Capital Stock intensive planning for the Indian electricity sector

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Contents

Motivation and Objective

Motivation:

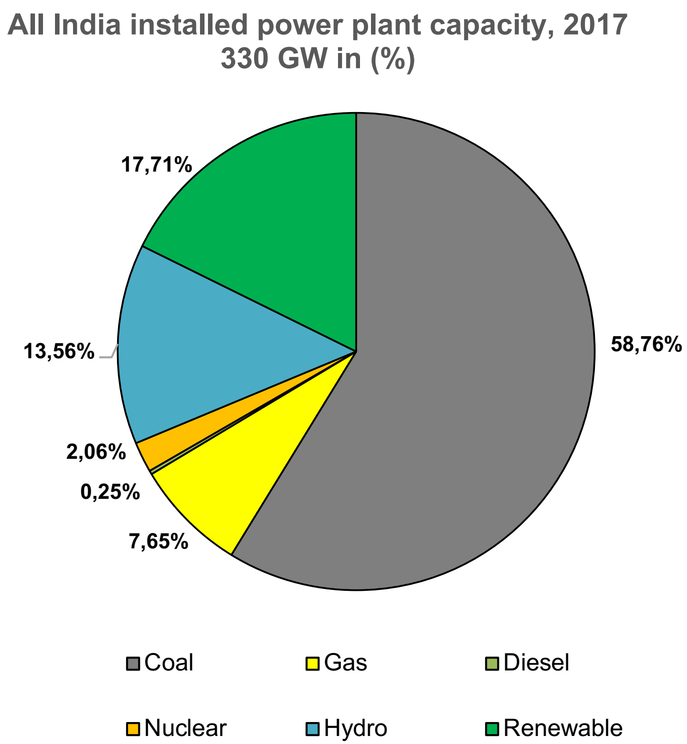
- India's energy transition towards carbon free energy
- Long term sustainability
- Smart investments
- Losing the coal dependency

Objectives:

- To calculate the capital stock of the current Indian power plant fleet
- To evaluate specific technology types

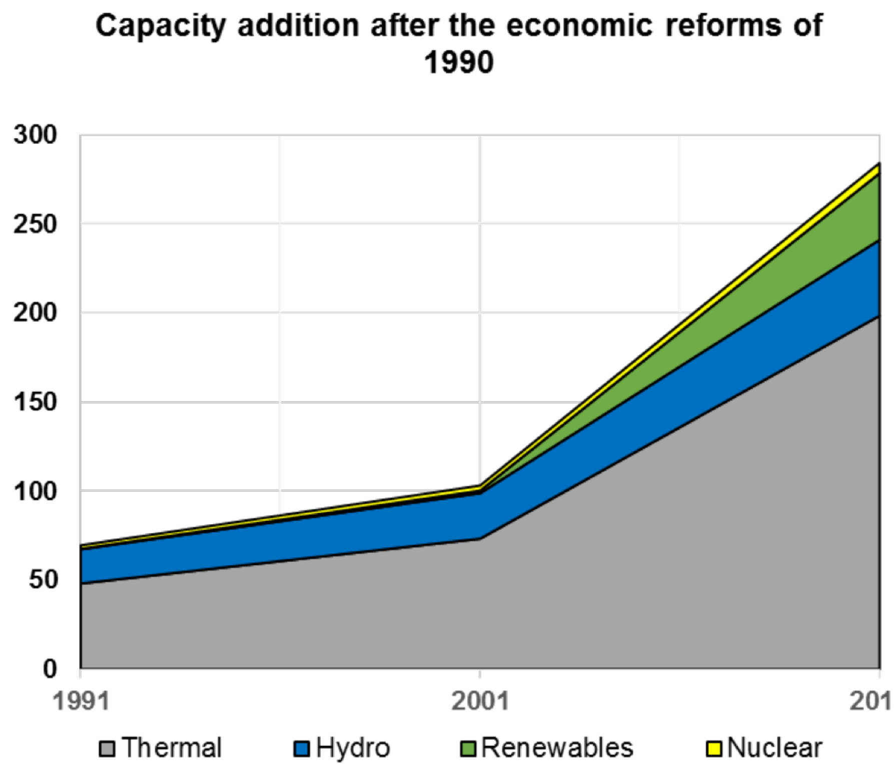
The Indian Electricity System

- Huge : Area and Capacity
- 5 power regions
- 330 GW of installed capacity
- 890 TWh of annual electricity consumption
- 145400 circuit kilometers of transmi: lines
- 58,76% coal capacity
- 18% renewable
- 14% hydro



The Indian Electricity System

- 1990 – 2006 : Large capacities of coal fired power plants added without check
- Cheap availability of domestic and imported coal
- Electricity generation from coal : ~70%
- Major CO_2 emissions source
- Use of super critical and ultra supercritical boilers

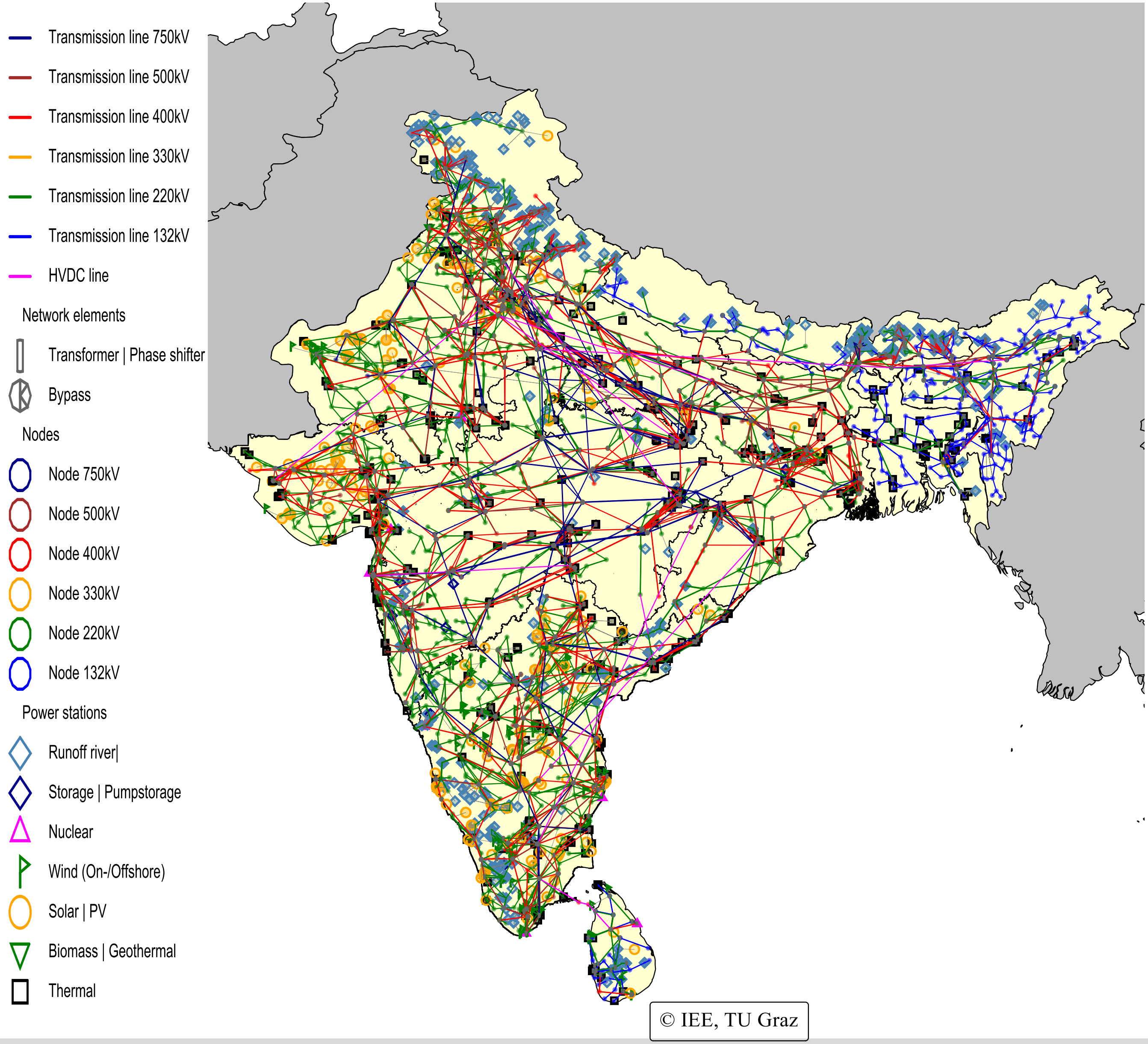


Challenges for the Energy transition

- High demand growth rate
- Huge dependency on coal
- Nuclear power : Standstill
- CO_2 emissions : Paris agreement, 30% reduction in intensity
- Transmission and Distribution losses
- Large scale renewable energy technology : Expensive a.t.m.
- Energy efficiency targets

Atlantis_India

- Reference to the model ATLANTIS, IEE, TU graz
- Unique techno economic model developed at the IEE
- Over 3000 nodes covering India, Bangladesh, Bhutan, Nepal and Sri Lanka
- More than 6000 transmission lines with physical restrictions
- Over 3750 power plants (smaller PPs aggregated)
- Node-specific demand model
- Additional demand model for e-mobility and other factors
- Economic market model : Copper plate, Zonal Pricing and Redispatch
- Emulation of real-like scenarios


Transmission line 750kV
Transmission line 500kV
Transmission line 400kV
Transmission line 330kV
Transmission line 220kV
Transmission line 132kV
HVDC line
Network elements
Transformer | Phase shifter
Bypass
Nodes
Node 750kV
Node 500kV
Node 400kV
Node 330kV
Node 220kV
Node 132kV
Power stations
Runoff river|
Storage | Pumpstorage
Nuclear
Wind (On-/Offshore)
Solar | PV
Biomass | Geothermal
Thermal
© IEE, TU Graz

Automatic Capacity extensions

- There is a scarcity of installed capacity ~10%
- Due to the highly increasing demand growth rates
- Results in a demand-supply gap
- In-built function to cover gap in capacity
- Gas CCGT power plants of specific capacity is added
- The model checks for demand covering, and then makes the addition
- 20-50 MW of capacity for each power plant added

Capital Stock in Energy Economics

- Total amount of a company/ firm’s capital
- Can be economically termed as the ‚Wealth’ of an energy system
- ‘Anlage Vermögen’
- Represents the invested capital
- Considers the economic and technical lifetimes of the assets
- Normally used for asset evaluation : Historical cost concept
- Historical cost concept : does not consider replacement values over time
- Leads to an under-evaluation of long term assets
- Highlights preservation of long lasting assets over nominal capital
- Information on investments of each power plant : very difficult to obtain

Gross Capital Stock

- Based on only the replacement values of power plants
- No depreciation is included
- Better measure of asset value than historical acquisition values
- Forms the basis for the net capital stock calculations

Net Capital Stock

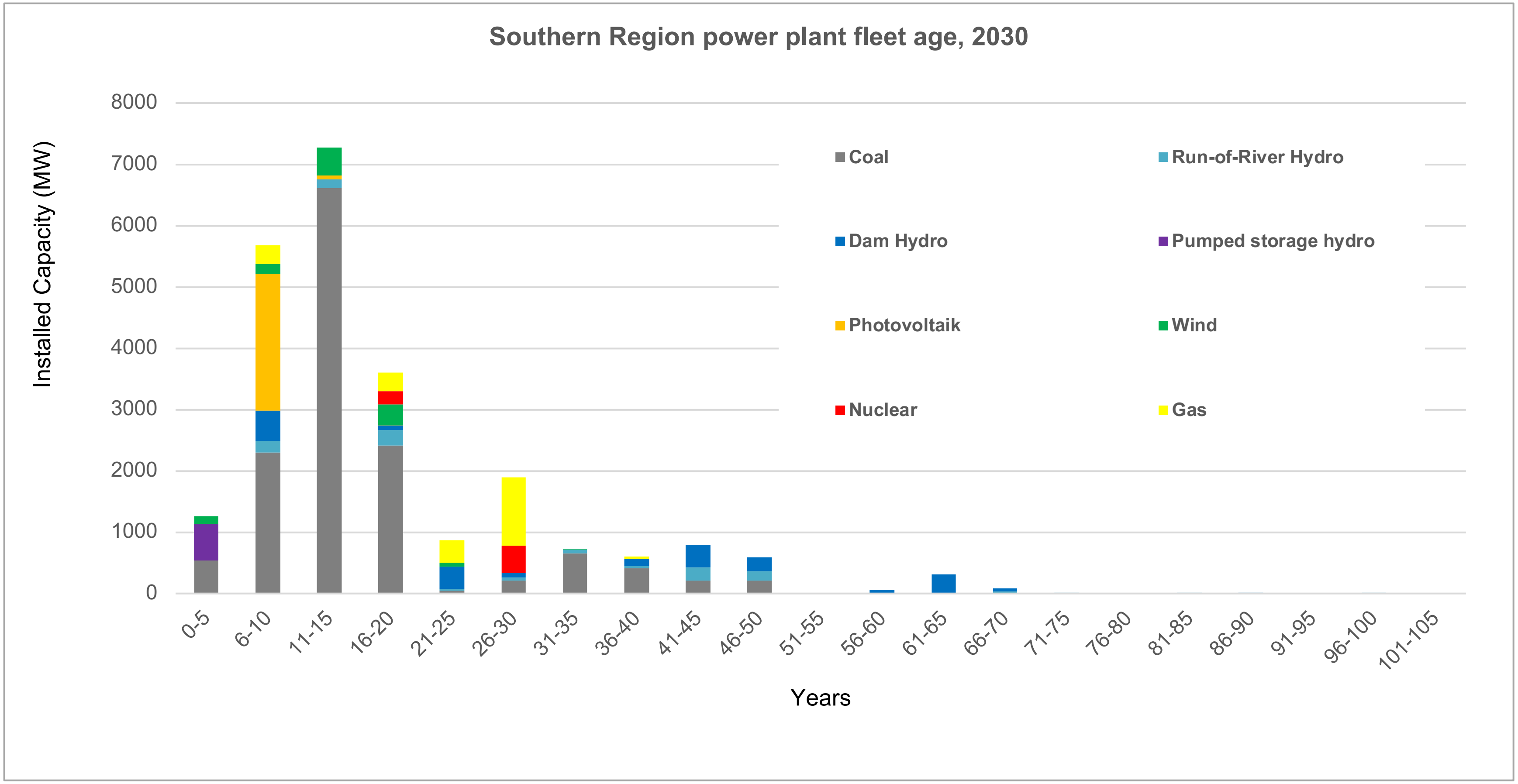
- Replacement values for power plants with consideration of depreciation over the life time of the power plant
- Depreciation : decrease in the worth of an asset due to ageing
- Gives an actual and fair measure of the value of the system’s invested capital
- Technical life times and economic life times
- Book keeping: normally with economic life time
- High capital intensity and high technical lifetimes : greater worth

Technical and Economic lifetimes

Power Plant Type	Economical Life Time	Technical Life Time
Biomass	20	25
Lignite	20	25
Gas Turbine	40	45
Gas CCGT	30	35
Bituminous Coal	45	50
Nuclear BWR	50	60
Nuclear CANDU	50	60
Nuclear Thorium	60	80
Oil	40	45
PV	25	30
Pumped Storage	60	100
Dam Hydro	60	100
Run of the River Hydro	75	100
Wind Onshore	25	30

When a power plant has a specific shut down date other than the end of its technical/ economical useful life, the shut down date is considered

Capital Stock intensive planning

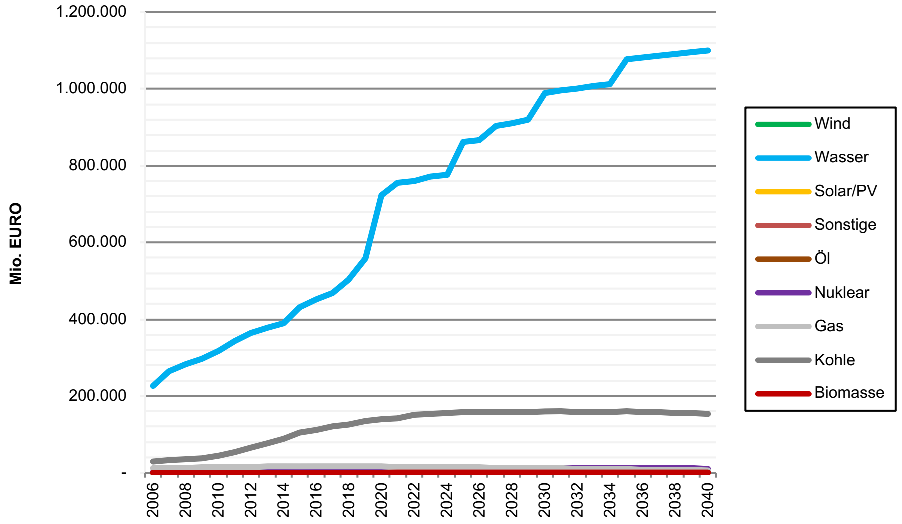


Capital stock intensive planning

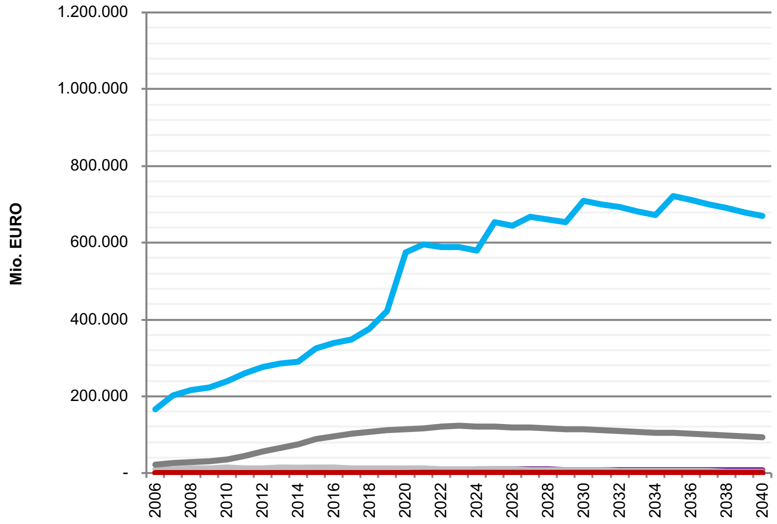
- Focus on Net Capital Stock of the futuristic fleet
- Building more hydro power plant capacity than VRE
- VREs are capital intensive and have shorter life times
- Hydro power plants: Capital intensive and large life times
- Also nuclear power : Capital intensive and relatively larger life times
- Considering Financial challenges
    - Focus on smaller run of river hydro investments
    - Improve nuclear capacity
    - Investments in neighbouring countries with high hydro potential

Historical acquisition values vs Replacement values, (All Regions)

Value of power plant fleet (Net Capital Stock)

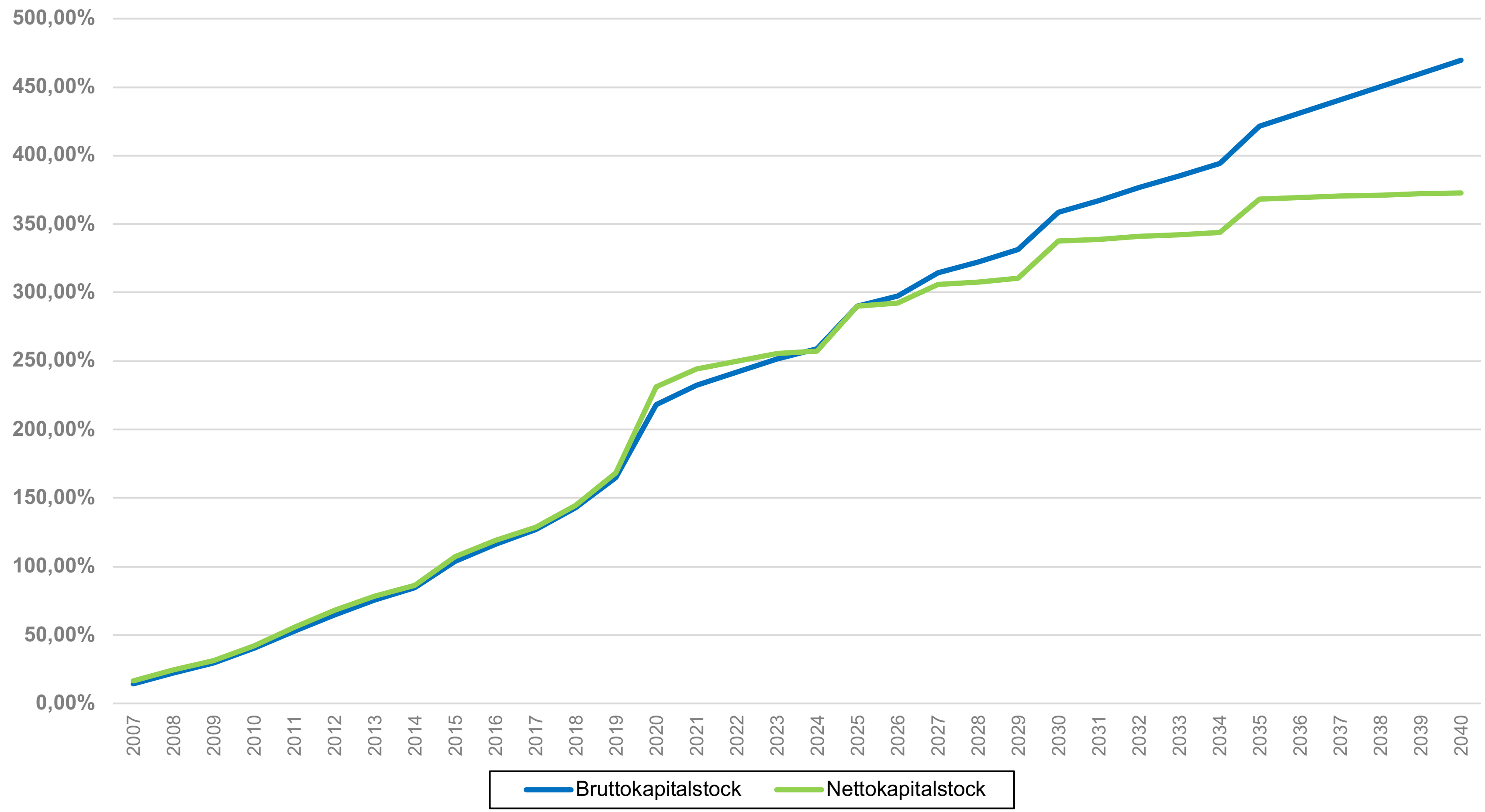


Replacement values

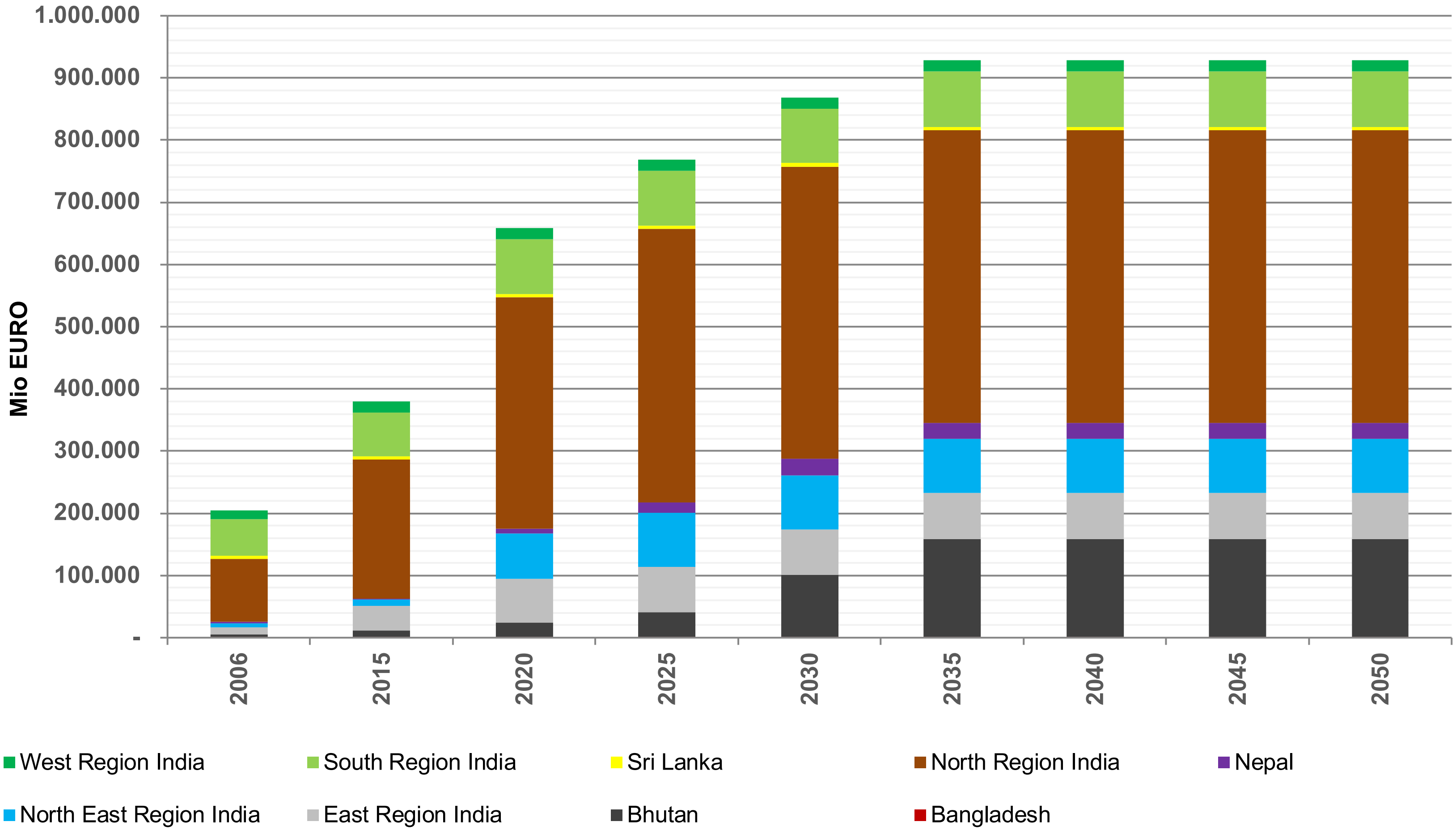


Historical Acquisition Values

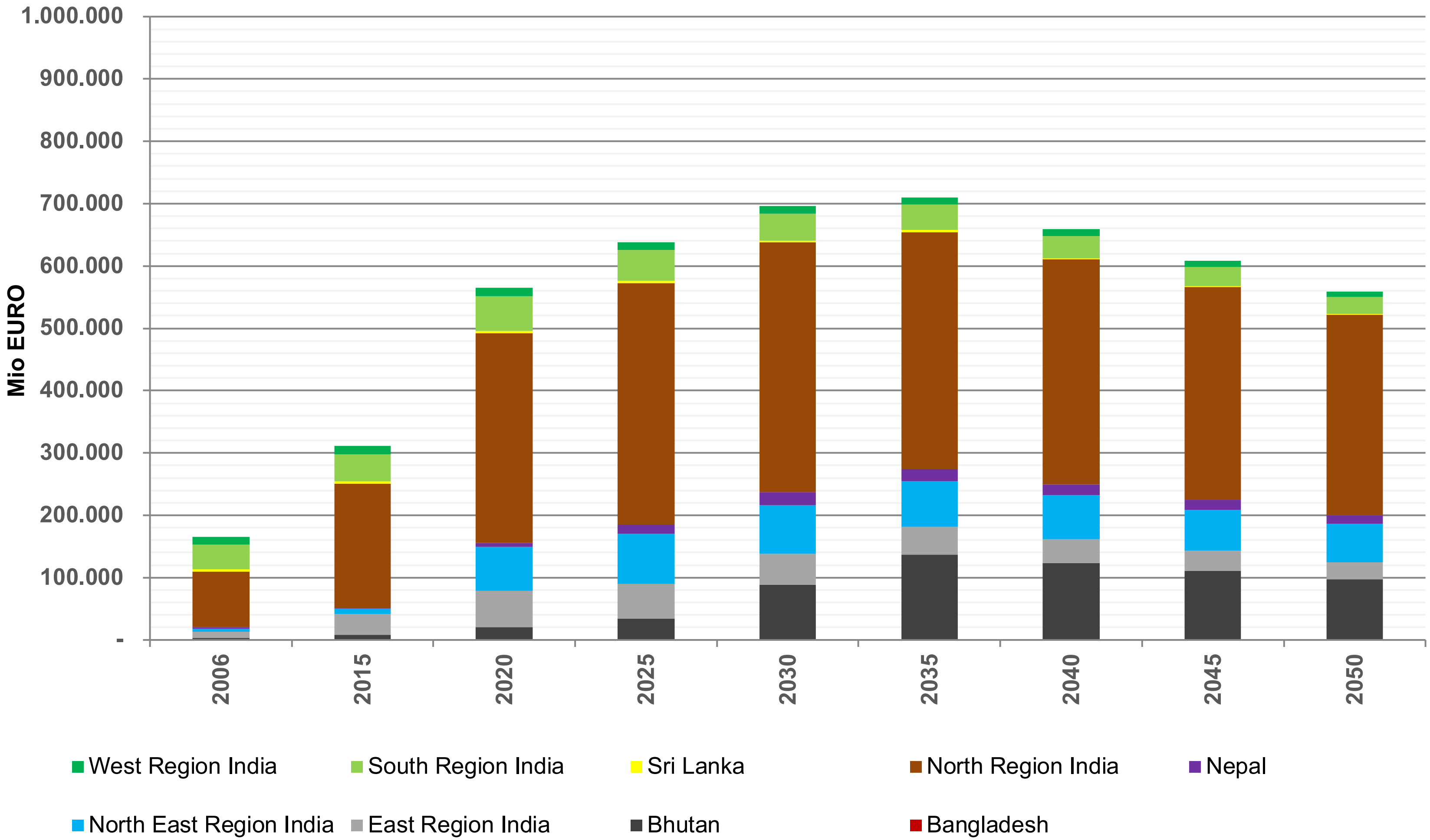
Increase: Gross and Net capital stock in % (all regions)



Results : Gross Capital Stock Regions

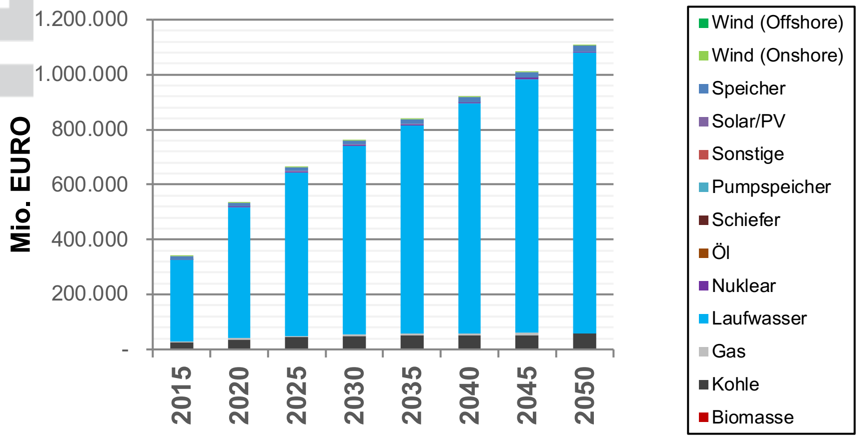


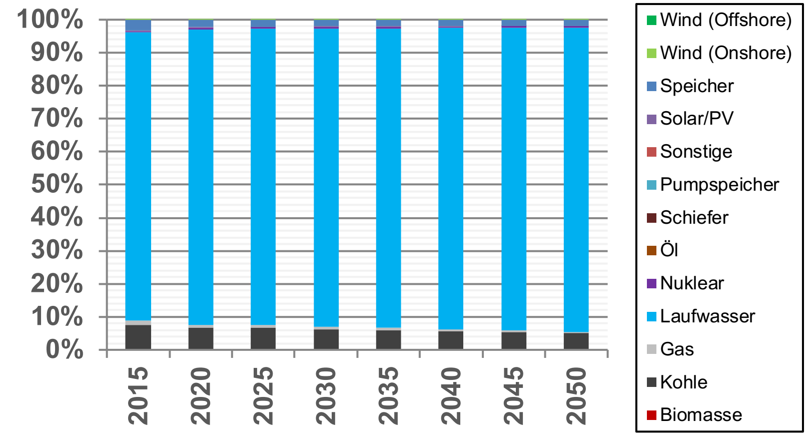
Results: Net Capital Stock Regions



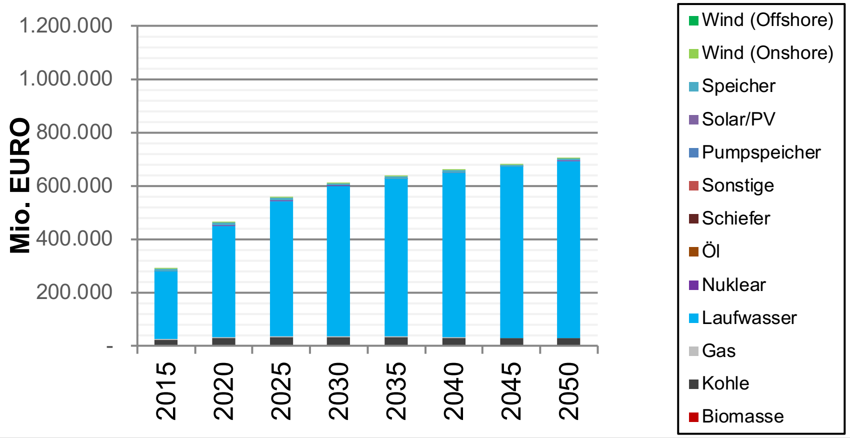
Results : By technology types, NR

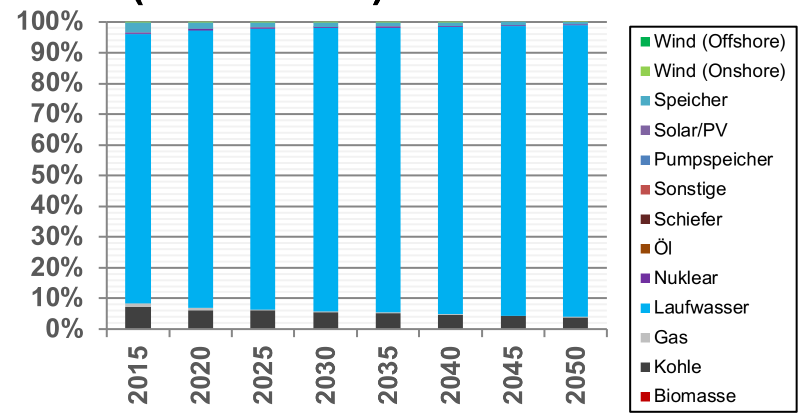
GROSS CAPITAL STOCK (Bil. EURO)





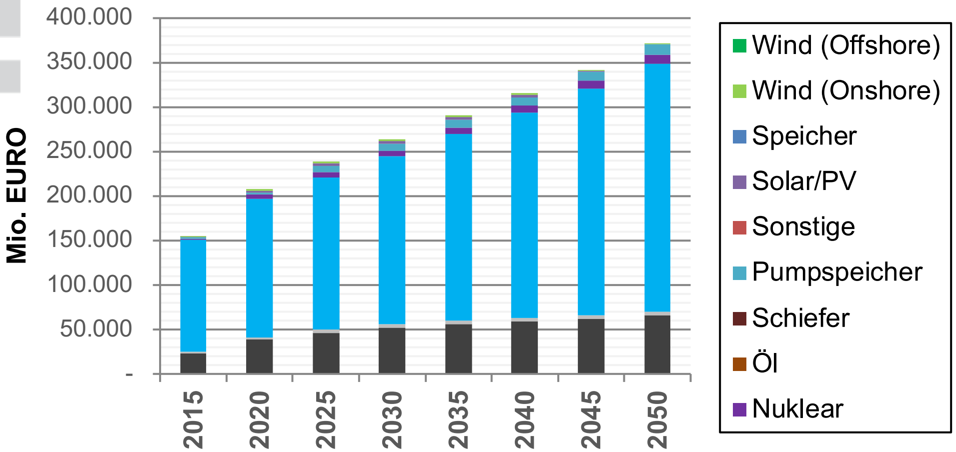
NET CAPITAL STOCK (Bil. EURO)

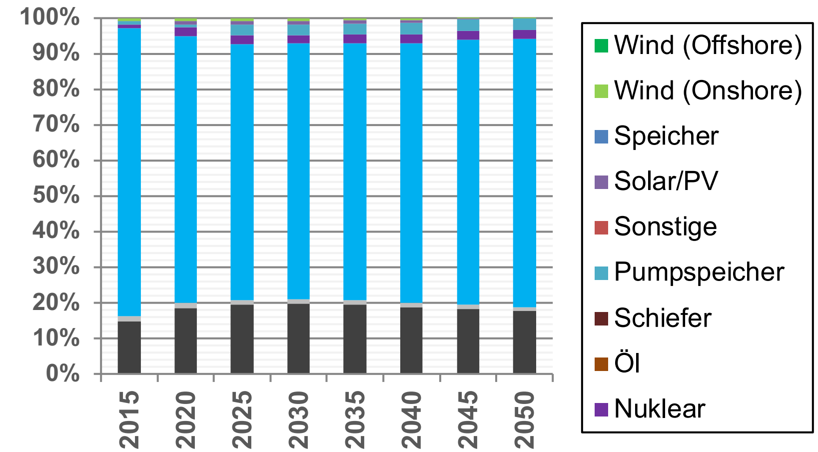




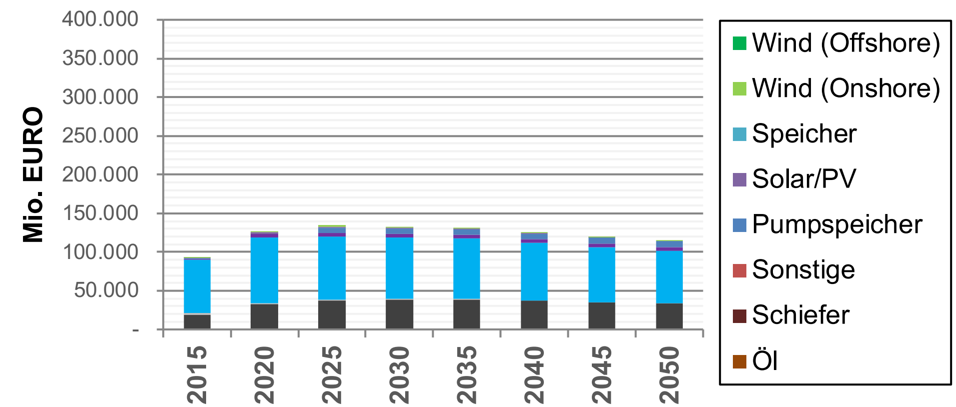
Results : By technology types, SR

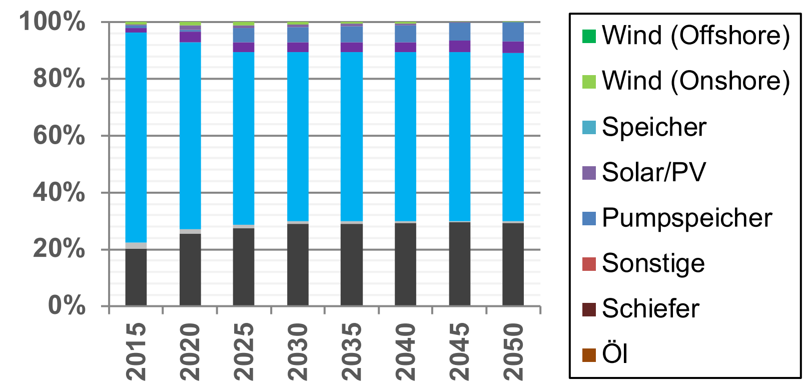
GROSS CAPITAL STOCK (Bil. EURO)



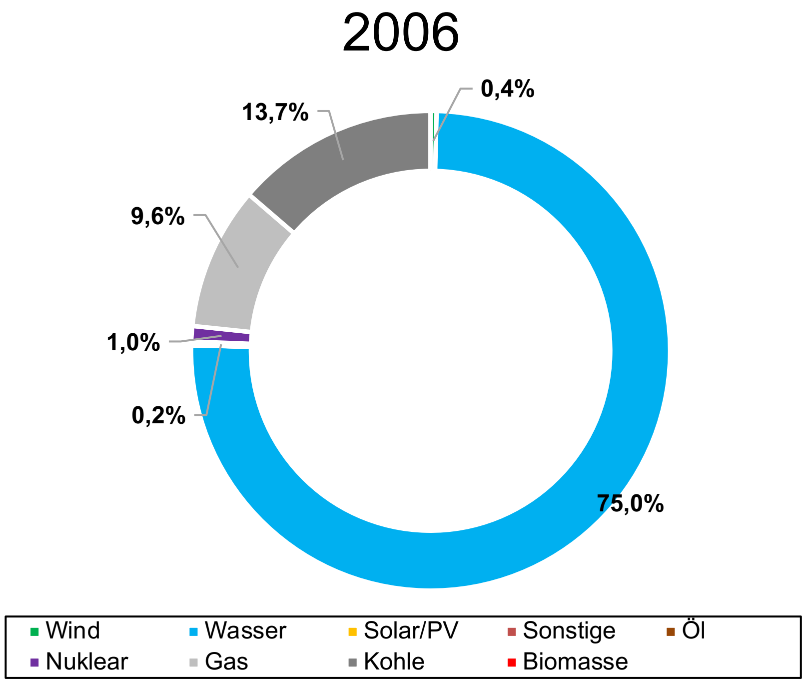


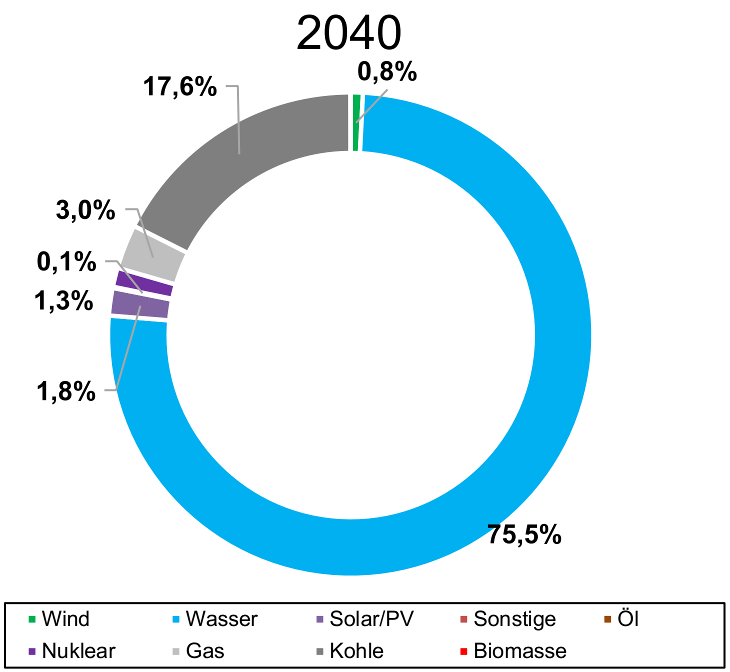
NET CAPITAL STOCK (Bil. EURO)



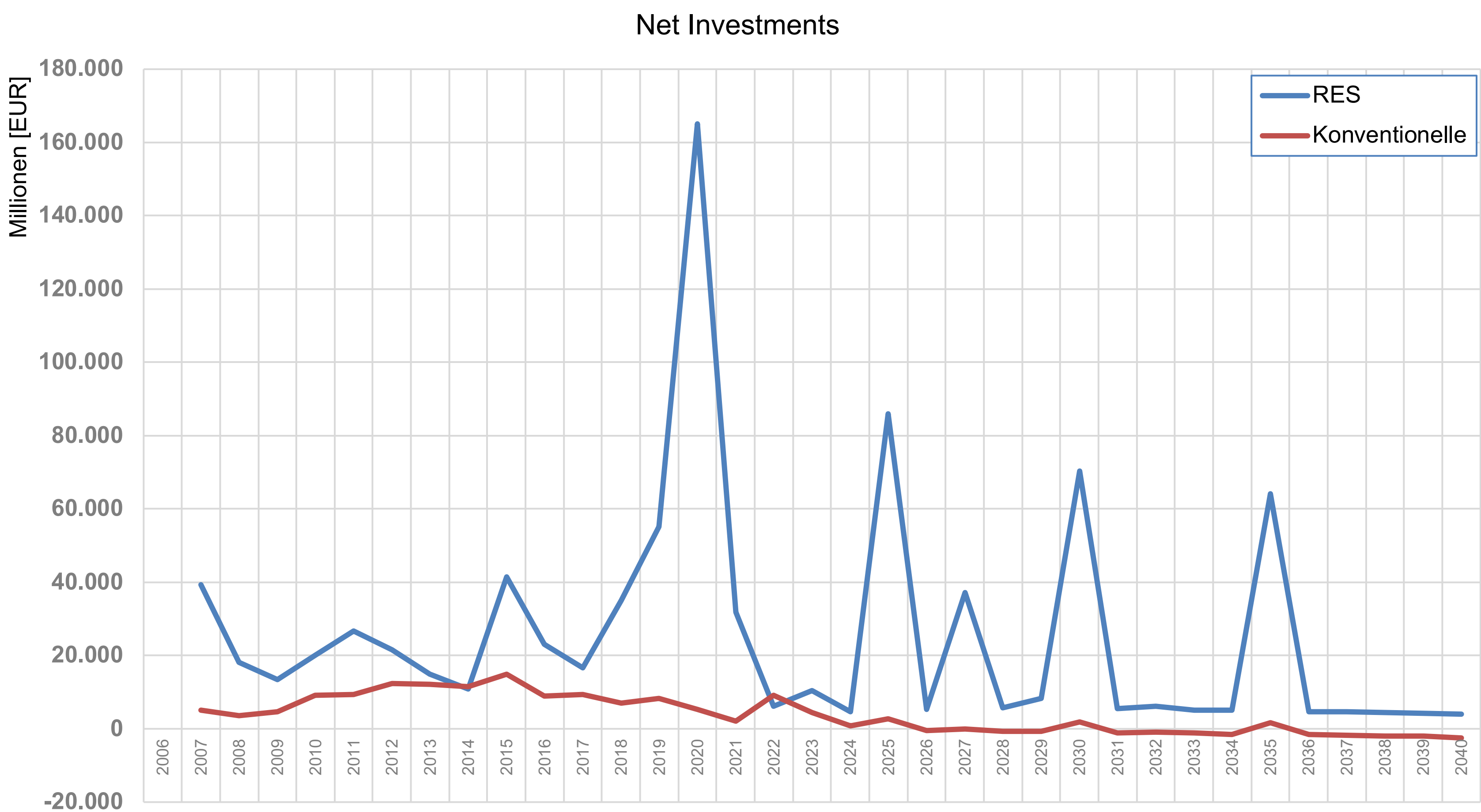


Depreciation values

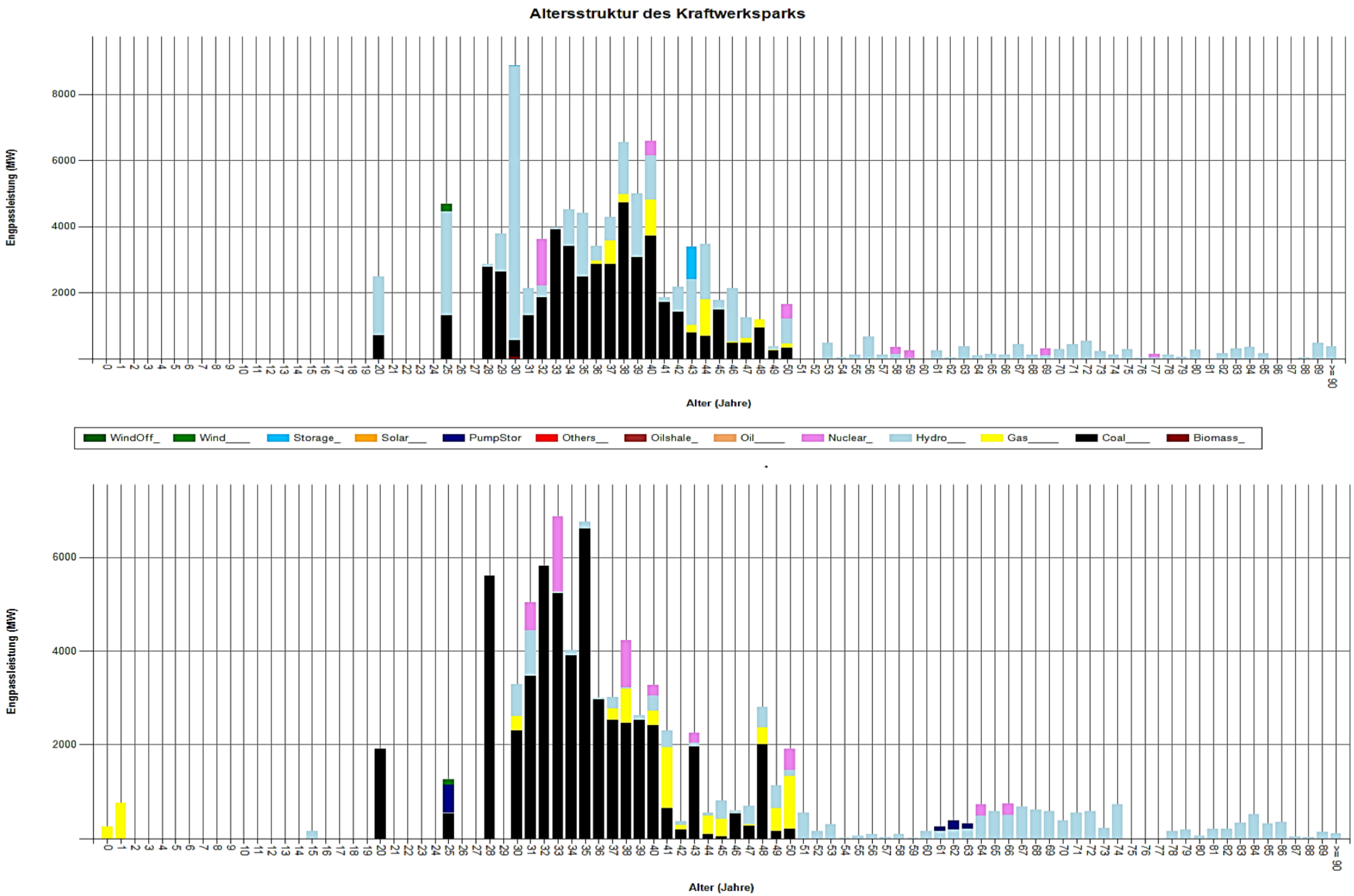




Investment over the years



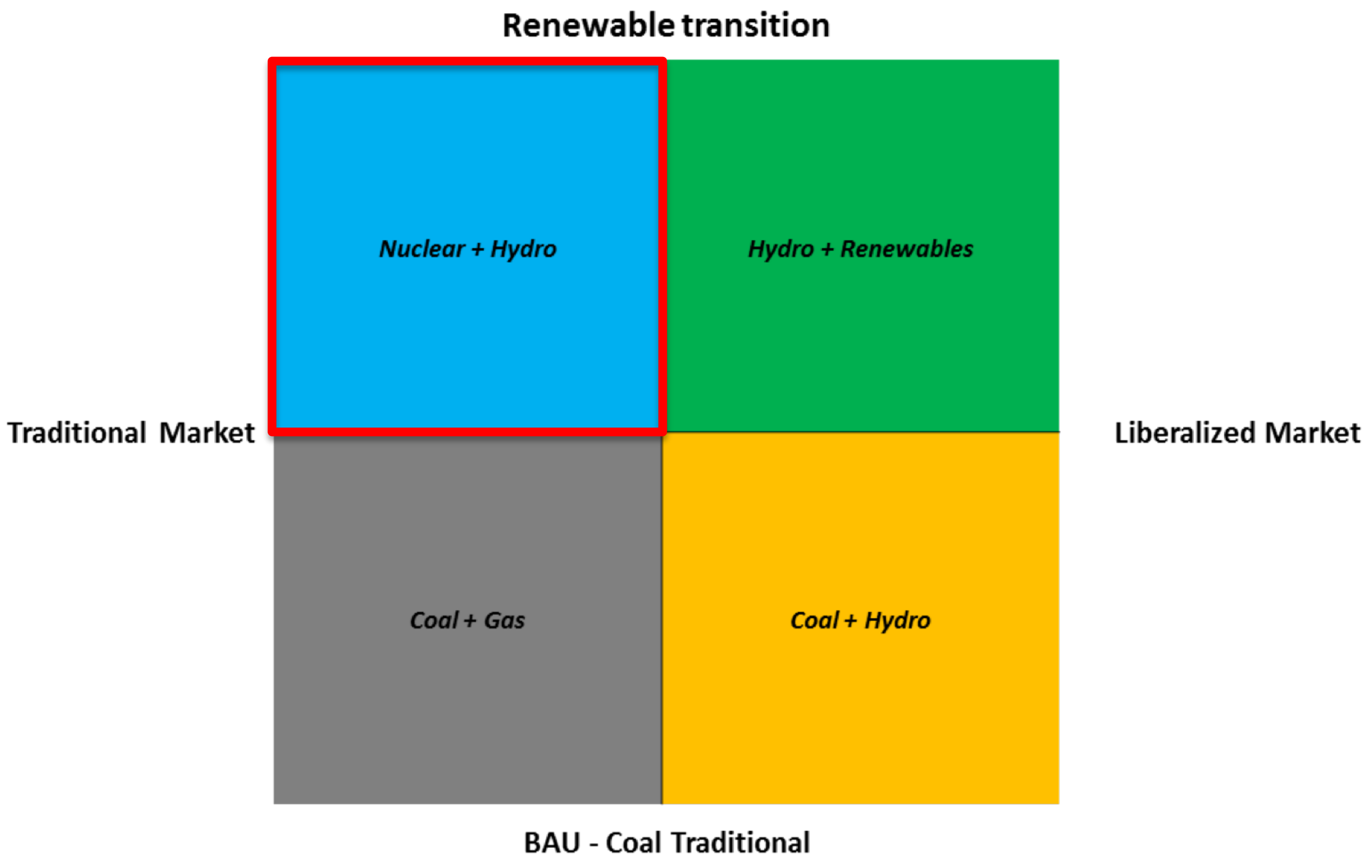
Power plant age 2050



NR

SR

Best Case Scenarios



Conclusions

- Transition towards carbon free energy : Possible goal
- Focus on technologies with high capital and large lifetimes
- Increase of hydro power capacity and nuclear capacity
- Longer life times : Inter-generational benefits from investments
- Small run of river hydro power plants must be encouraged
- Blind investments in PV and Wind : Shorter lifetimes, could lead to asset stranding
- Avoid short term visions : think long term sustainability

Danke für Ihre Aufmerksamkeit!

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