

Analysis of the EU Renewable Directive by TIMES-Norway

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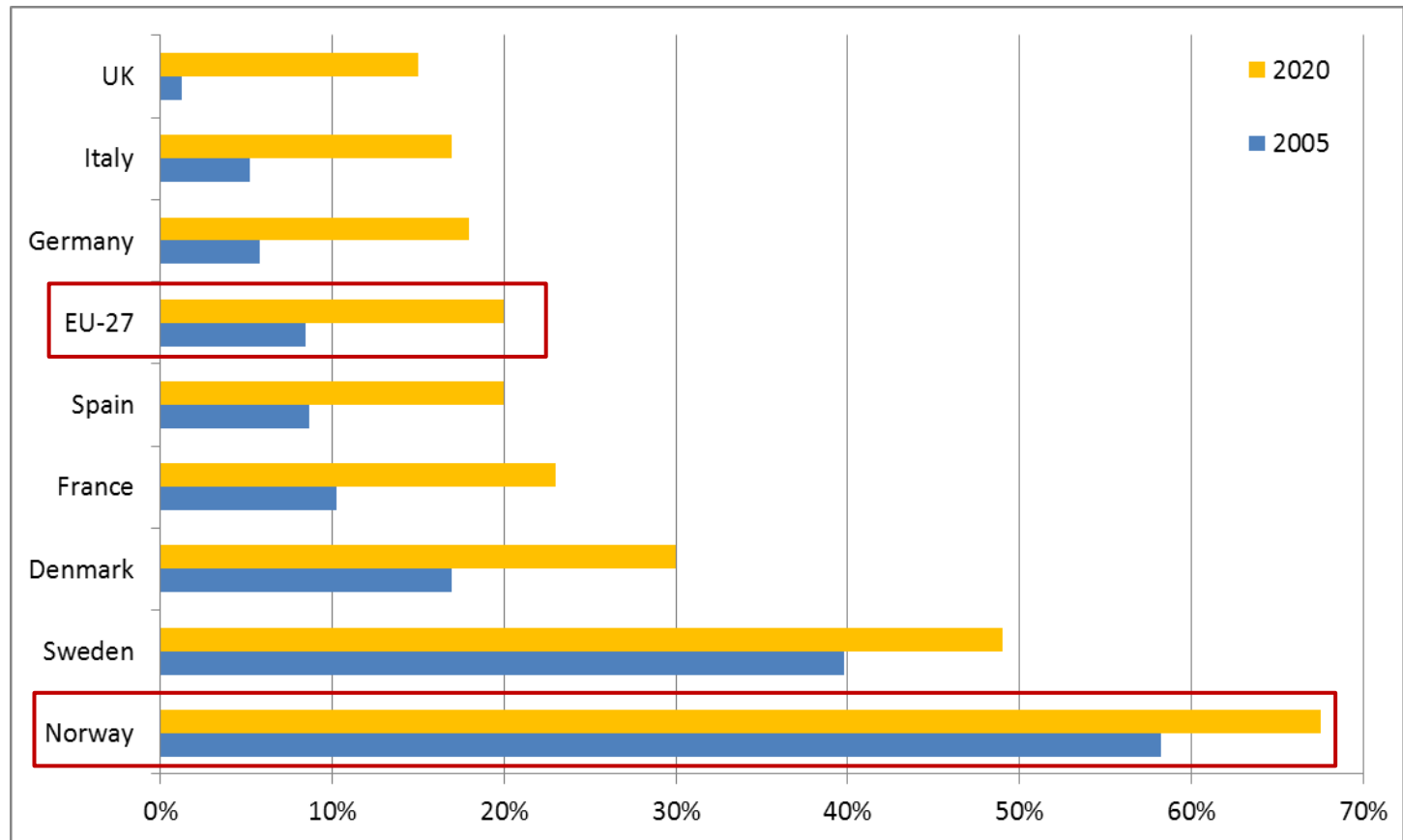
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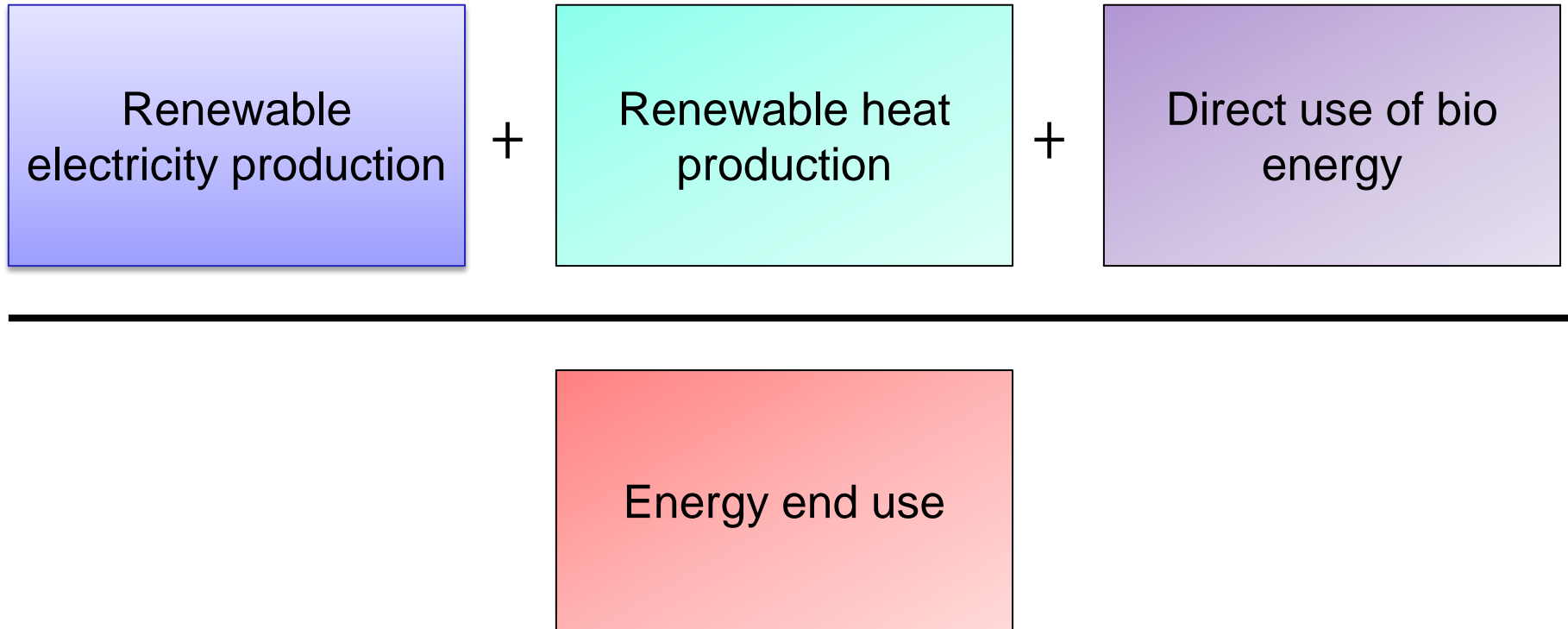
The EU Renewable Energy Directive

- Background
 - Agreed by the European Parliament and Council in December 2008
 - Adopted in April 2009 and came into force in June 2009
 - Implemented into the EEA Agreement at the end of 2011
- Motivation
 - Reduce greenhouse gas emissions
 - Promoting the security of energy supply
 - Promoting technological development and innovation
 - Providing opportunities for employment and regional development
- Targets
 - Every Member State has to reach individual targets for the overall share of renewable energy
 - All Member States have to reach a target of 10% share of renewable energy for transport

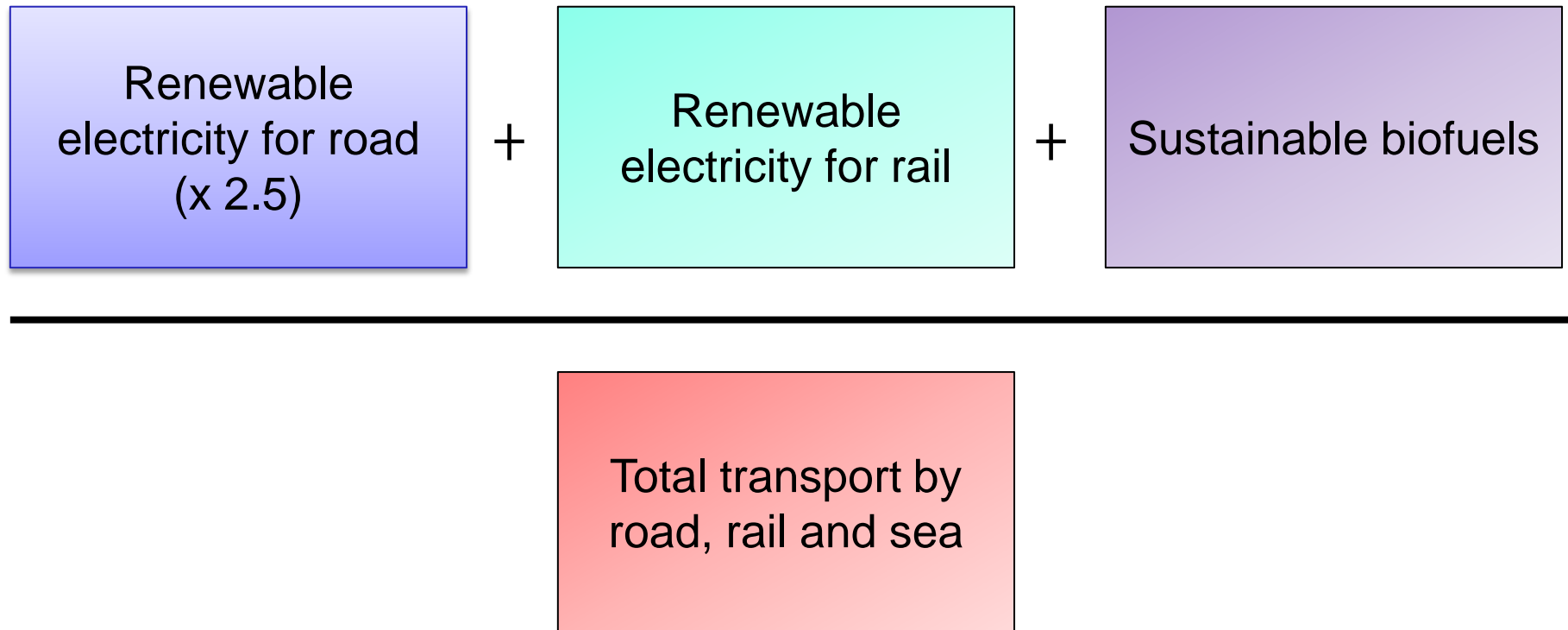
The 2020 target for selected countries



Calculation of the renewable share



Calculation of the renewable transport share



Modelling framework: TIMES-Norway

National energy system model (TIMES-Norway)



- TIMES-Norway is a national, bottom-up, techno-economic optimisation model
 - Developed by IFE and NVE
 - Norway is divided into 7 regions
 - The model has a high time resolution
 - Model horizon from 2006 to 2050
- The model assumes perfect competition and perfect foresight and is demand driven
- Energy demand is exogenous input to the model
 - 75-78 end use groups per region
 - Each end-use sector is divided into sub-sectors and energy services
 - ✓ Electricity, heat, cooling, feed stock, vehicle-km, tonne-km

Exogenous input

Demand

- 7 regions
- 70-80 end-use groups
- 2-3 energy services (heating, cooling, non-sub. electricity, feed stock, vehicle-km, tonne-km)

Energy prices

- Import price oil products etc.
- Export/import price electricity
- Taxes
- Bio energy prices

Resources

- Renewable resources (w/potentials)
- Import of bio energy (w/constraints)
- Electricity export /import

TIMES-Norway

Conversion / Processes

- Electricity production
- Heat production
- CHP
- Bio mass processing
- Hydrogen production

Transmission / Distribution

- Electricity grid – high voltage
- Electricity grid – low voltage
- District heating grid

Demand technologies

Industry sector

- Boilers
- CHP
- Feed stock
- Energy efficiency measures

Transport sector

- Cars
- Buses
- Trucks
- Trains etc.

Residential & service sectors

- Boilers
- Stoves
- Electric heating
- District heating
- Energy efficiency measures

Model Output

Energy production

- Technology
- Region
- Time

Shadow prices

- Electricity
- District heat
- Other energy carriers

Energy use

Use of energy carriers as a function of:

- Time
- Region
- Demand sub-sector

End-use technologies

- Type of cars
- Type of heating equipment
- Implementing of energy efficiency
-etc.

Other

- Total system costs
- Emissions

Analysis of the EU renewable energy directive by TIMES-Norway

Modelling of the RES directive

- The RES directive is modelled as two constraints in TIMES-Norway
- Constraint 1: Overall RES target at 67.5% on a national level by 2020
- Constraint 2: 10% share of renewable energy for transport on a national level by 2020
- Green certificate market and RES directive
 - Maximum contribution on the RES share in 2020 is 13.2 TWh regardless of actual production in Norway
- The TIMES model will choose the optimal investment portfolio for each of the seven regions to achieve the national target
 - This also involves making operation decisions

Scenario assumptions

- Energy prices
 - Export/import prices of electricity are given exogenously to the model
 - ✓ The trading prices are calculated based on forward prices from selected European electricity exchanges
 - ✓ The various price profiles for each time slice are calculated based on historical prices
 - Fossil fuel prices are set constant through the model period
 - The price of imported bio energy products are set slightly higher than the price of the corresponding fossil fuel
- Renewable energy resources
 - A domestic biomass potential of approximately 30 TWh/year
 - Bio fuels can be imported at a given price without limitations
 - ✓ There are no restrictions regarding replacing the use of fossil oil with bio oil
 - ✓ Biodiesel is mixed with fossil diesel for use in road traffic with a minimum of 5 % and maximum of 20%

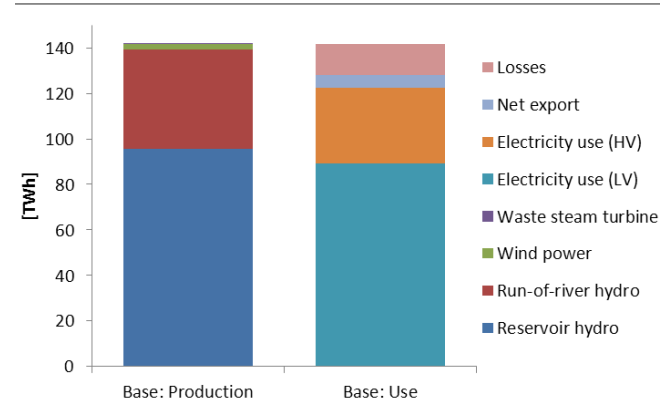
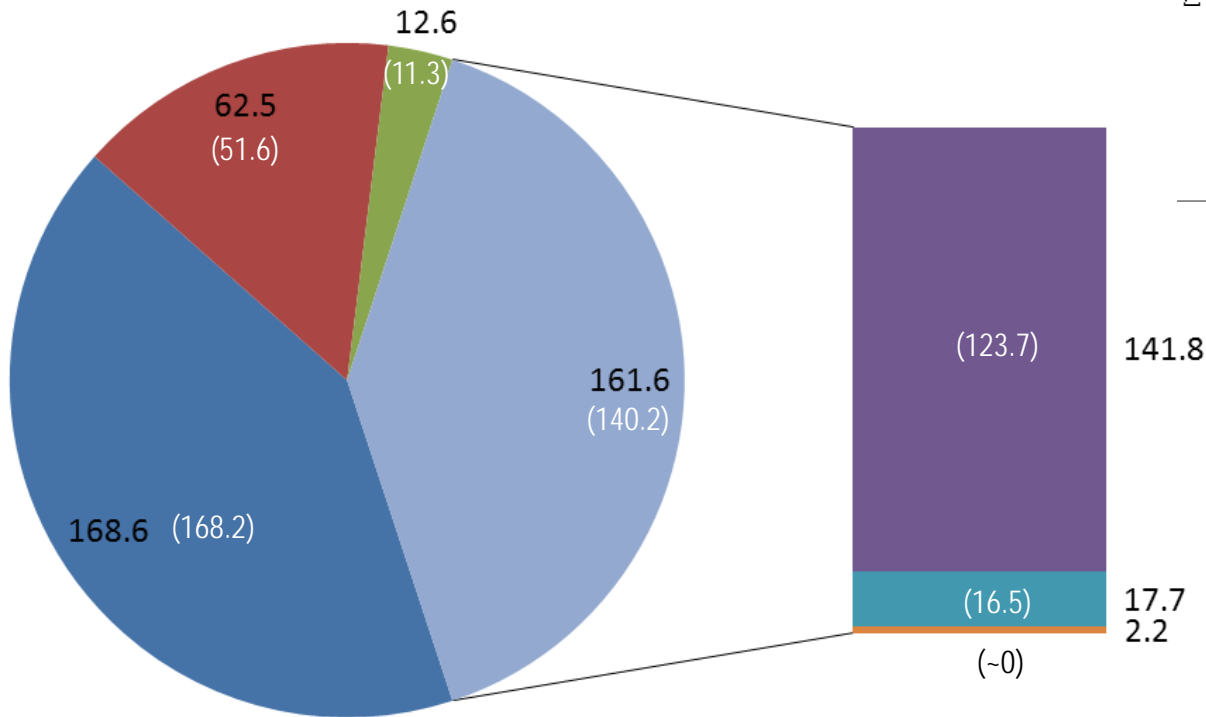
Scenarios

Scenario	Description	Sensitivity analyses
Base (1a)	<ul style="list-style-type: none"> No RES constraint 	High Hyd (1b): <ul style="list-style-type: none"> Increased investment costs for reservoir and run-of-river hydro
RES + CER (2a)	<ul style="list-style-type: none"> Active RES constraint Transport restriction Green certificates (140 NOK/MWh) 	High Bio (2b): <ul style="list-style-type: none"> 50% higher import prices for biodiesel and bioethanol Low Exp/Imp (2c): <ul style="list-style-type: none"> 25% lower electricity export and import prices to neighbouring countries
CER (3a)	<ul style="list-style-type: none"> Green certificates (140 NOK/MWh) 	High CER (3b): <ul style="list-style-type: none"> Green certificates (240 NOK/MWh)

Results

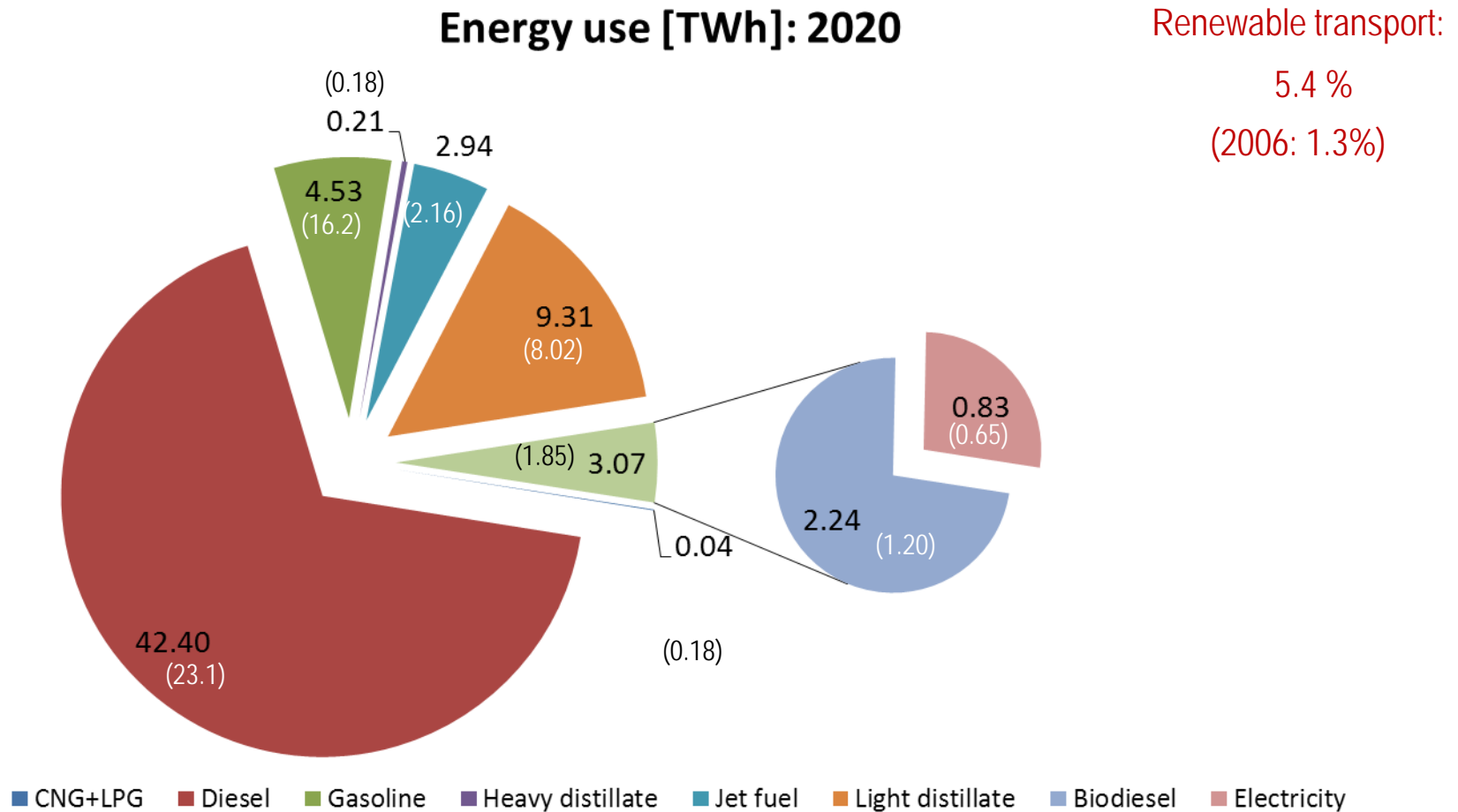
Base scenario: Energy use and production in 2020 [TWh]

■ Stationary: End use ■ Transport : End use ■ Miscellaneous losses
■ Renewable power ■ Renewable heat ■ Bio fuels in transport

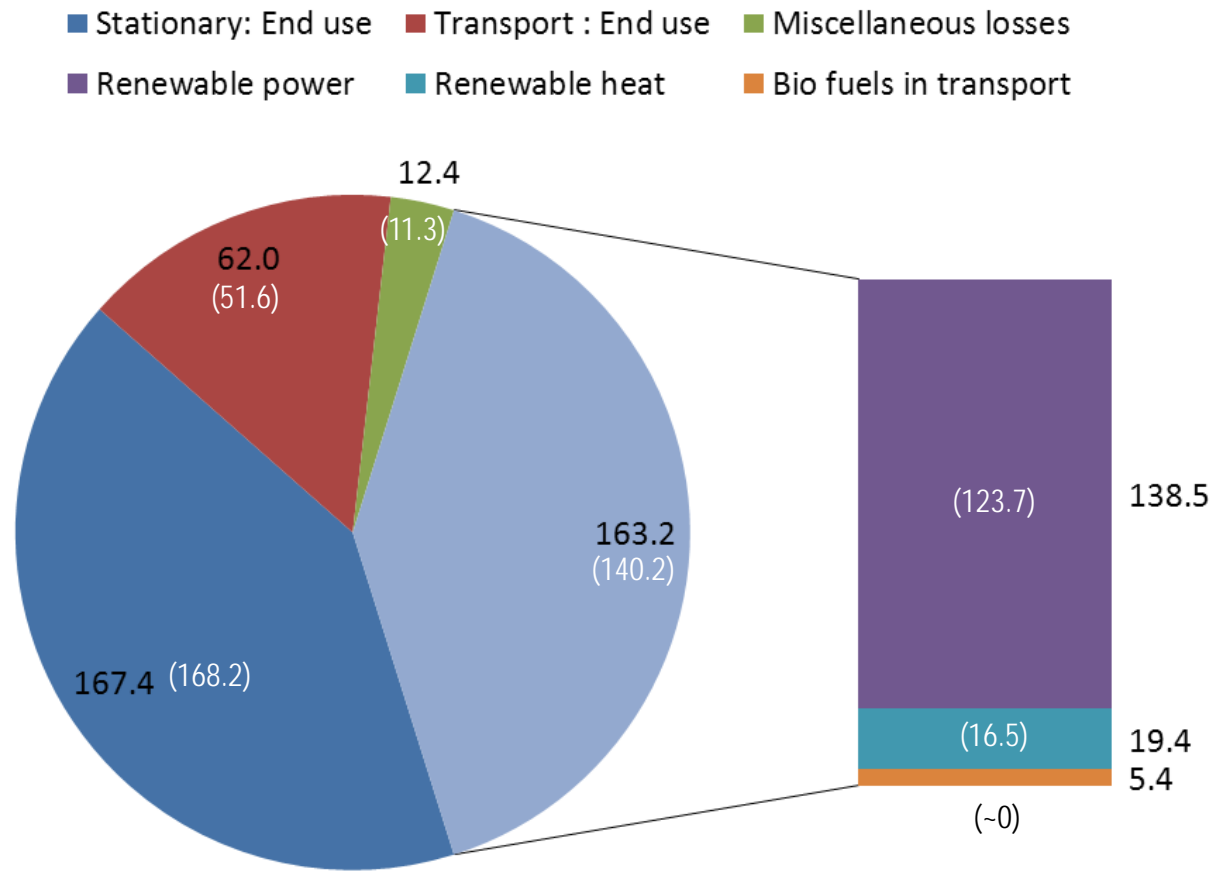


Fraction:
 66.6%

Base scenario: Transport sector

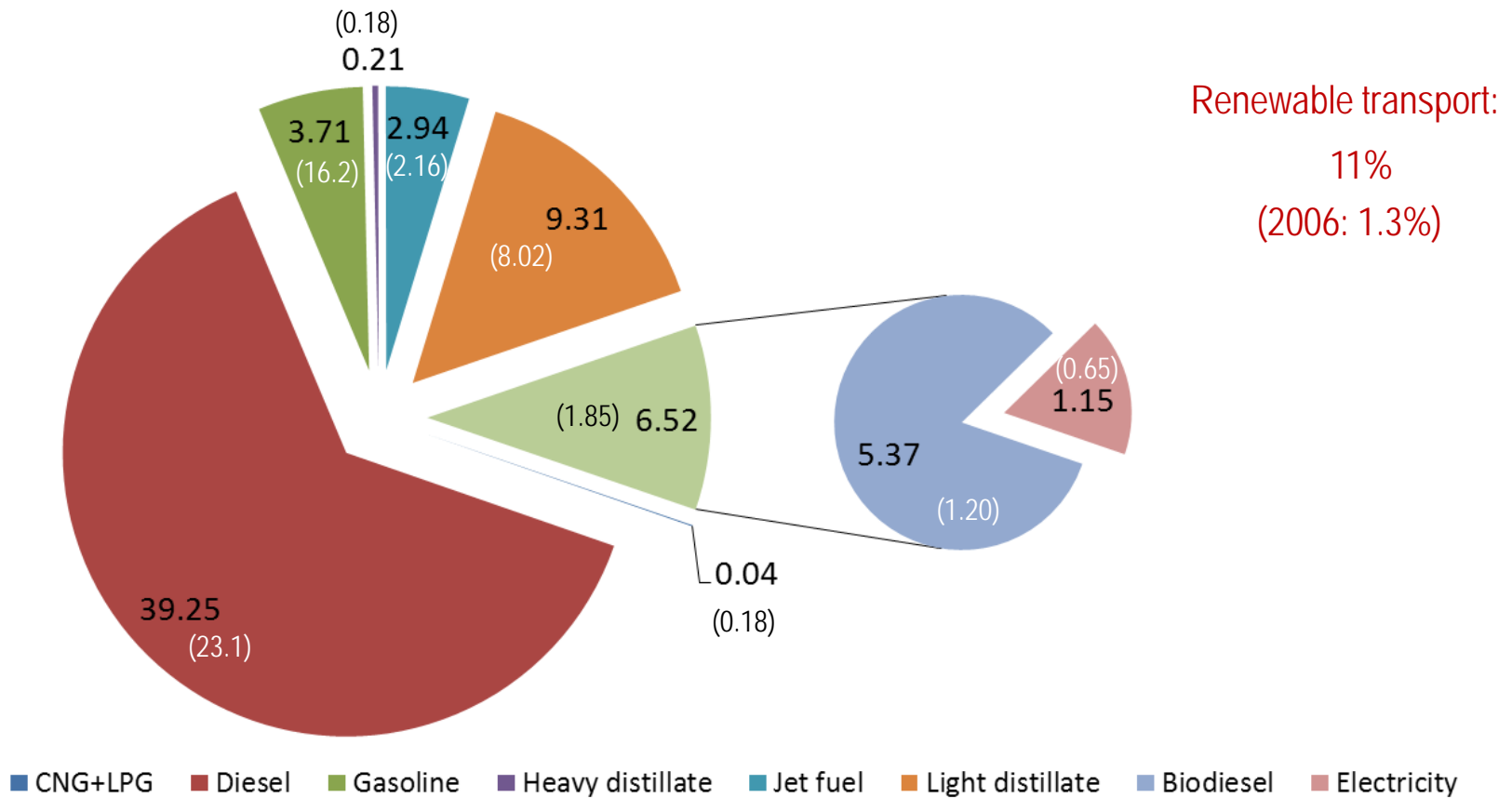


RES + CER scenario: Energy use and production in 2020 [TWh]



RES + CER scenario: Transport sector

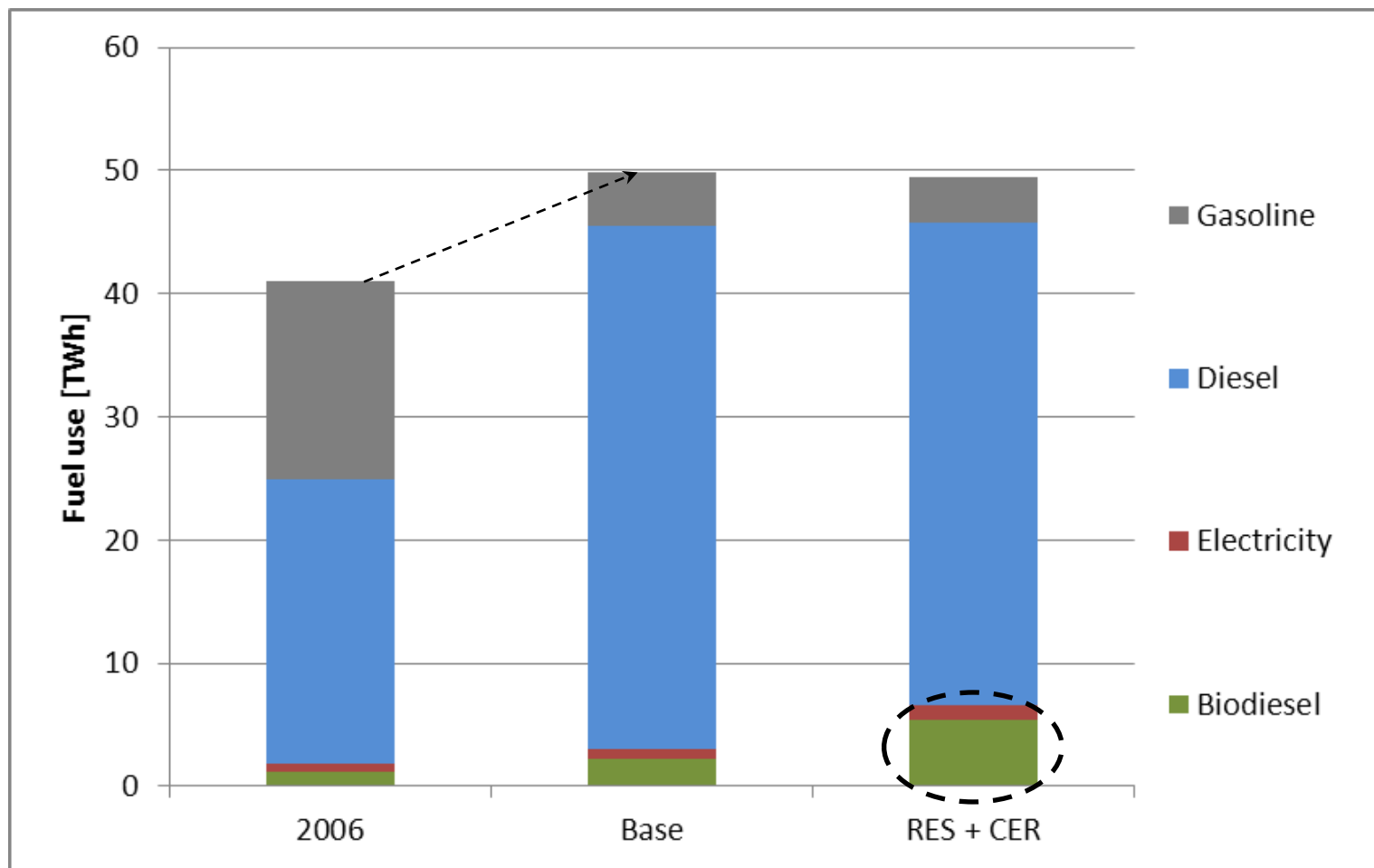
Energy use [TWh]



Base vs RES + CER

	Increased use of	Decreased use of
Stationary end use	<ul style="list-style-type: none">• Biomass from forestry• Pellets• Wood• Heat pumps• Energy efficiency measures	<ul style="list-style-type: none">• Electricity• Natural gas• Liquefied petroleum gas• Light distillate, industrial use
Transport sector	<ul style="list-style-type: none">• Electricity• Biodiesel	<ul style="list-style-type: none">• Diesel• Gasoline
Renewable heat production	<ul style="list-style-type: none">• Biomass from forestry• Pellets• Wood• Heat pumps	

Fuel use: Rail and road transport (2020)



Sensitivity analyses

- Increased investment costs for reservoir and run-of-river hydro
 - Limited changes in electricity production
 - The projects are still interesting due to high economic lifetime
- Higher import prices for biodiesel and bioethanol
 - No changes in electricity production
 - Reduction in net electricity export
 - Reduced energy consumption in the transport sector
 - ✓ Increased use of electricity and gasoline
 - ✓ Reduced use of biodiesel and diesel
- Lower electricity export and import prices to neighbouring countries
 - Reduced electricity production
 - Significant reduction in net electricity export
- Higher certificate prices
 - Increased electricity production (from wind power)

Discussion and conclusion

Discussion

- All scenarios show an increase in hydro and wind power production
 - “Low” investment costs and high electricity export prices
 - However, TIMES-Norway does not take into account some of the barriers that need to be addressed
 - ✓ Including issues like license, local resistance, etc
 - Consequently, the model may be too optimistic regarding the volume of new renewable capacity (or too fast)
- The uncertainty of future energy prices and demand for electricity may reduce the investment level of new renewable power
 - In the model, the demand for energy services and energy prices are known for the entire model horizon (perfect foresight)
 - The cost effective solution for the entire country does not necessary imply that individual actors in the market consider the investment profitable

Conclusion

- Analyses with TIMES-Norway show that it is possible to achieve both the overall RES target and the RES transport constraint for 2020
- The targets can be achieved with a diversity of measures
 - Investments in hydro power, wind power, high-voltage power lines, various heat pump technologies, energy efficiency measures and more use of biodiesel and electricity in the transport sector
 - As demonstrated in some scenarios, the green certificate market contributes to increased investments in wind power technologies
- The results comply well with the action plan of the Ministry of Petroleum and Energy

Thank you!