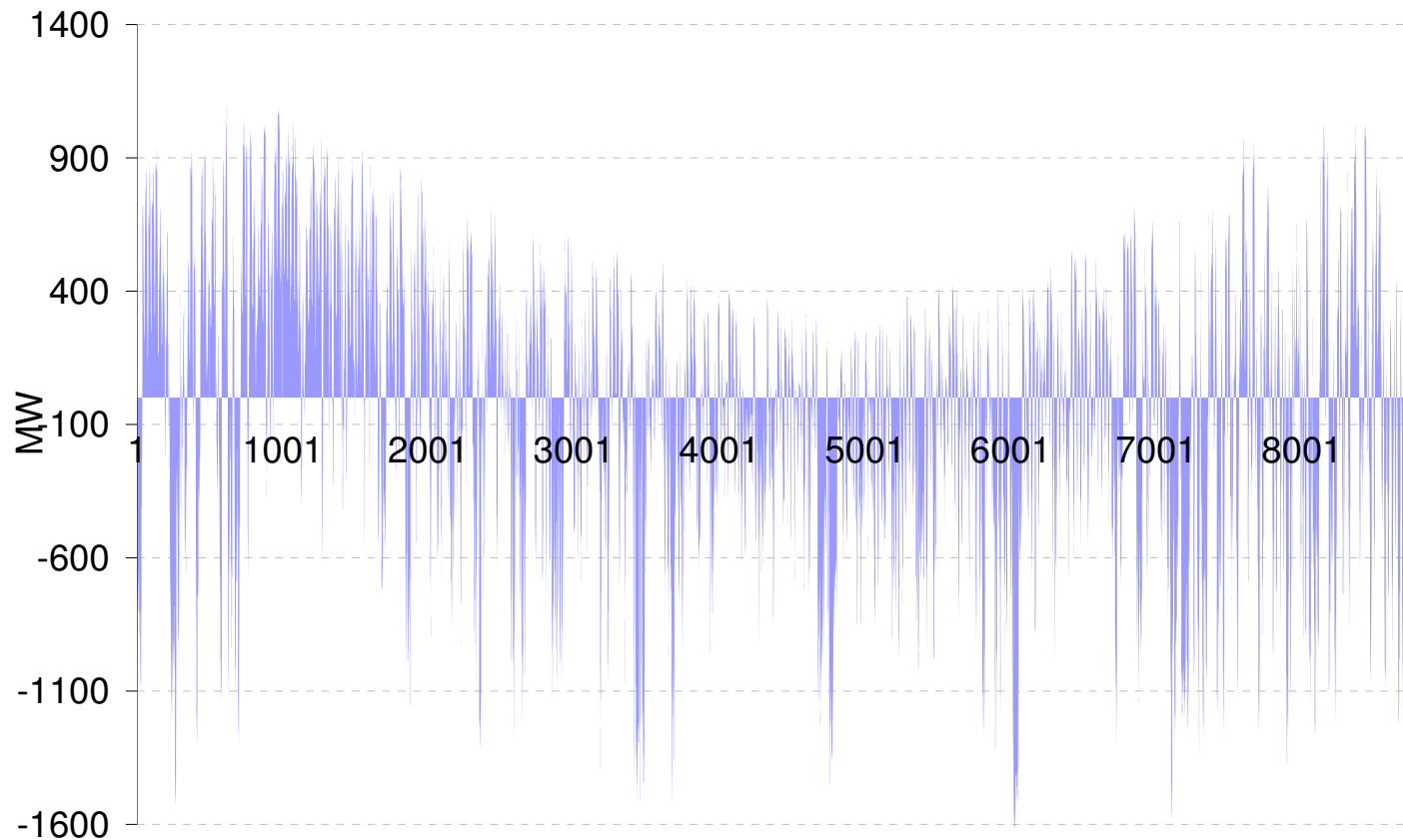
# Duration curve of additional capacity utilisation to cover domestic demand in 2025. Nuclear power plant 1000 MW



# Need for additional capacity (weekly maximum) to balance system in addition to 1000 MW of nuclear power



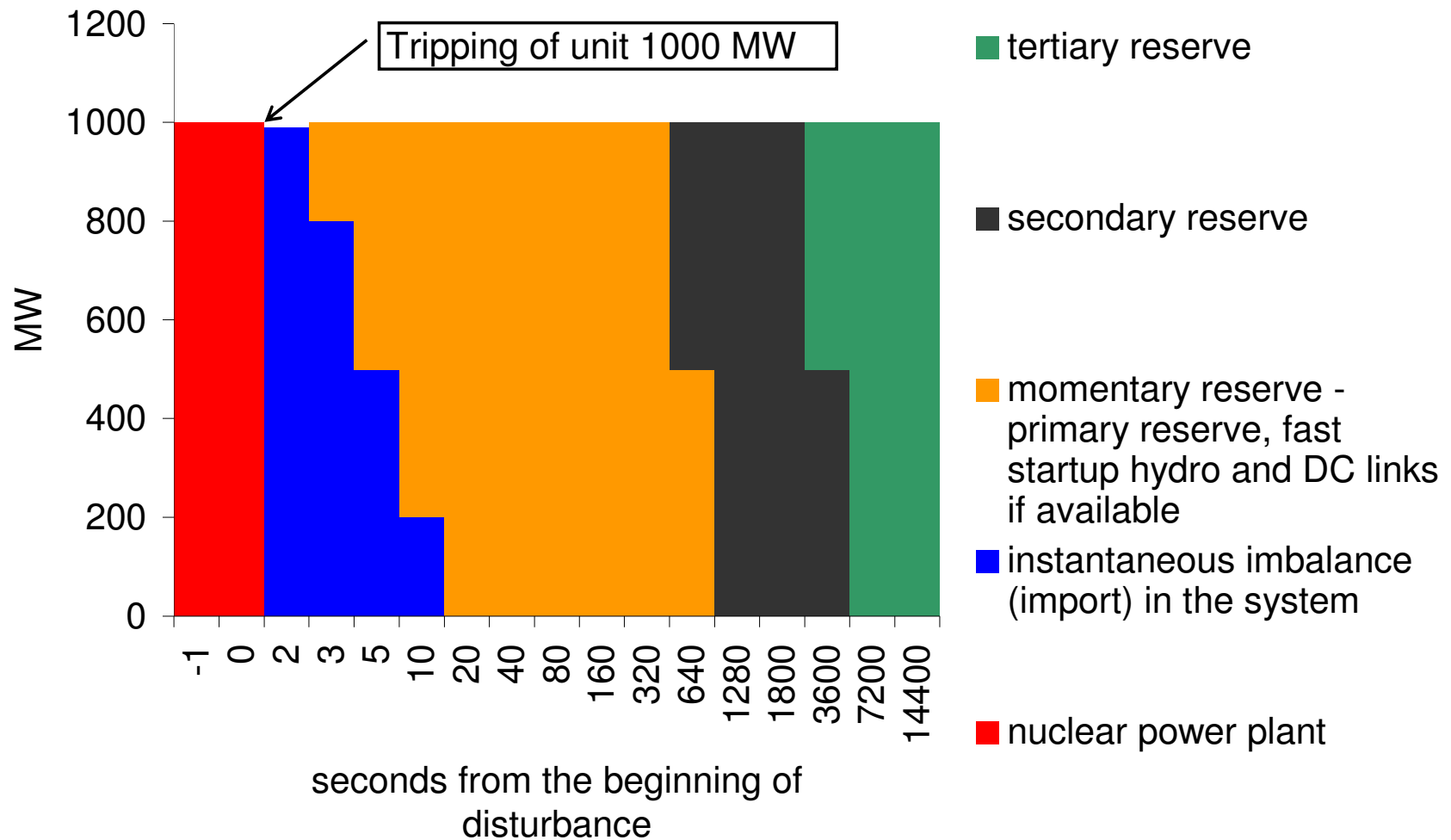
Need for additional capacity to cover domestic demand in 2025. Nuclear power plant 1000 MW and renewable (wind) power sources 1500 MW



# Disturbance reserve for nuclear power

- There must be sufficient generating capacity in the system to cover:
  - initial power imbalance,
  - secondary (fast start-up or running) and
  - tertiary (start-up after 15 minutes or running) reserves after tripping of the nuclear unit
- Reserves must be available in the same amount as provided by the biggest unit in the system
- Part of the reserves could be imported from the neighboring power systems, but the amount of the imported reserves depends on the export-import capability of the system

# Balancing of system after disturbance (tripping) of nuclear unit



# Accommodation of nuclear power in the power grid

- When considering construction of a nuclear power plant there must be cooling water available. Therefore, three coastal sites are briefly studied from the viewpoint of grid connection.
- Preliminary contingency analyses show that it is possible to connect a generating unit with a capacity of up to 1000 MW into the Estonian power grid, but substantial reinforcements in the internal grid are required.
- The Estonian 330 kV network has relatively good interconnections, but limitations can occur in real situation from external grid
- Additionally, there must also exist a second interconnection between Finland and Estonia, third interconnection to Latvia and associated system protection for cases where the import capability from synchronous area is limited

# The Estonian transmission system in 2020,



- Location near to existing substations:
  - Harku 330kV
  - Püssi 330kV
  - Balti 330kV
- Capacity variants :
  - 2x500MW
  - 1000MW

\* - red dotted lines are needed in conjunction with nuclear power plant

# Reccomendations

- The recommendation from the results of the study is to start with a medium-sized nuclear power plant with a capacity of 500-700 MW.
- Adequate reserves must be available in Estonian power system
- The introduction of a larger unit could also be considered starting from 2025, but it is associated with risks of overcapacity in the system which can be eliminated by means of:
  - larger market area,
  - larger interconnection capacities with neighboring power systems
- Another possibility is to introduce energy storing power plants such as pumped hydro or compressed air power stations

# Conclusions

- Nuclear power is considered to be the lowest-risk option for future power generation. The impacts of fossil fuel and CO<sub>2</sub> prices are insignificant
- Technical solutions can be created for accommodation of units with capacity up to 1000 MW.
- Higher growth rate of the load and later introduction (after 2030) of larger units can considerably reduce the risks and improve the economics of larger units
- Large-scale introduction of wind power can create additional problems with balancing of the system

**Thank You!**