The Role of Nuclear in European Scenarios aiming at lowering GHG Emissions

By Prof. P. Capros
E3MLab/NTUA

PRIMES Energy System model for the EU

- Market oriented energy demand and supply model for all European countries and their bilateral trade
- Economic and engineering oriented model
- Modular and detailed by sector and market
- Power generation model includes
  - Endogenous investment with distinction between greenfield investment, on-site investment, retrofitting and extension of lifetime
  - Economies of scale and learning
  - Non linear cost-supply curves for fuel and resource potentials
  - Grid representation and endogenous electricity trade

Baseline Scenario for the EU - end of 2007

http://ec.europa.eu/dgs/energy_transport/figures/trends_2030_update_2007/index_en.htm

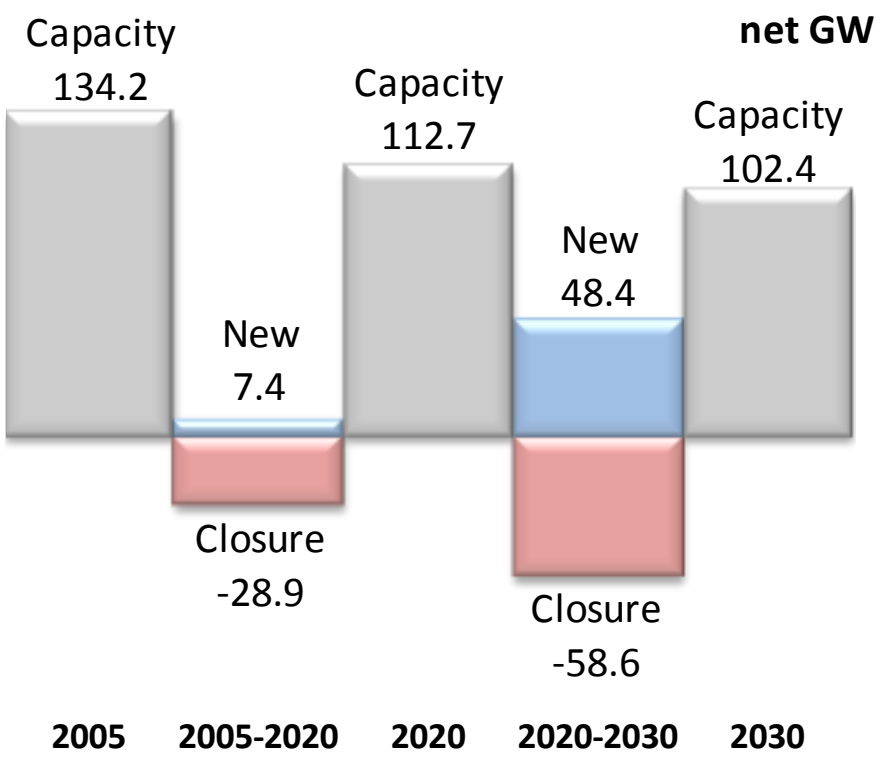
- ***Analysis carried out by NTUA by using the PRIMES energy system model***

- Assumptions
  - Strong Economic Growth
  - Moderate Oil and Gas prices
  - No new climate policies, other than Kyoto
  - Energy Efficiency driven by economics
  - Continuation of current (2006) nuclear policies in the Member-States

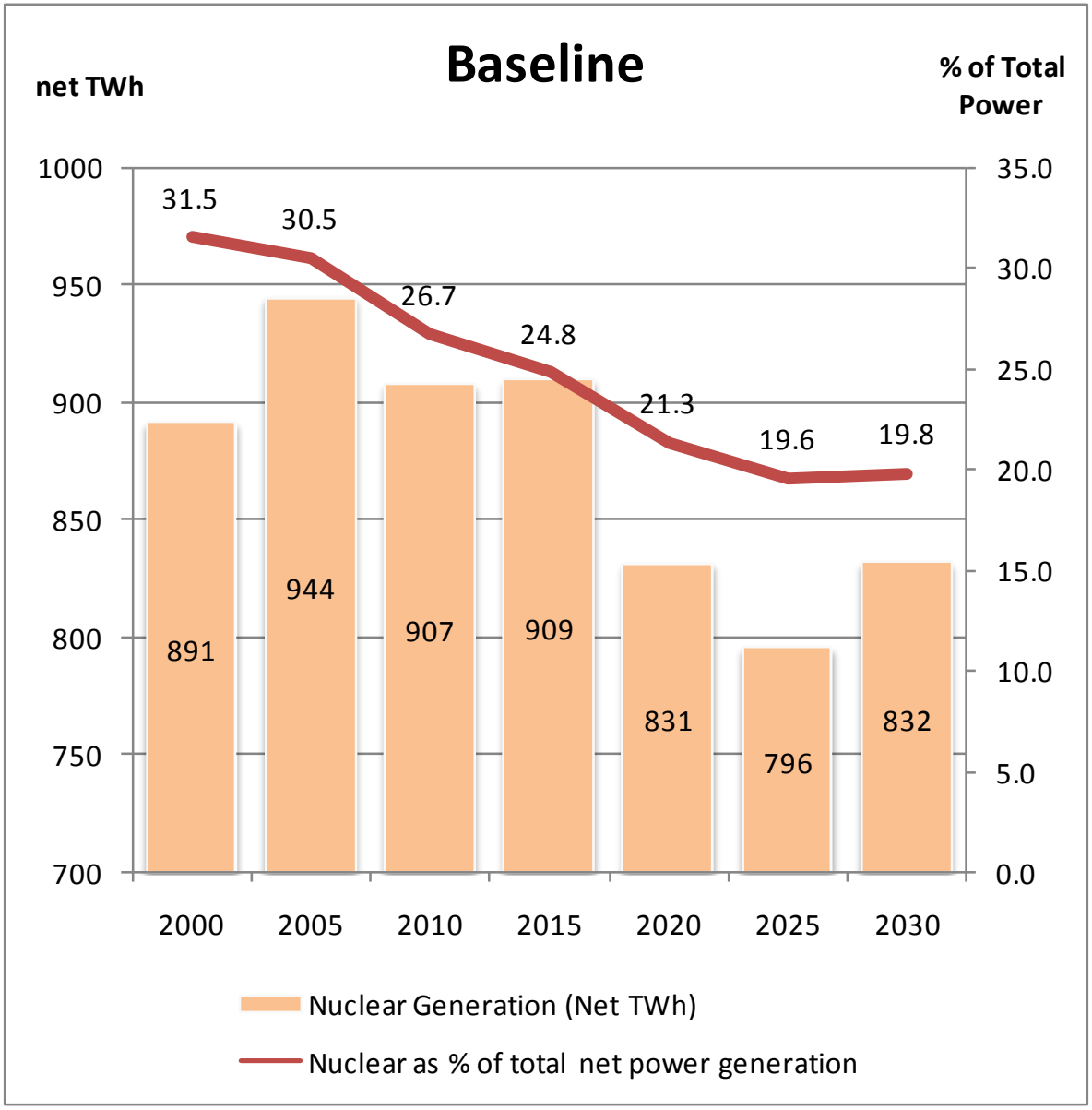
Assumptions about Nuclear in Baseline

- *Nuclear Phase-out:*
  - Belgium, Germany, Sweden (but only after already decided extension of lifetime)
- *No Nuclear Power:*
  - Austria, Cyprus, Denmark, Estonia, Greece, Italy, Ireland Latvia, Luxembourg, Malta, Portugal
- *Possible Nuclear Investment but no extension of lifetime of old plants (40 years or otherwise provided in the plant's license):*
  - Bulgaria, Czech Republic, France, Finland, Hungary, Lithuania, Poland, Romania, Slovakia, Slovenia, Spain, UK
- *Early Decommissioning of Nuclear plants in new MS before 2010:*
  - Bulgaria (1760 MW), Lithuania (2600 MW), Slovakia (880 MW)
- *Confirmed Decisions about Commissioning new Nuclear plants:*
  - Bulgaria (2000 MW, 2020-2025), Finland (1600 MW, 2015), France (1600 MW, 2015), Lithuania (1600 MW, 2020), Romania (706 MW, 2010)

Nuclear Capacity of EU27 in Baseline

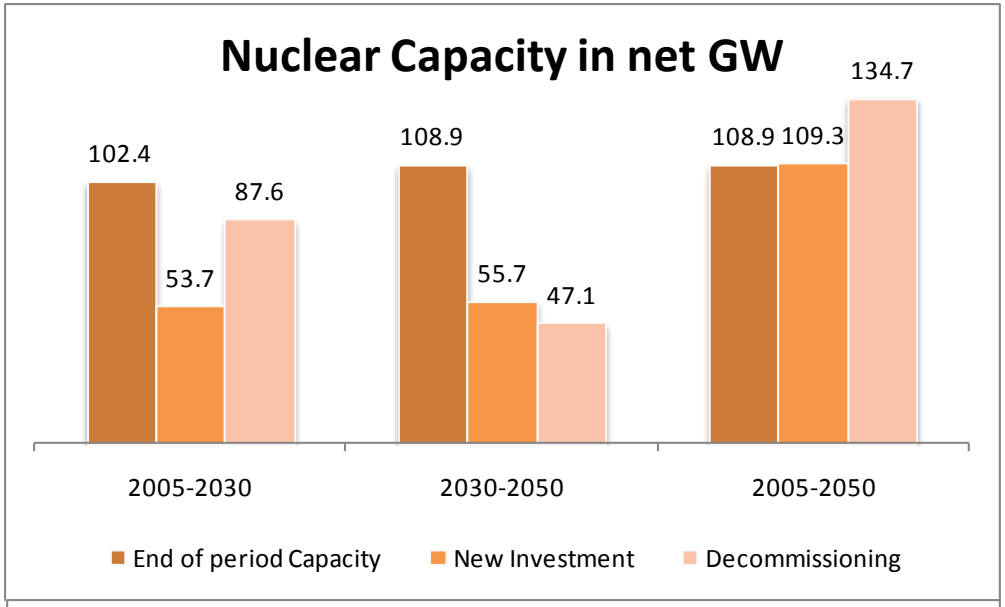


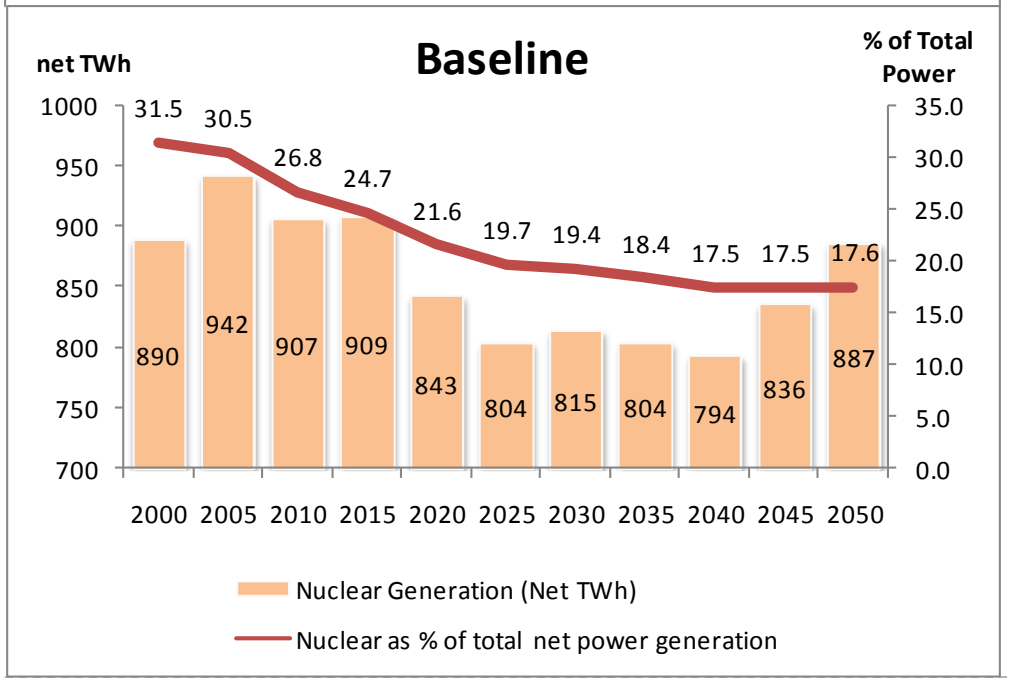
- 87.5 net MW or 65% of current nuclear capacity is projected to stop operation until 2030, of which 20 MW because of nuclear phase out policy and the rest because of no extension of lifetime
- New nuclear investments of 48.4 net MW are found to be economic under the baseline assumptions
- Nuclear operating capacity by 2030 will be 25% lower than today



Nuclear Energy in Baseline

- Because of decline of nuclear capacity power generation from nuclear decreases over time and despite new investment it is 12% lower in 2030 compared to 2005
- The share of nuclear power in total power generation drops continuously and stabilises at roughly 20% in 2030, down from 30.5% in 2005





Baseline Scenario up to 2050

- The entire nuclear capacity as available today will be decommissioned until 2050
- The model projection finds economic (under baseline conditions) to invest in new nuclear capacities some 55.7 new GW between 2030 and 2050
- Operating capacities by 2050 are higher than in 2030 but remain 6% below today capacity
- The share of nuclear power in total power generation drop even further reaching 17.5% in 2050

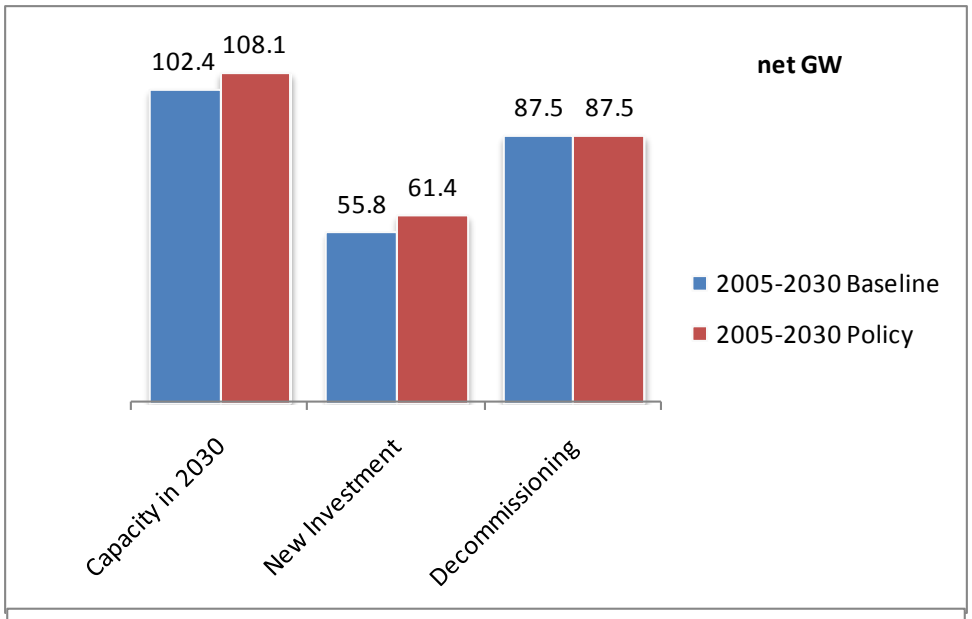
New EU Policy: Climate Action and Renewables Package (20-20-20)

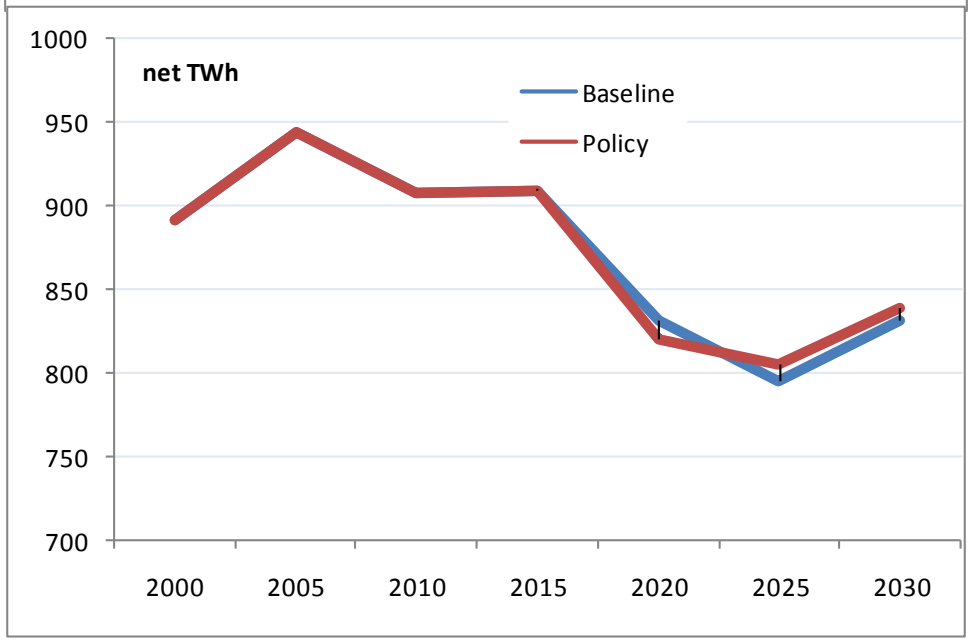
Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables

By P. Capros, L. Mantzos, V. Papandreou, N. Tasios
- *Primes Model – E3MLab/NTUA*
- June 2008

http://ec.europa.eu/environment/climat/climate_action.htm

- Targets
  - Reduction of GHG Emissions by 20% in 2020 compared to 1990
  - RES share in total energy consumption by 2020 at least 20%
  - Biofuels 10% of liquid transportation fuels
  - (Indicative) 20% Energy Efficiency
- Assumptions about Nuclear Unchanged from Baseline scenario
  - Phase-out takes place in Germany and Belgium
  - New nuclear investment not allowed in several Member-States, as in the Baseline
  - Rest of countries are projected to invest in new nuclear capacity on economic basis, given the new conditions (EU ETS price, Renewables share high)
  - No extension of nuclear plant lifetimes
- The analysis goes up to 2030 by assuming enhancement of Climate Action (-30% in 2030) and RES targets (25% in 2030)
- Forecasted EU ETS price: 40 €/tCO2 in 2020 and 48 €/tCO2 in 2030





Climate Action and RES scenario

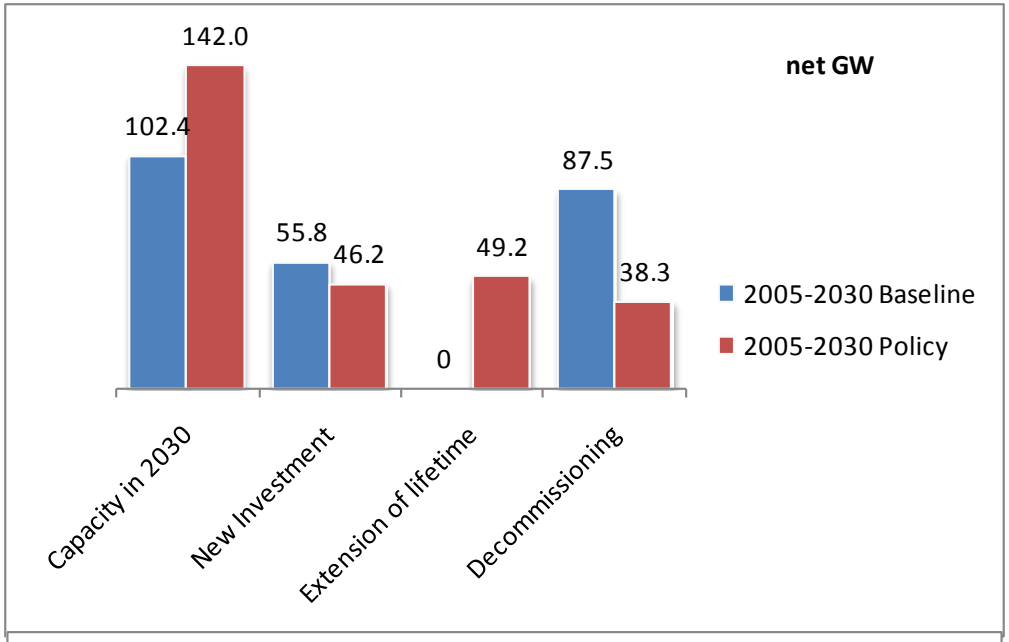
- Roughly 6 GW additional nuclear investment implied by the Climate Action and RES policy assuming baseline nuclear policies
- Nuclear power generation increases only by 1% in 2030 relative to Baseline and reduces slightly in 2020 as a result of reduced electricity demand
- The RES policy target is not responsible for low additional nuclear development as sensitivity analysis has shown, the main reason being the assumption about nuclear policies

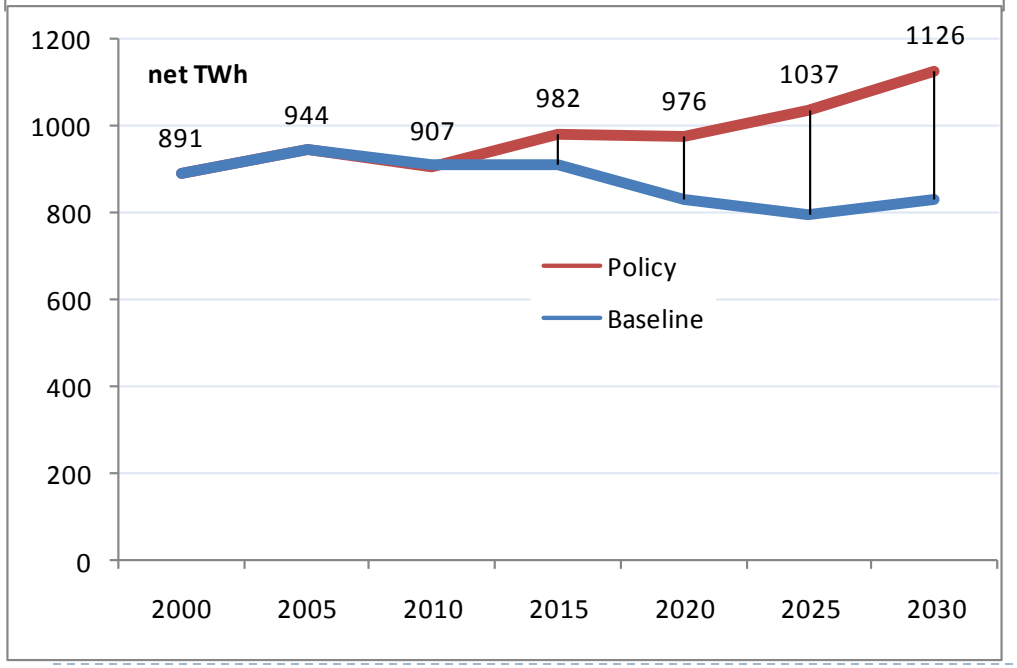
What-if nuclear policies change and the Climate Action and RES policy is pursued

New Assumptions

- Germany: No phase-out, no permission for new investment, extension of lifetime
- Belgium: No phase-out, possibility to invest one additional unit, extension of lifetime
- France: Extension of lifetime and possibility to invest
- UK: Extension of lifetime possible only for very few old plants, larger possibility for new investment than in the Baseline
- Spain: Extension of lifetime, larger possibility for new investment than in the Baseline
- Italy: possibility to operate nuclear plants from 2025 onwards
- Czech Republic, Slovakia, Slovenia, Poland, Lithuania, Bulgaria, Romania, Finland: few changes from the Baseline
- Netherlands: larger possibility to invest beyond 2025
- Countries that today do not envisage nuclear continue not to allow new nuclear investment

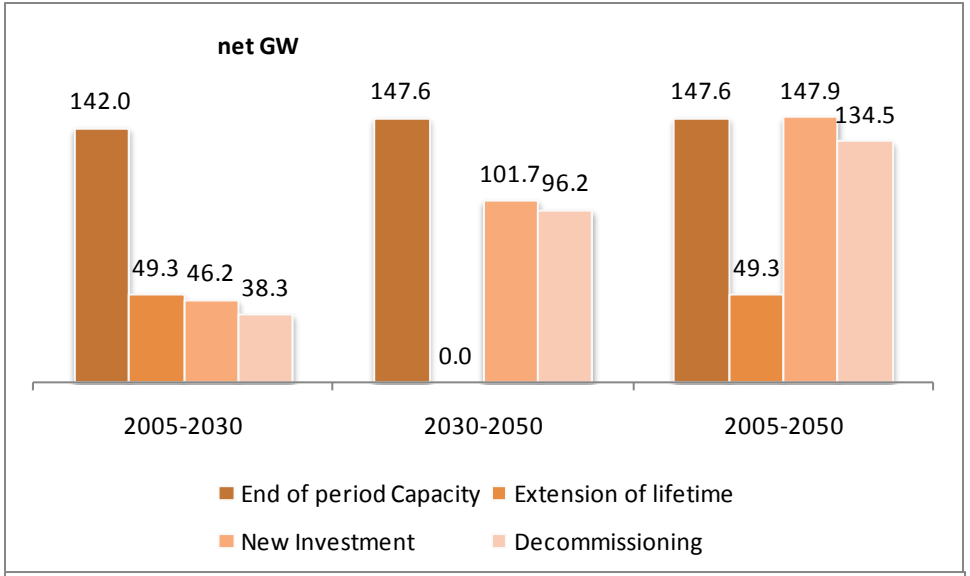
NOTE: all assumed new possibilities for investment are not imposed but are results of model-based economic decisions

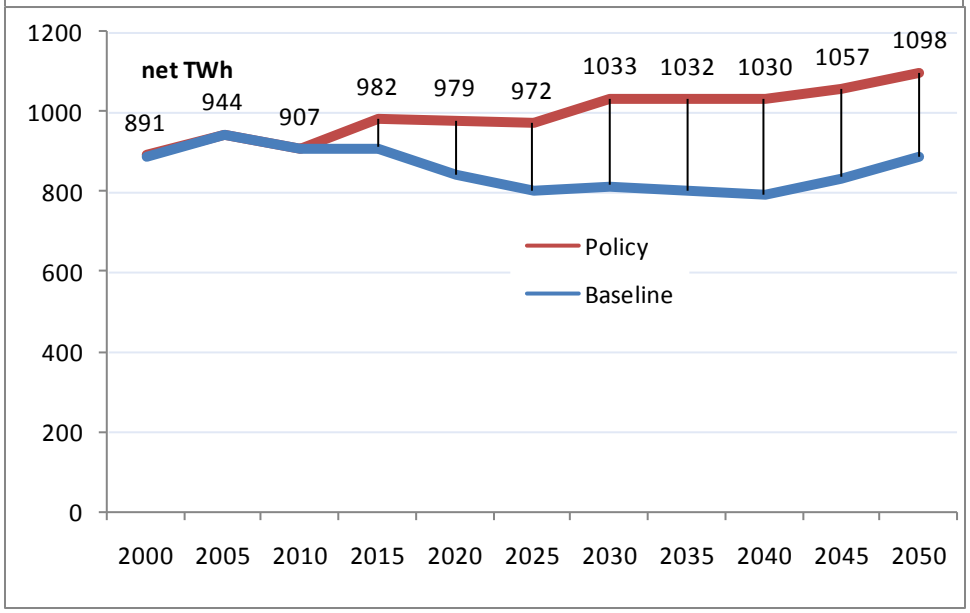




New nuclear policy context and same Climate Action and RES targets

- Operating nuclear capacity in 2030 becomes slightly higher than today's (6%)
- New nuclear investment is lower than in Baseline, because of 49.2net GW of plants extending their lifetimes
- Power generation from nuclear increases over time being in 2030 35% up from Baseline
- The share of nuclear in power generation remains in 2030 (27.1%) below that of today
- The additional nuclear lowers the EU ETS price in 2030 at 36 €/tCO_2 instead of 48 €/tCO_2 in the absence of new nuclear policy. This reduces total compliance cost.





- Climate Action in 2050 : -60% from 1990
- RES target in 2050 : 25% of total energy

Extrapolation to 2050 under ambitious Climate Change and RES targets

- Operating capacity in 2050 increases marginally from 2030, owing to massive decommissioning between 2030 and 2050 as the new nuclear investment program during that period has a considerable total volume (about 100 net GW)
- In the period 2030-2050 new nuclear competes against new CCS coal
- Total power generation from nuclear increases at a slow rate between 2030 and 2050, well above the Baseline scenario. However, the share of nuclear in 2050 is 23% down from 30.5% in 2005.
- See the EURELECTRIC Role of Electricity project for more details (performed with the PRIMES model)

Conclusions

- If current nuclear policies continue in the future, nuclear will decline and will play a minor role within the Climate Change and RES policy
- Even if considerable changes in current nuclear policies take place it is rather unlikely that nuclear energy develops by 2030 at a level higher than today
- Extension of lifetime, if possible, plays a significant role and also moderates total investment in new nuclear plants, easing the nuclear contribution
- Nuclear development beyond 2020 and mainly beyond 2030, even without significant increase from nuclear today level, is of utmost importance to reduce compliance costs associated with more ambitious climate change mitigation targets

Caveat: only conventional and currently known nuclear technologies are considered in the model-based analysis