

# An Energy System Road Map towards Very Low Carbon Emissions

Professor Pantelis CAPROS  
E3MLab National Technical University of Athens

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# Climate Change Mitigation Targets

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- ▶ Limiting global temperature rise at 2° C requires drastic reduction of CO<sub>2</sub> emissions
- ▶ The EU issued Directives with mandatory targeting for 2020: - 20% for GHG (-21.5% for ETS with full auctioning of emission allowances), 20% for Renewables, 20% for energy efficiency (optionally for the time being)
- ▶ The GHG target will become -30% if Copenhagen summit is conclusive
- ▶ The USA, Japan, Australia and others make for the first time legal commitments for ambitious emission cuts
- ▶ For 2050, the 2° C commitment of the EU imply that the EU domestically has to cut energy derived emissions by 65 to 75% relative to 1990  
→ this a truly very low carbon energy system

# Use of E<sup>3</sup> models of E3MLab / NTUA

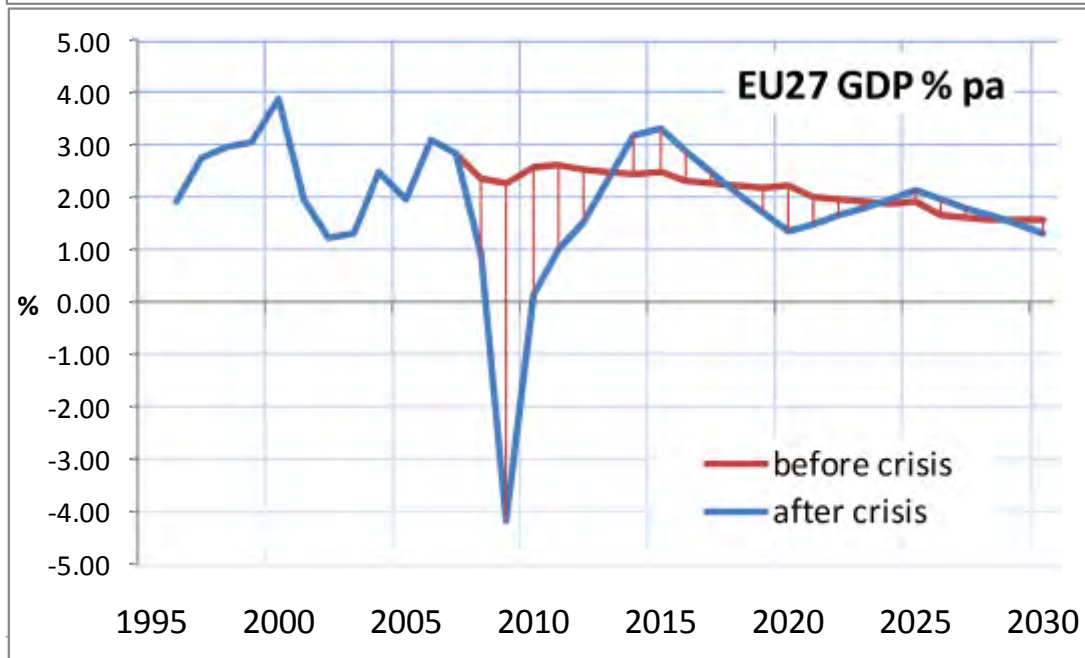
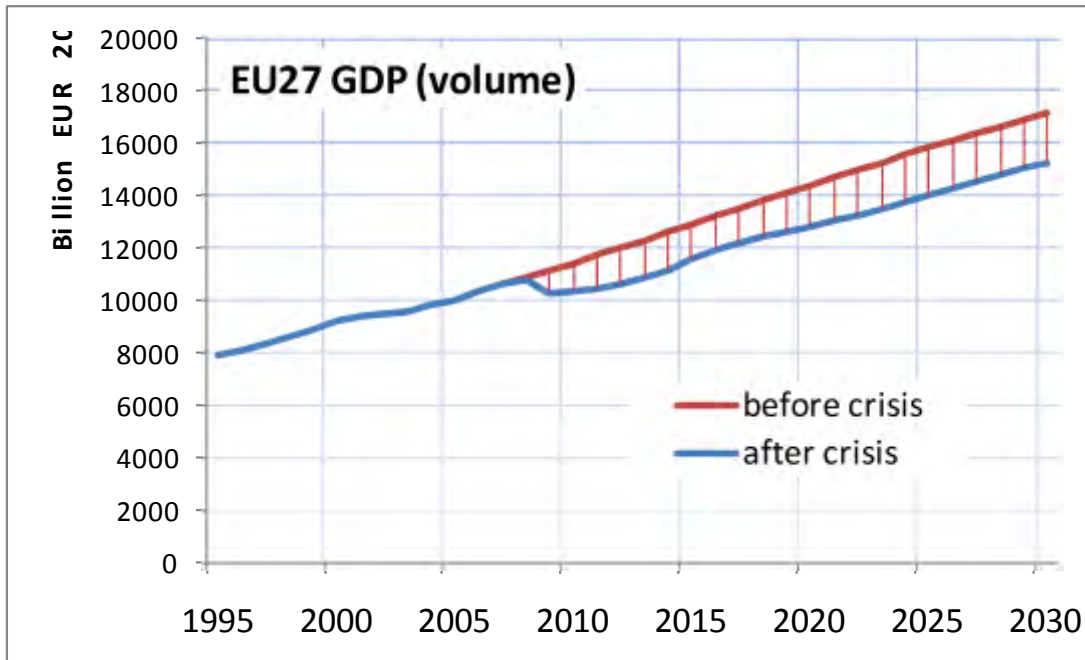
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1. PRIMES (energy system and markets of Europe 37 countries)
2. GEM-E3 (general multi-sector equilibrium for Europe and the World)
3. Prometheus (world energy system and markets with uncertainty)
  - ▶ Policy analysis and impact assessment of the 20-20-20 package and recommendations for effort sharing and targeting by member-state (2007-2008)
  - ▶ Scenarios as background material of Copenhagen summit
    - ▶ New Baseline Scenario for the EU after the economic crisis (Oct. 2009)
    - ▶ Impact assessment of a mandatory energy efficiency target
    - ▶ Ambitious targets within the context of global cooperation for climate change mitigation
  - ▶ EURELECTRIC - 2009
    - ▶ Road Map and sensitivities aiming at zero CO<sub>2</sub> from power generation by 2050, within the context of a -75% GHG target for the EU by 2050 and massive electrification of road transportation

# A post Crisis energy outlook

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- ▶ The economic crisis has significant downscale effects on energy consumption and carbon emissions
- ▶ The Climate Action and RES policy package of the EU (the 20-20-20 policy) has been defined before the crisis
- ▶ By using the PRIMES and GEM-E3 models, E3MLab is currently updating the energy-economy scenarios by including the effects of the crisis and the post-crisis economic developments
- ▶ The first results show that some new issues ought to be considered in the policy agenda



## Baseline 2009 vs. Baseline 2007

- Shaded area corresponds to permanent loss of real GDP
- Economic recovery after the crisis enables higher productivity gains, allowing faster growth rates between 2014 – 2018
- However, not enough to compensate for the losses
- Growth rate convergence in the long term

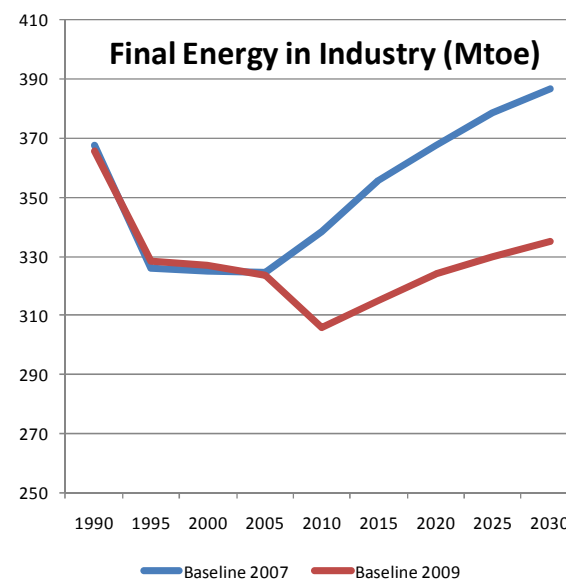
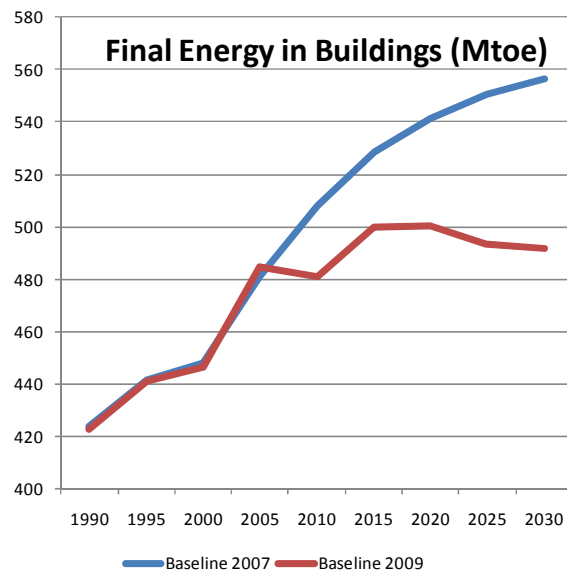
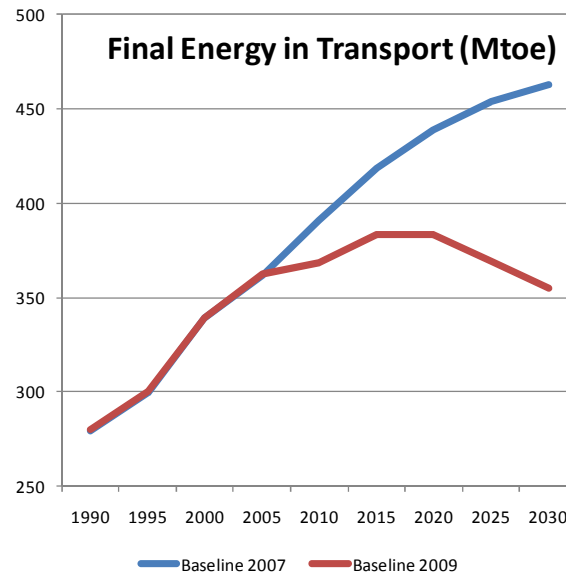
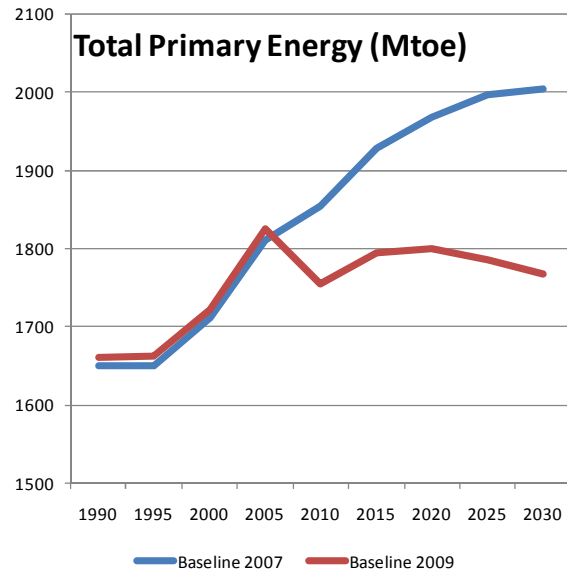
## ▶ Different policy context

- ▶ Baseline 2007 was reflecting business as usual trends incorporating rather weak policies for climate, energy efficiency and RES
- ▶ Baseline 2009 incorporates policies adopted up to Spring 2009
  - ▶ New EU ETS binding cap, including auctioning for getting allowances
  - ▶ A series of energy efficiency directives and regulations (buildings, lighting, appliances, ...)
  - ▶ Regulation on cars (specific emissions)
  - ▶ Strong RES supporting national policies
  - ▶ CCS demonstration plants
  - ▶ Nuclear revival in some countries (despite continuation of banning by others)

## **Baseline 2009 vs. Baseline 2007**

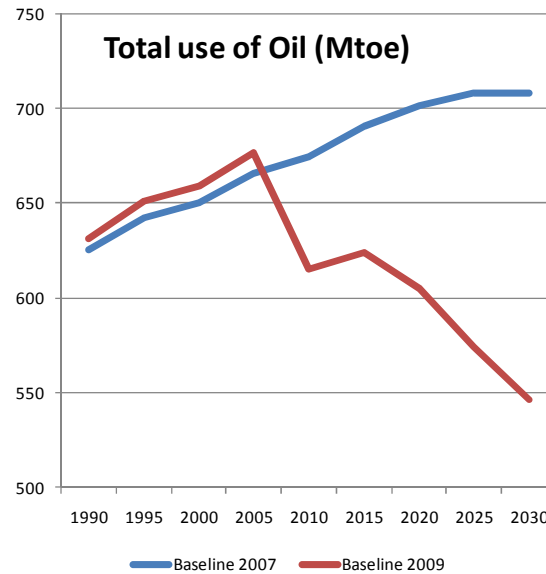
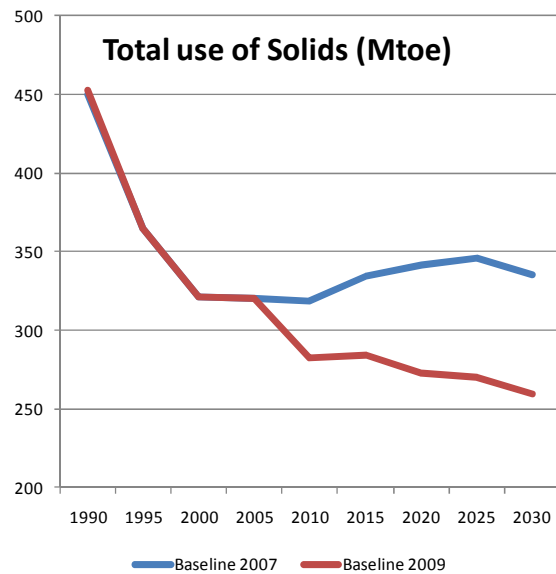
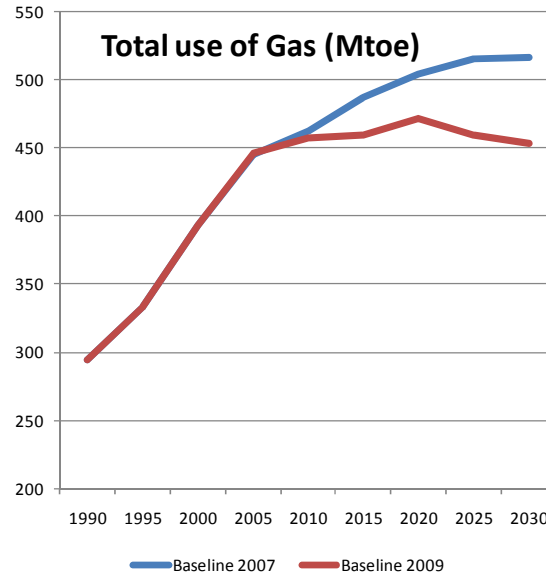
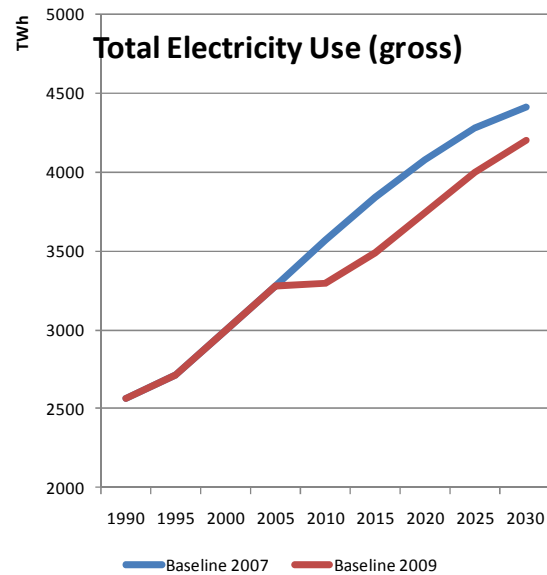
World energy prices are expected to increase in the period post crisis

The Baseline 2009 scenario involves a projection showing oil prices reaching 100 \$/bbl (in constant money) before 2030



## Baseline 2009 vs. Baseline 2007

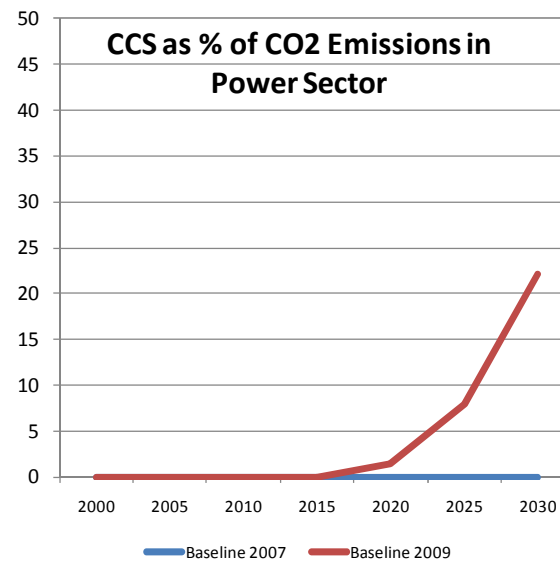
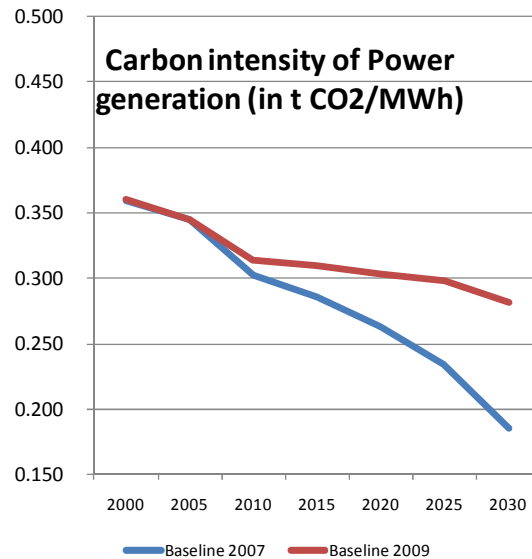
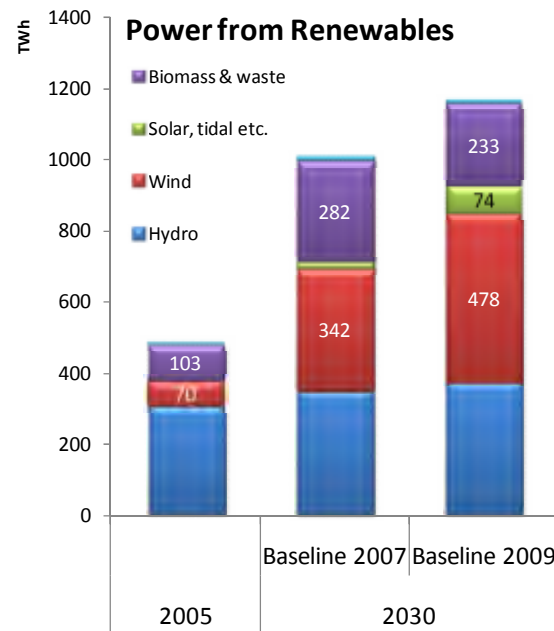
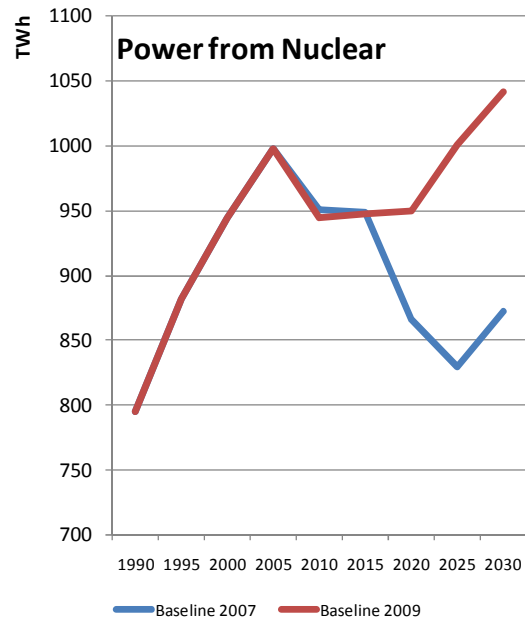
- Energy requirements are found reduced between 8 and 15% from Baseline 2007
- Obviously, the differences are not only due to the crisis but also to policies
- Total primary energy do not increase relative to 2005 in the Baseline of 2009
- Important reversal of past trends in transportation



## Baseline 2009 vs. Baseline 2007

- Demand for electricity slows down during the crisis period but its growth rate recovers post crisis (avg. growth 1% pa)
- Oil demand downturn starts during the crisis and continues owing to new efficient cars
- Gas demand is lower than expected in 2007, but gas overall preserves a significant market share
- Coal and lignite re-emergence, expected in 2007, is cancelled owing to higher RES and nuclear



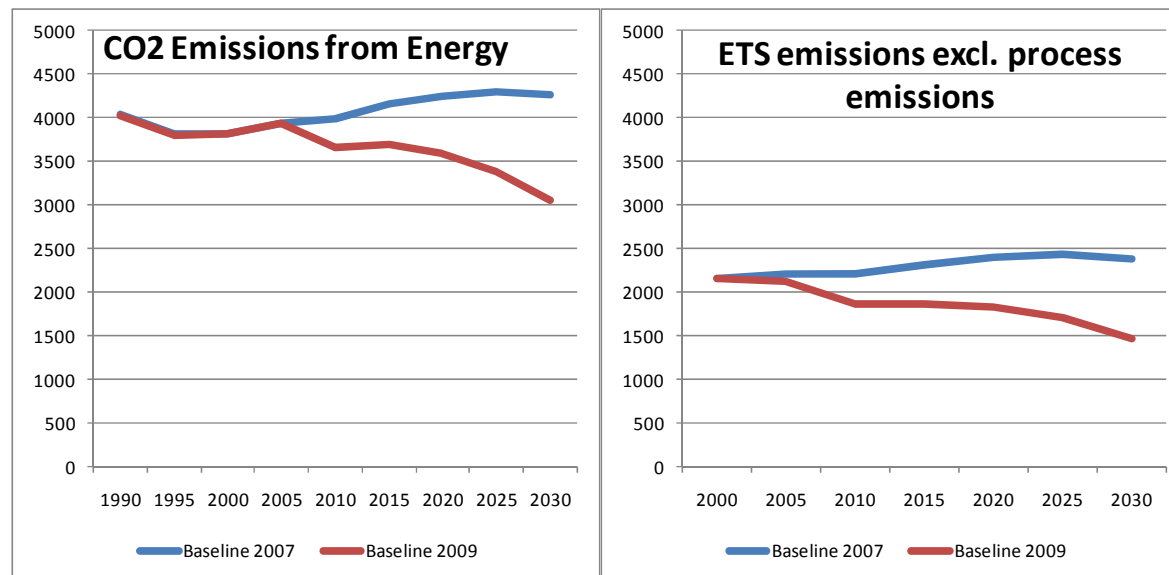


## Baseline 2009 vs. Baseline 2007

- The policies favouring RES, nuclear and CCS contribute to de-carbonization of power generation
- Power generation from nuclear is slightly larger in 2030 compared to 2005, but significantly higher than projections in 2007 (Germany and Belgium are assumed to pursue phase-outs)
- The new projection involves 50 GW of new solid fuel plants equipped with CCS

## ▶ ETS

- ▶ The projections of 2009 ensure that ETS emissions (plus limited use of CDM credits) just meet the ETS cap
- ▶ Carbon prices clearing the ETS market are found 20 €/t CO<sub>2</sub> in 2020 and 30 €/t in 2030
- ▶ These prices are significantly lower than the estimations performed end 2007 for the Climate and RES policy package (40-50 €/t)



## Baseline 2009 vs. Baseline 2007

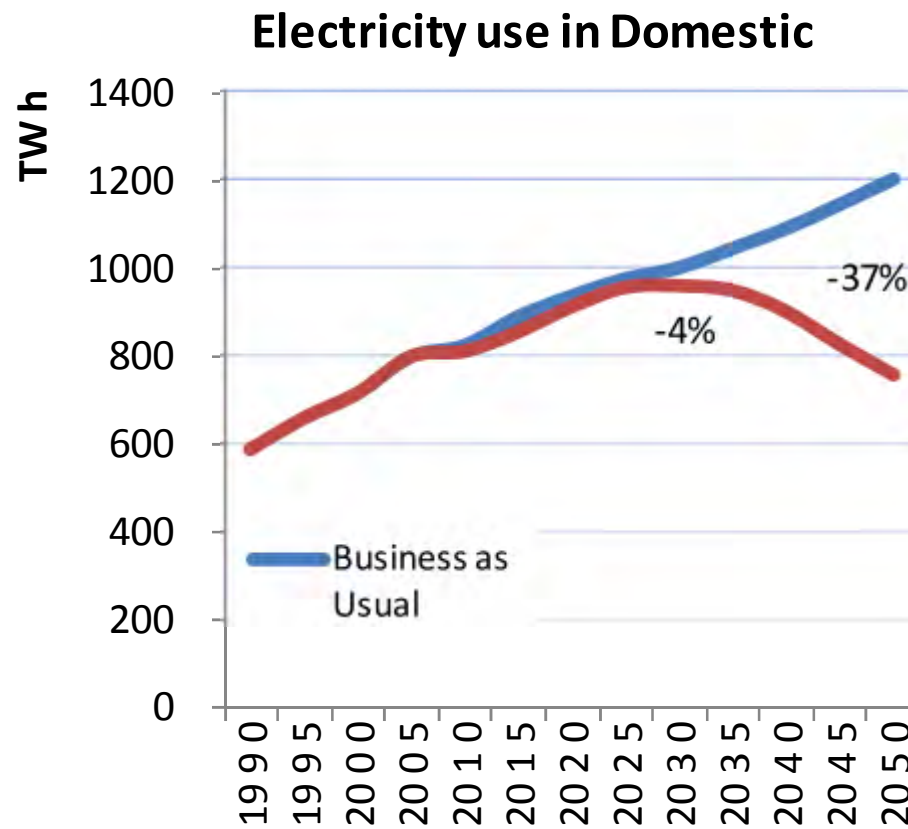
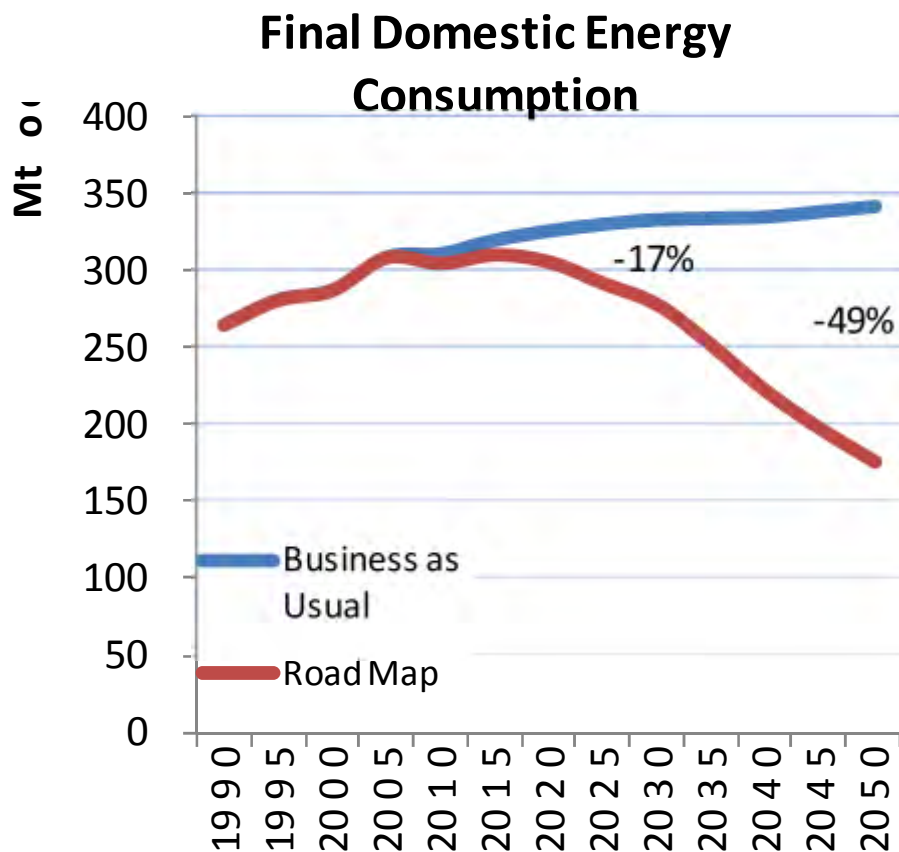
- CO<sub>2</sub> emissions from energy decline continuously in the Baseline 2009 projection
- However, additional policies are needed to meet ambitious targets, as those envisaged for Copenhagen
- RES formal target (20%) is not met in the Baseline 2009 (between 14 and 16%)

# Road Map for -75% GHG by 2050

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- ▶ **Energy efficiency in buildings, houses, electric appliances, lighting, heat pumps. Results for domestic sector**
  - ▶ -17% by 2030 relative to business as usual
  - ▶ -50% by 2050
- ▶ **Electrification of Road Transportation**
  - ▶ 25% by 2030
  - ▶ 90% by 2050
- ▶ **Renewables in Power generation**
  - ▶ 35% by 2030
  - ▶ 39% by 2050
- ▶ **CCS**
  - ▶ 45 GW 2030
  - ▶ 85% of CO<sub>2</sub> captured in 2050
- ▶ **Nuclear energy**
  - ▶ Investment to preserve current capacity until 2030 (128 GW)
  - ▶ Expansion up to 161 GW by 2050 (135 GW by 2005)

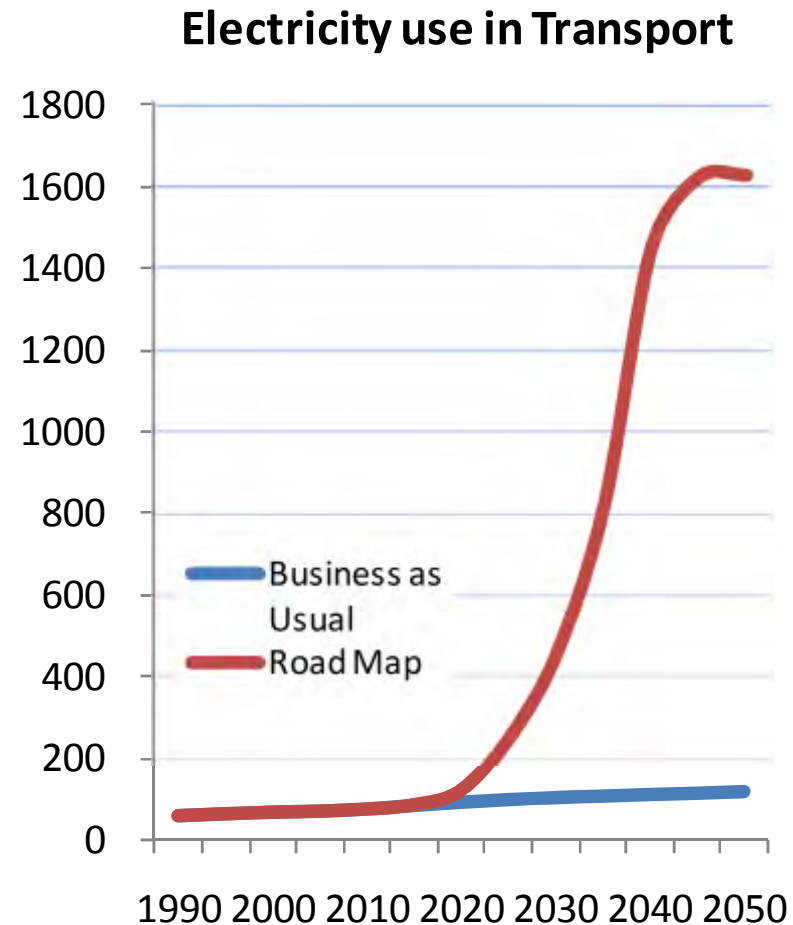
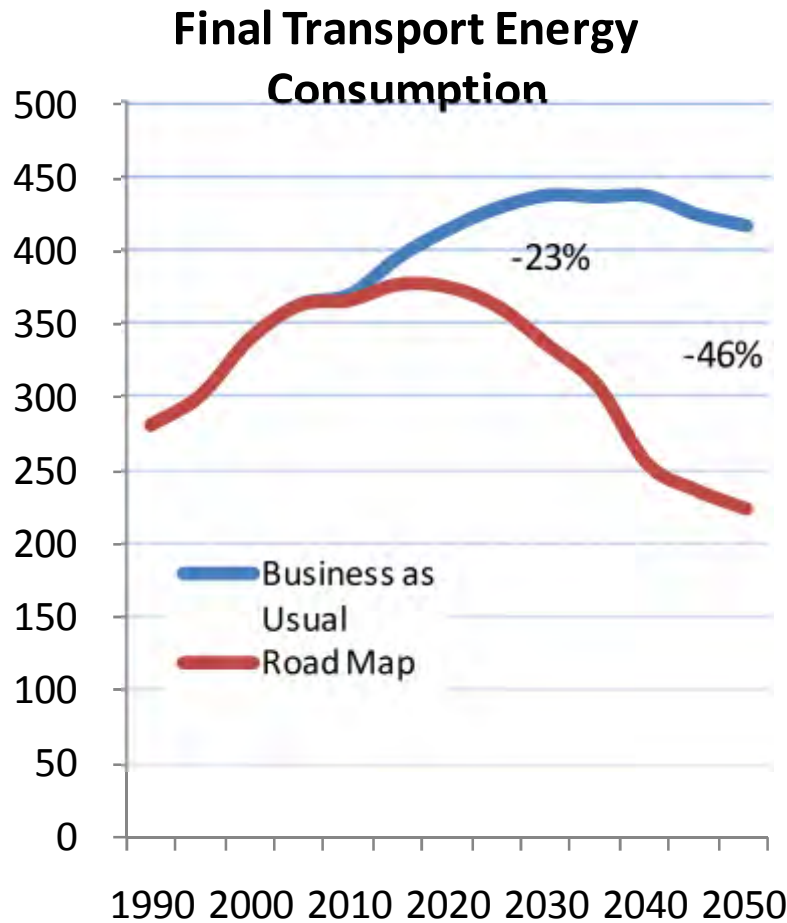
# Energy Efficiency Improvement in all sectors, especially in residential and tertiary sectors



*Note:* the business as usual projection assumes that both Climate Action and RES targets are ignored in policy making (latest EU legislation is also ignored)

PRIMES, 2009 – EU27

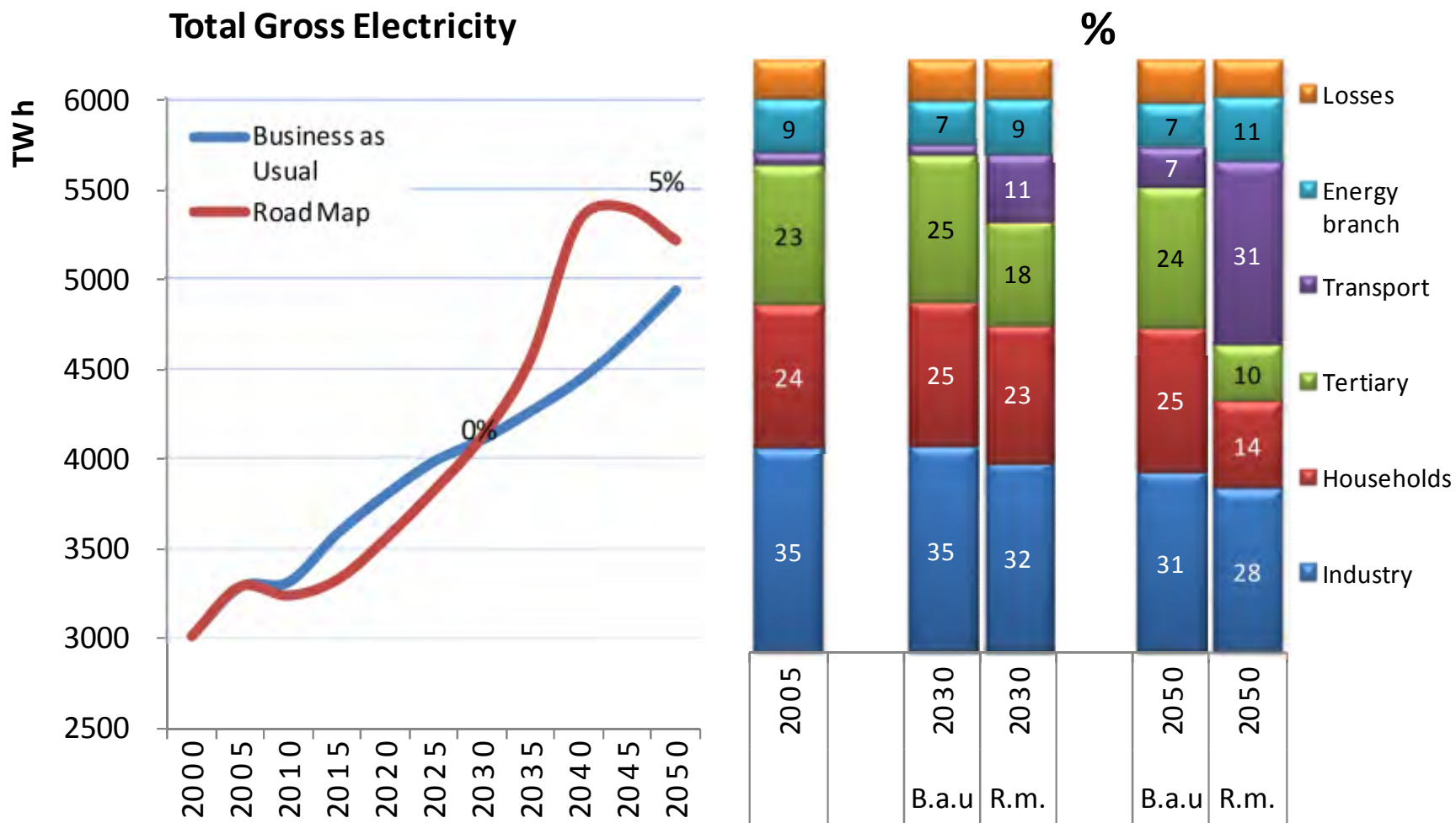
# Transportation: Improvement of energy efficiency and electrification



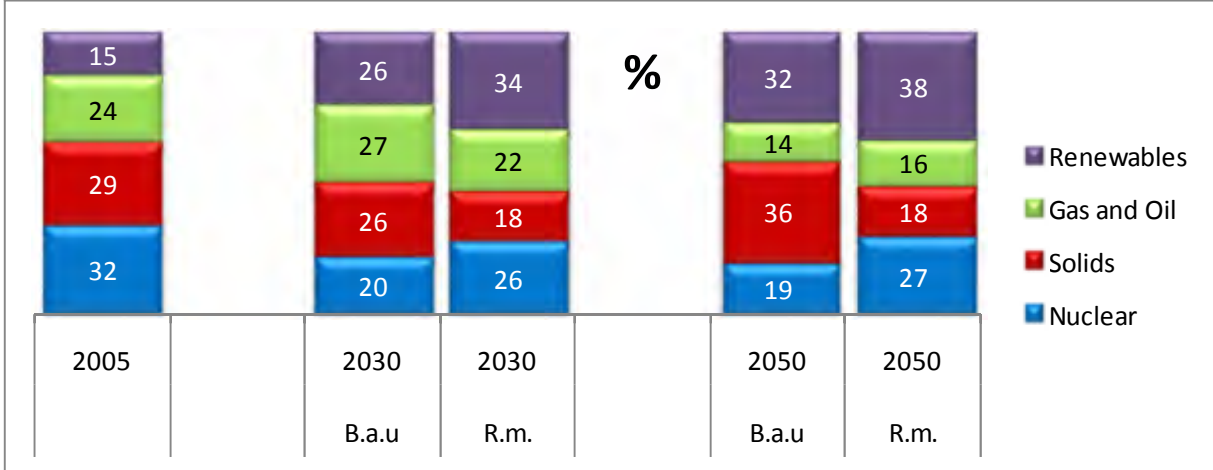
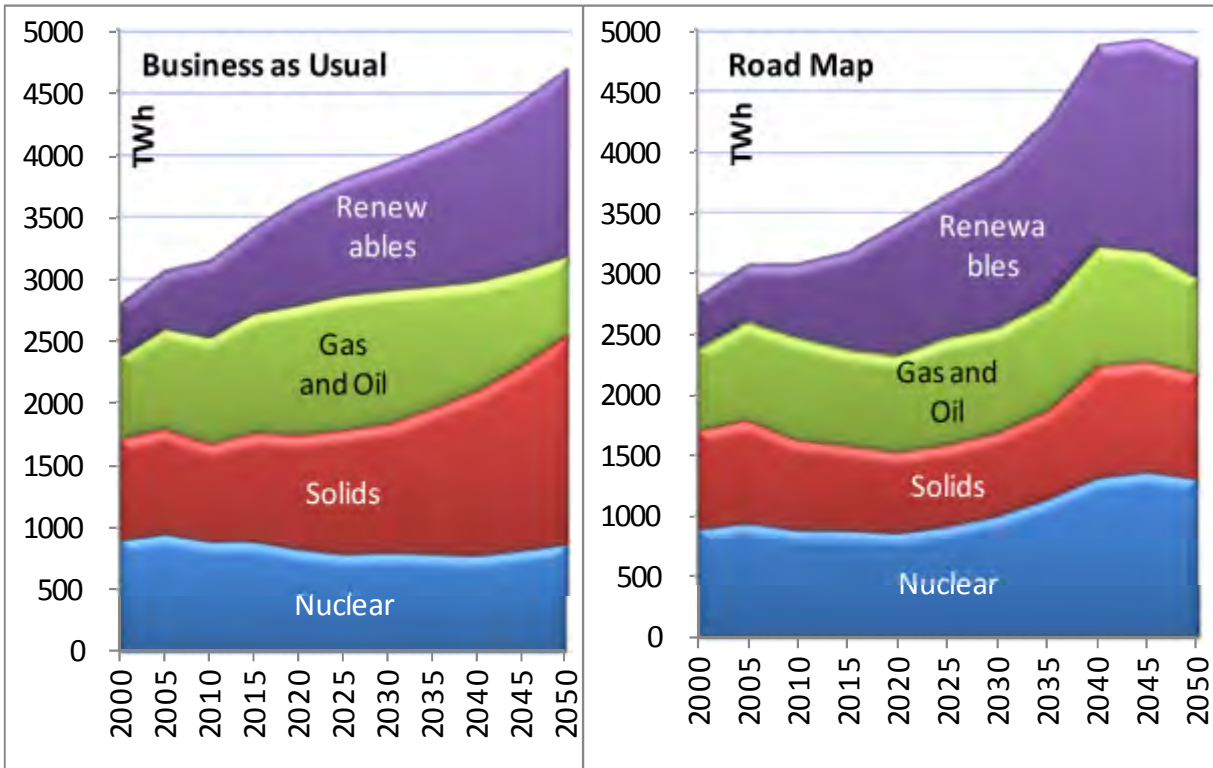
Note: the business as usual projection assumes that both Climate Action and RES targets are ignored in policy making (latest EU legislation is also ignored)

PRIMES, 2009 – EU27

# Electricity saved in final demand sectors is similar in magnitude to new electricity used in transportation



PRIMES, 2009 – EU27



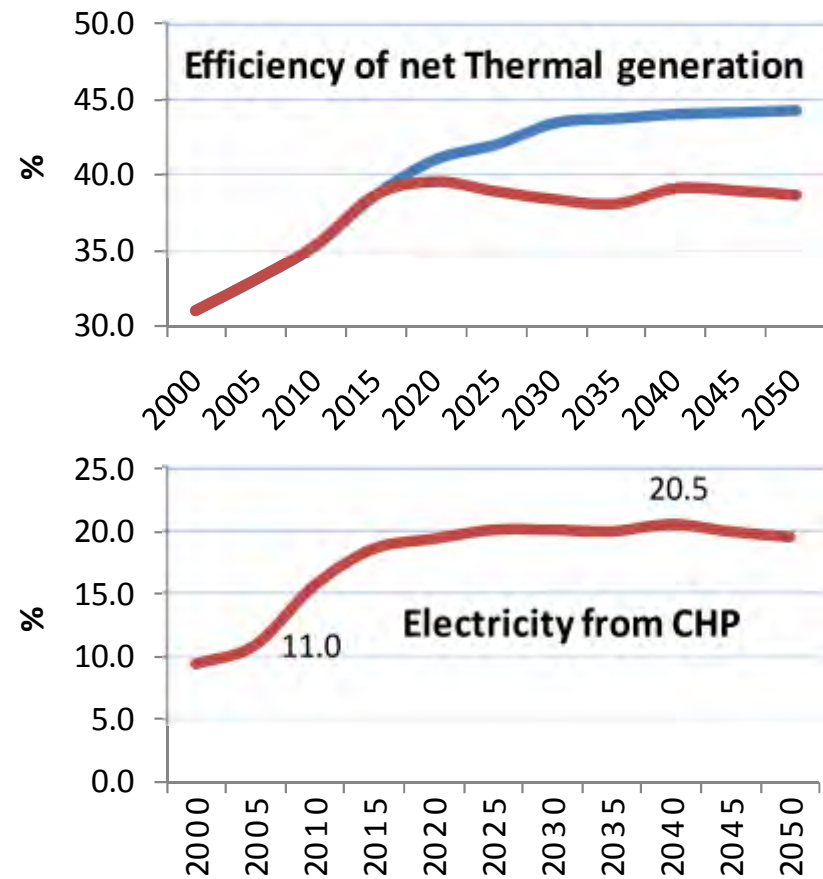
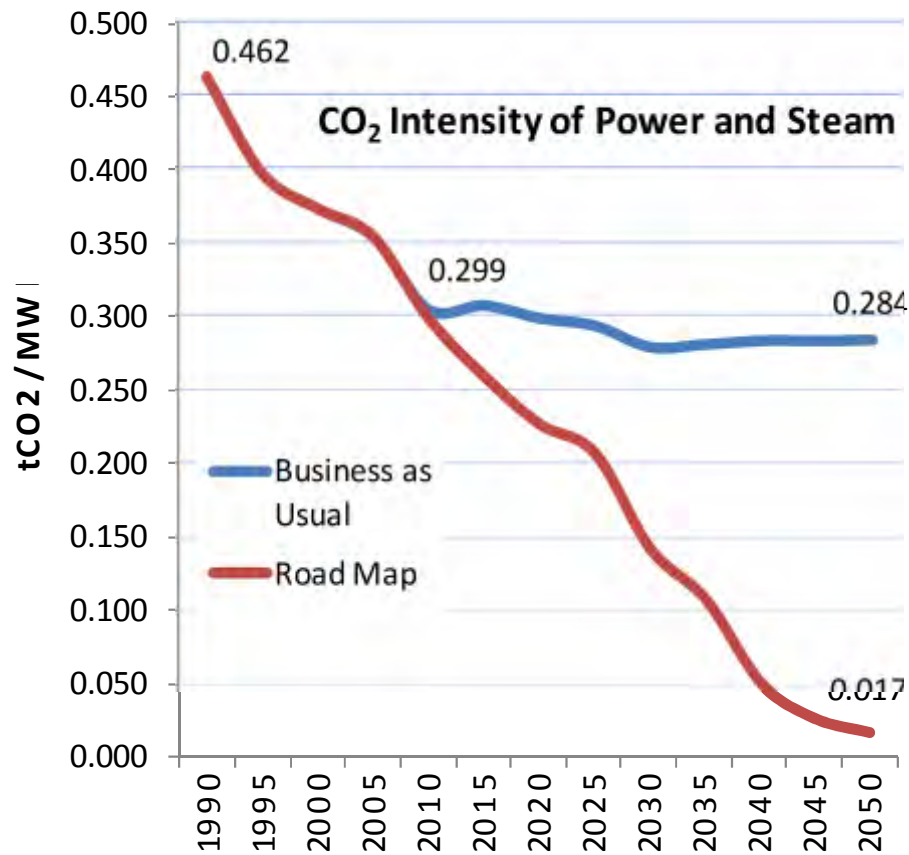
## Power generation restructuring

- Spectacular increase in RES generation
- Important role and preservation of gas-based generation
- Decrease in coal-based generation and application of CCS in almost all new coal plants
- Expansion of nuclear generation beyond 2030 (albeit lower in share)

**PRIMES, 2009 – EU27**

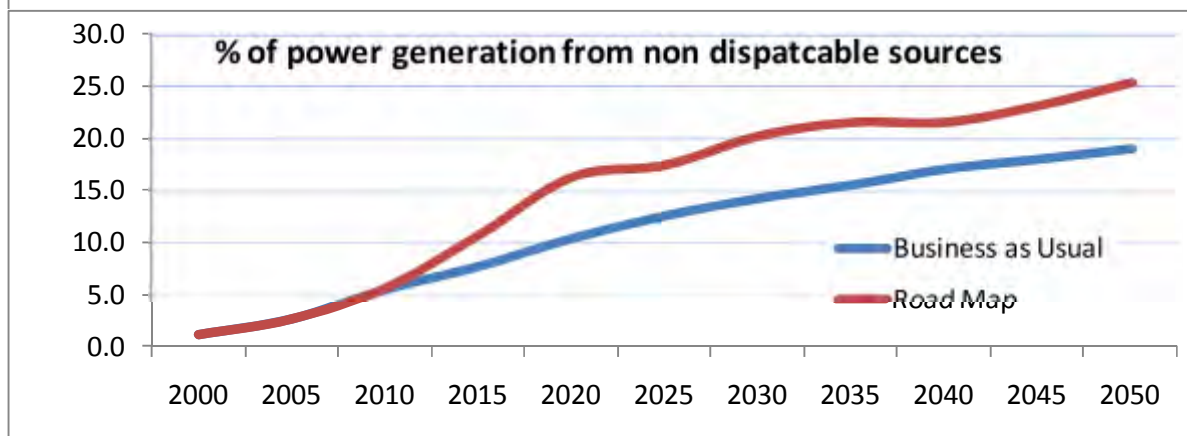
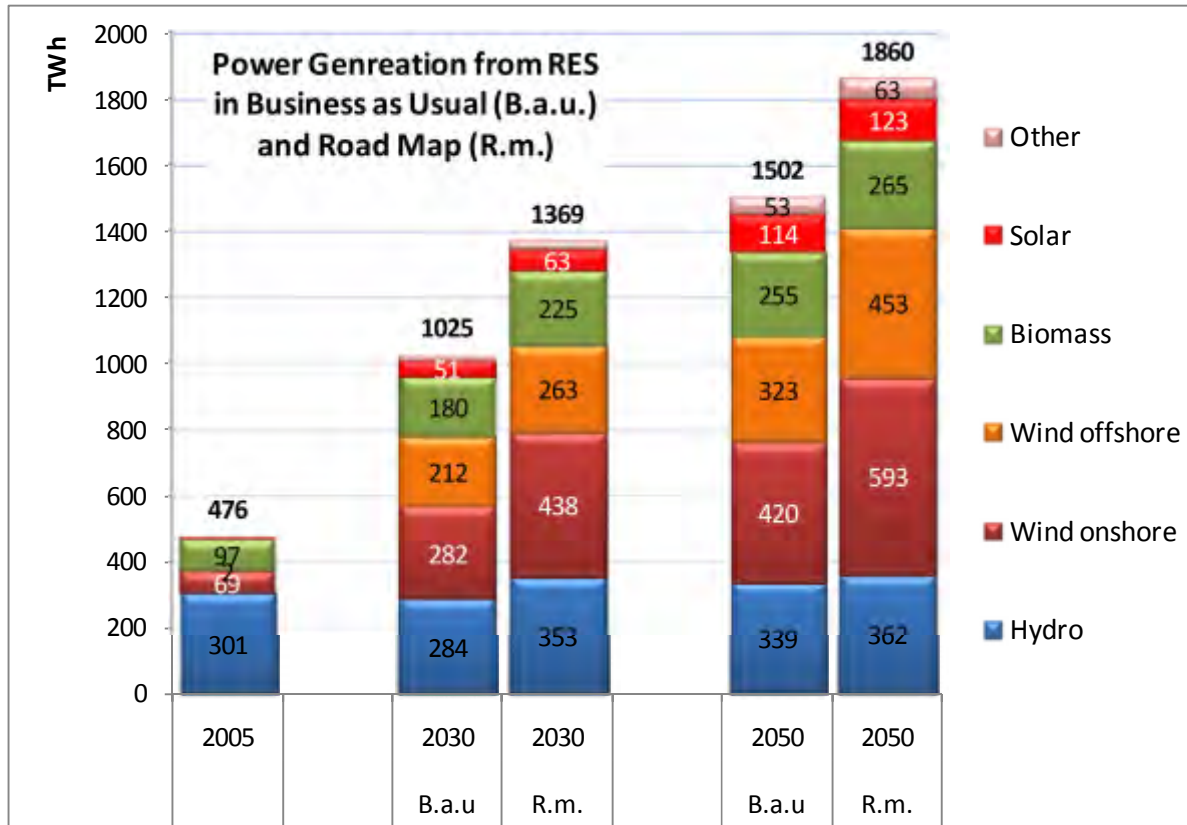


# Almost zero CO2 emissions by 2050 from generation of electricity and industrial steam



PRIMES, 2009 – EU27





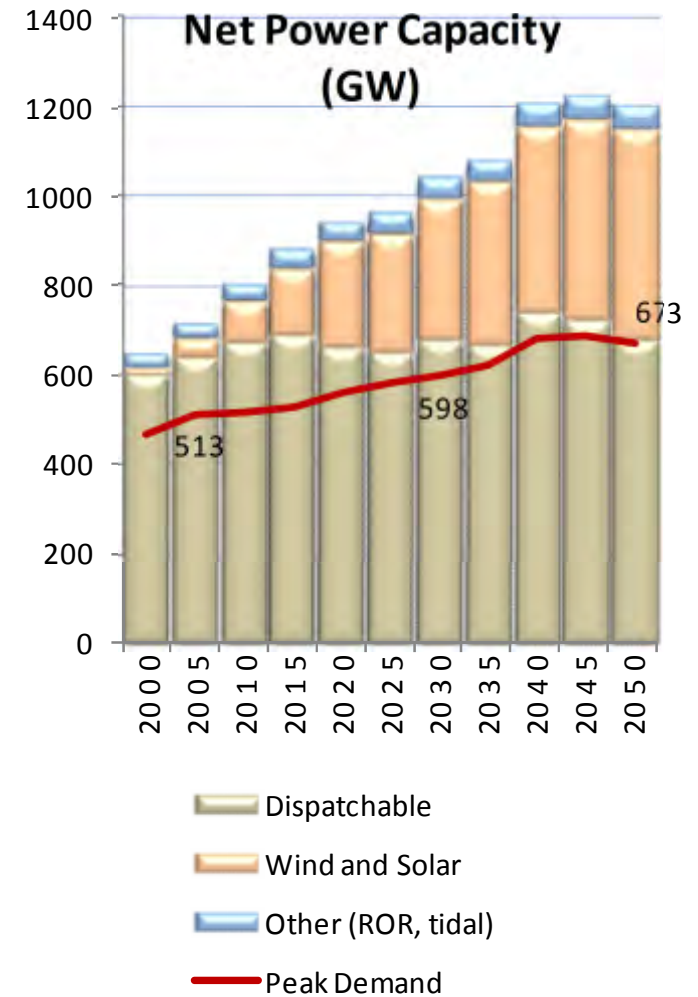
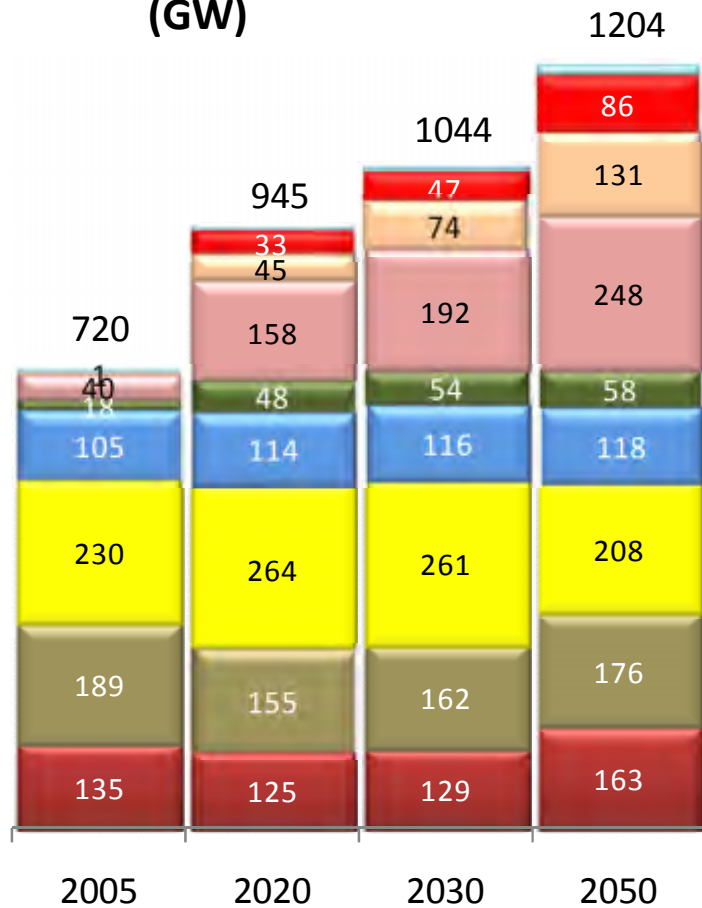
## RES in Power generation

- Accelerated investment in wind onshore and offshore (40-50% up from bau)
- 63 GW solar power by 2030 and 123 GW by 2050
- Significant development of biomass/waste use for co-firing and CHP (new energy crops are needed)
- Improvement of transmission/distribution systems to handle 25% generation from non

PRIMES, 2009 - EU27

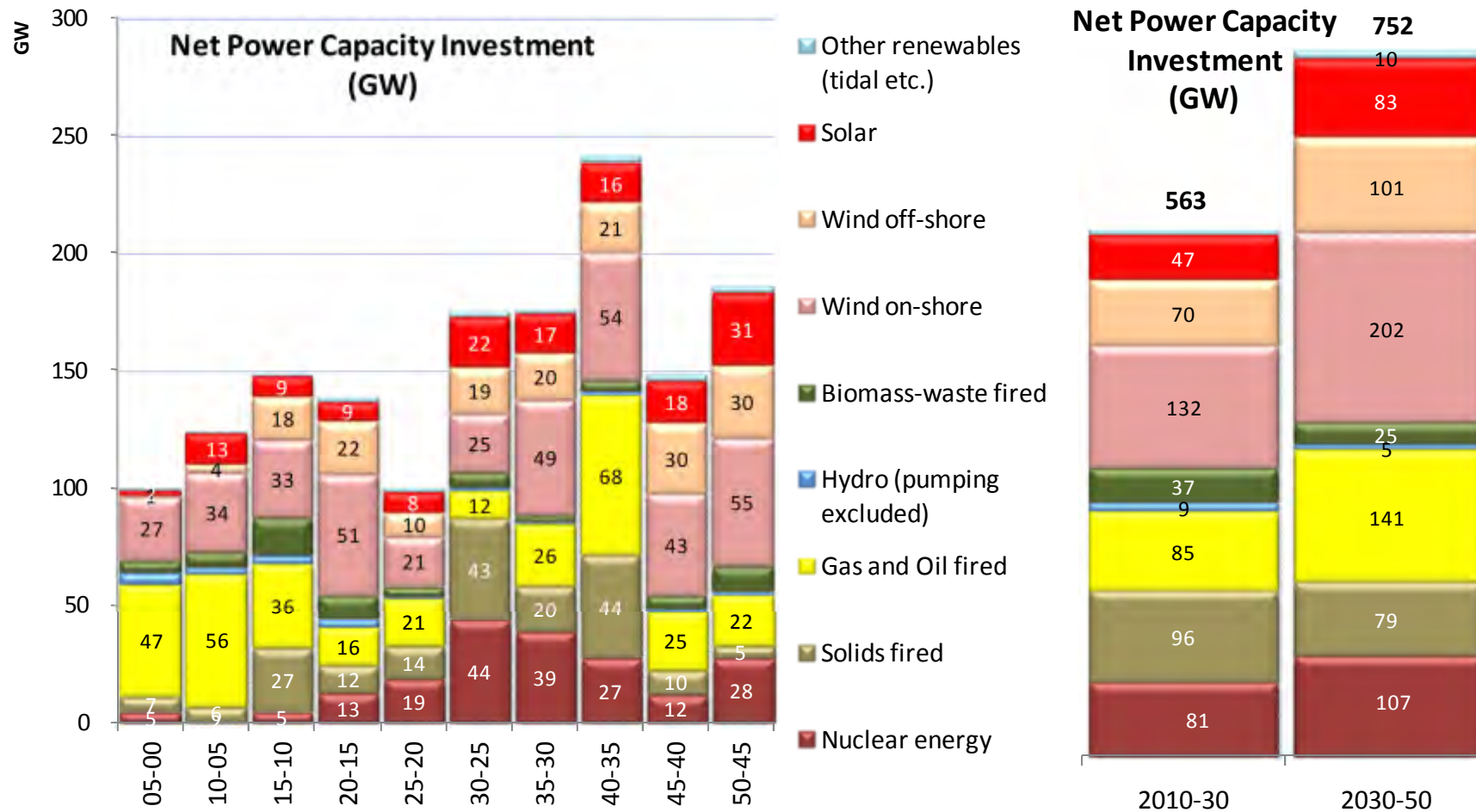
# RES capacity increase, thermal power use CCS, new nuclear after 2030, reserve/balancing from gas-fired plants

## Net Power Capacity (GW)



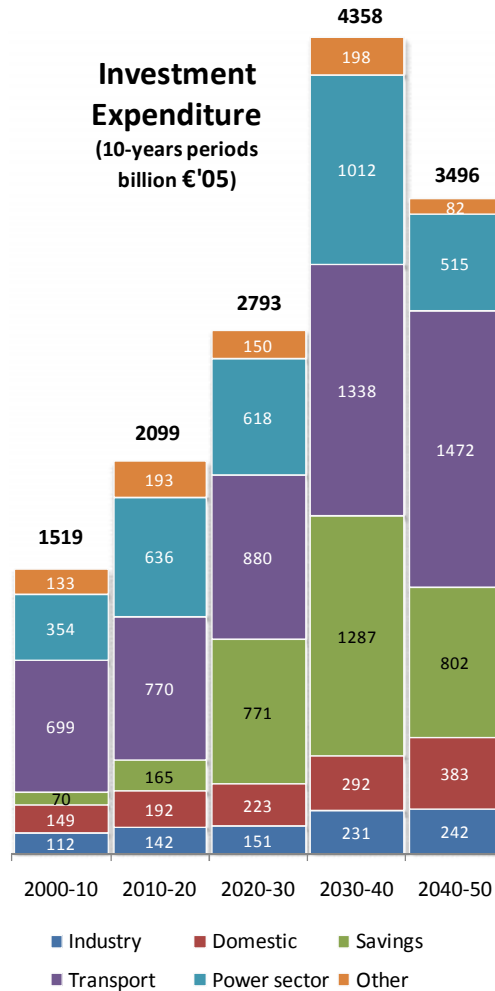
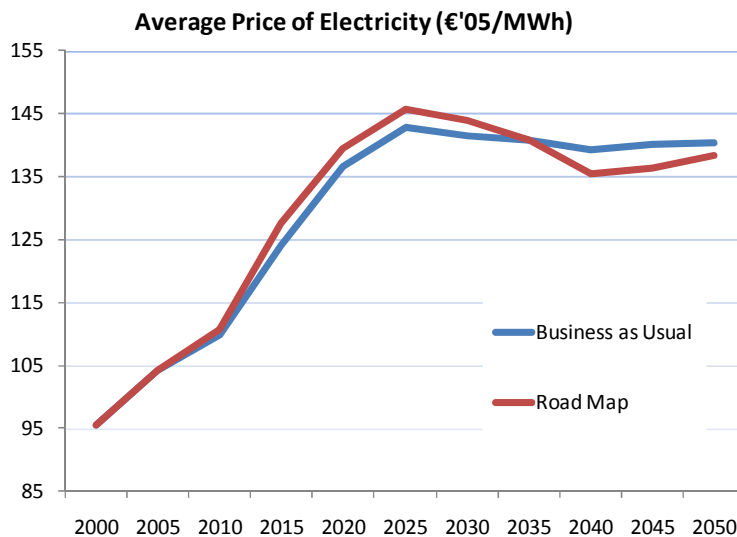
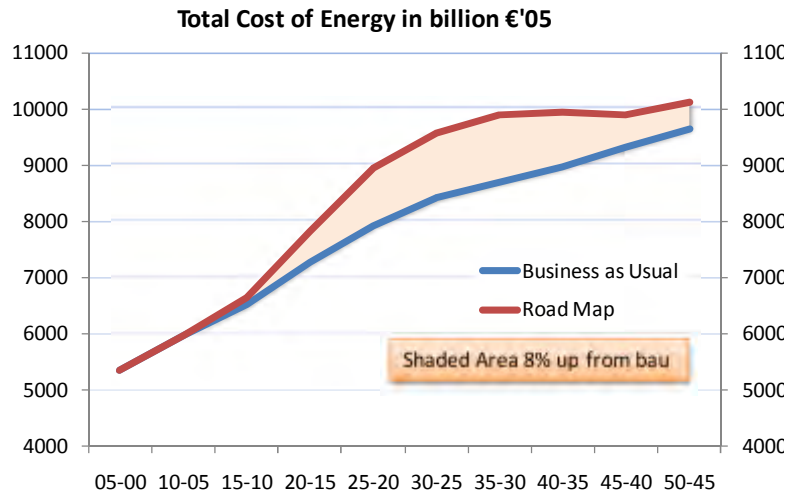
PRIMES, 2009 – EU27

Investment: RES (334 GW wind, 130 GW solar, 63 GW biomass), CCS solid fuel plants (125 GW), nuclear (188 GW) and natural gas (220 GW, of which 94 GW with CCS)



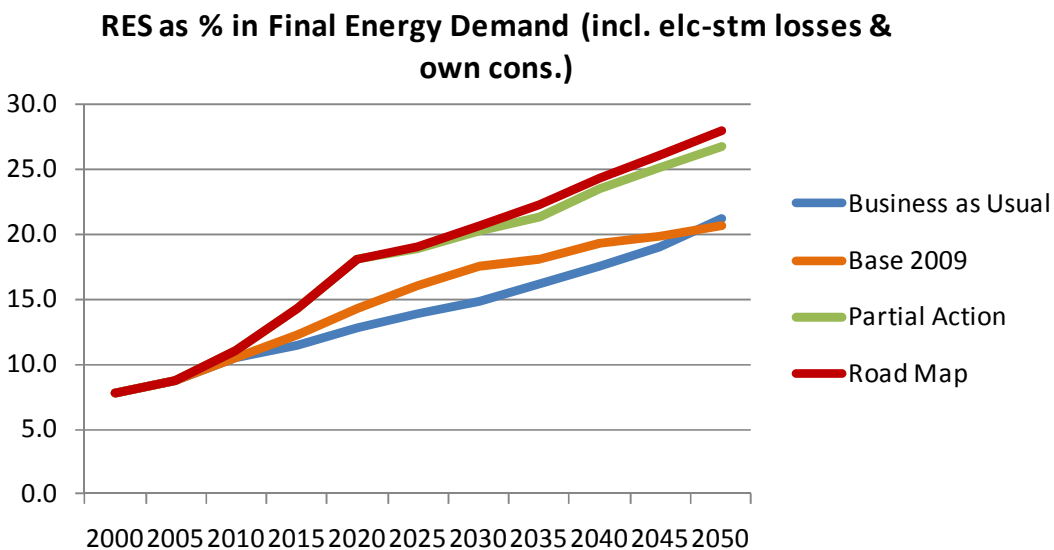
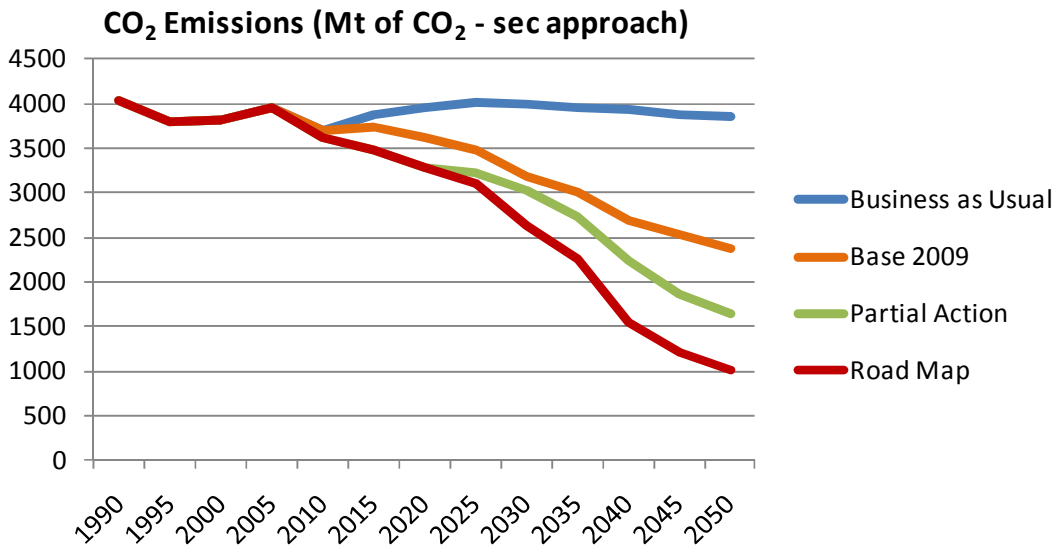
PRIMES, 2009 – EU27

# Implications on energy costs and prices



- Total cost of energy services (including expenditures for energy savings) increase by 8-9% on average relative to business as usual
- Electricity prices increase, compared to present, but the increase is moderate, as transportation electrification and electricity savings smooth out the load curve
- Total investment in power generation 2 trillion EUR (11% up from business as usual)
- Total energy system investment around 14 trillion EUR until 2050 (over doubled from current level), of which 3 trillion for energy savings

PRIMES, 2009 – EU27



**PRIMES, 2009 – EU27**

## Performance against GHG and RES targets

The Road Map includes scenarios with alternative targets and many sensitivity analyses (about CCS, nuclear energy, wind, etc.)

For example, eventual delay in CCS development would imply additional costs and some locked-in choices

Abolishment of nuclear phase-out in two countries decrease costs

Lower wind deployment increases cost of emission reduction

# Synthesis for the Road Map

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- ▶ The analysis demonstrates that zero carbon emissions from power generation by 2050 is feasible, within the context of a -75% GHG emission reduction in the EU
- ▶ Cost implications are reasonable, provided that electricity is saved in domestic uses and in the same time its use expands considerably in road transportation
- ▶ Additional capital intensive investment costs are partly offset by cost cuts induced by a smoothed out load curve, as cars are charged at off peak time
- ▶ With reasonable technical and system operation constraints, it is suggested for the Road Map to expand considerably the Renewables in power generation (up to 25% of generation from intermittent sources), implement CCS on almost all new coal plants, preserve and moderately expand (beyond 2030) nuclear power while maintaining and expanding gas-based power capacity (for reserve, balancing and small CHP)
- ▶ The Road Map assumes considerable acceleration of investment in all energy sectors (demand and supply), in energy savings and in grid infrastructure. Cost-effective success depends crucially on the removal of long term uncertainties and on sufficient price signals through carbon pricing. The latter is estimated at 40 EUR/tCO<sub>2</sub> for 2030 and 100 EUR for 2050.



# Policy Discussion

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- ▶ Despite electricity demand slowdown in medium term, the power sector will need acceleration of investment
- ▶ Higher investment is needed for the following reasons:
  - ▶ old and inefficient power plants will need to decommission even prematurely, entailing stranded costs to companies,
  - ▶ the RES target is clearly ambitious and massive capital intensive investment has to be undertaken far beyond business-as-usual,
  - ▶ power grid infrastructure requires higher investment, relative to baseline, in order to operate the RES (30 -35 % of power generation in 2020),
  - ▶ companies must start investing in advanced low carbon technologies, such as nuclear, CCS, off shore wind etc. in order to comply with ambitious targets for the period close to 2030
- ▶ The long term will look more optimistic for company sales, as electricity demand will start rising sharp again because it is likely to replace fossil fuels in final energy demand, including transportation.
- ▶ Is that trade-off over time possible from a private perspective?

# Policy Discussion

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- ▶ A range 20 – 30 €/t CO<sub>2</sub> until 2030 is insufficient to trigger large scale restructuring investment, as needed by ambitious climate action policies
- ▶ The uncertainty surrounding ETS prices combined with uncertainty about electricity demand is likely to induce postponement of power generation investments
- ▶ A carbon price floor would probably help
- ▶ The cost-price margin is also very volatile and uncertain. Ensuring revenues that remunerate capital intensive investment over the long term requires off take contracts. Is that a retrograde step?
- ▶ State support policies will increase for RES, but also for infrastructure and facilitation of large scale CCS and new nuclear investment



# Policy Discussion

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- ▶ State intervention in the energy market of the EU is expected to increase significantly
- ▶ The basic concepts of the EU internal energy market liberalization are likely to be under threat
  - ▶ First because of various new forms of **state-aid** situations driven by national governments, since except the EU ETS all other supportive policies stay at national jurisdiction and are likely to be implemented asymmetrically
  - ▶ Second because the portion of the power market that will be under free competition and without any form of state intervention will be shrinking over time, and is likely to reach a share less than **30%** by 2030 (according to our analysis); the rest of the market will involve activities protected by the state in one way or another
  - ▶ Third because increasing capital intensiveness will induce higher market **concentration**
- ▶ National champions will drive regulatory capture

Thank you for your attention

<http://www.e3mlab.ntua.gr>

[kapros@central.ntua.gr](mailto:kapros@central.ntua.gr)