

# 100%RE FINLAND – FIRST STUDY

**Michael Child & Christian Breyer**  
**Lappeenranta University of Technology**

TEM  
100%RE keskustelutilaisuus

3.10.2016

# EnergyPLAN modelling tool

## General description:

- Developed in 1999 at Aalborg University in Denmark
- Major tool for the Energy Transition discussion in Denmark
- Energy system analysis carried out in hourly steps for one year
- Model includes analysis of electricity, heating and transport sectors

## Simulated events:

- Reference scenarios for 2014, 2020 and 2050 (BAU)
- Test scenarios for 2050 (Low and High Biomass) with various capacities of nuclear power (low, medium, high)
- Target of essentially zero carbon emissions and complete energy independence – Finland as an island



NEO  
CARBON  
**ENERGY**

# EnergyPLAN modelling tool

## Advantages:

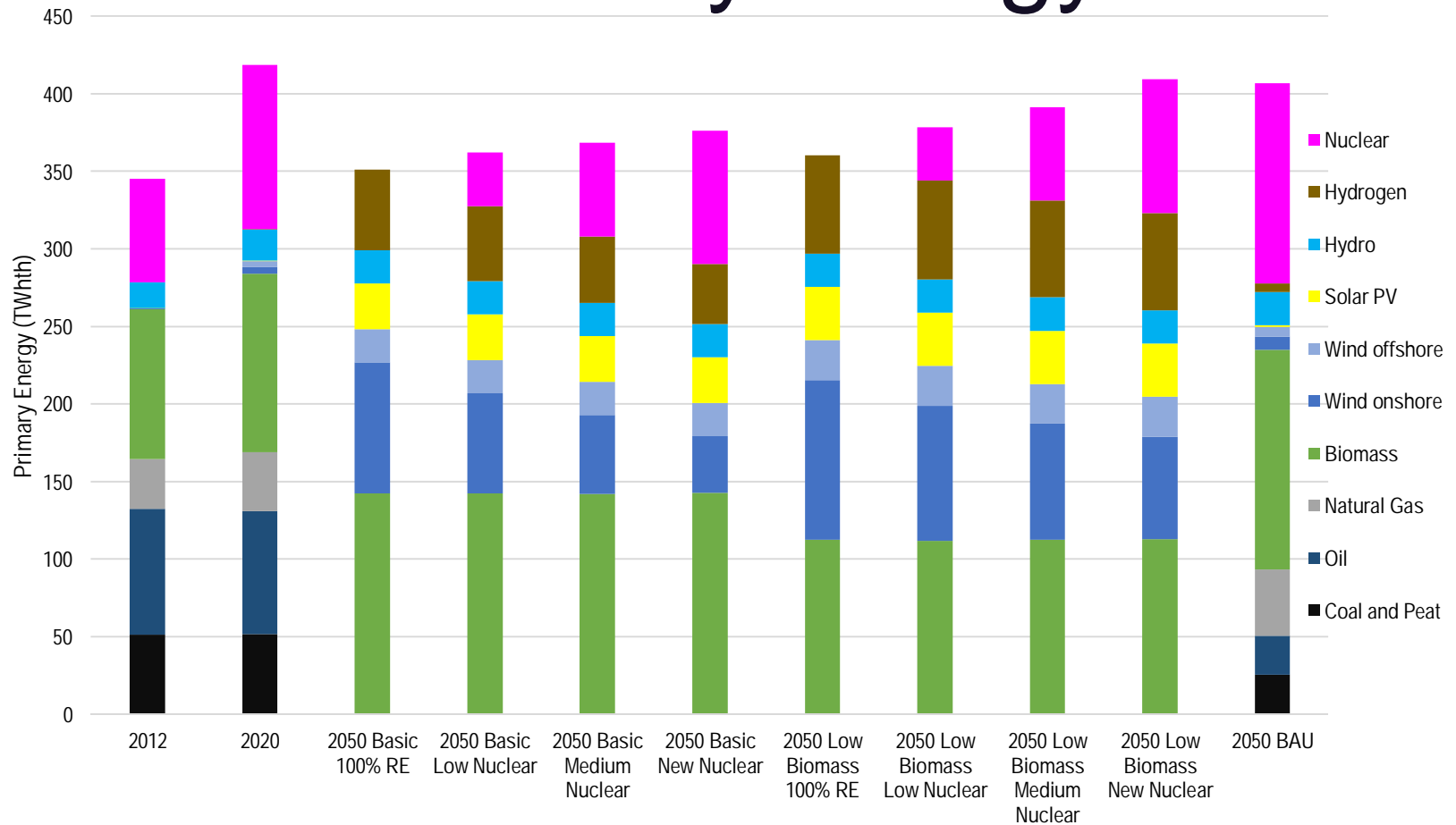
- Free, open model can be applied to larger and smaller scales
- Widely used and respected
- Hourly resolution for all sectors

## Limitations:

- Copper plate model of entire country does not account for heterogeneity
- Limited representation of complex electricity market and interconnections in Finland
- Cost optimisation performed by user manually

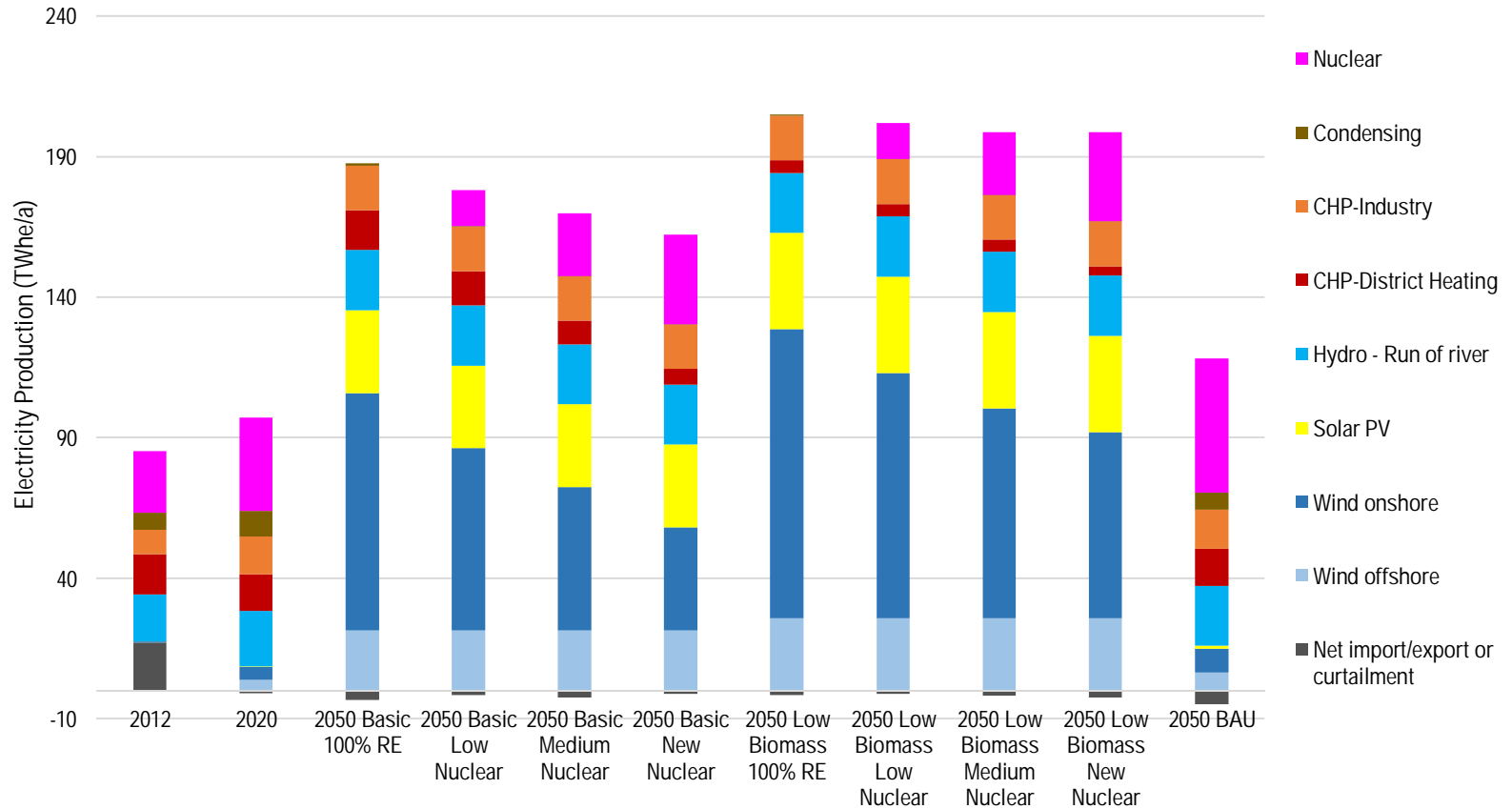


# Primary energy



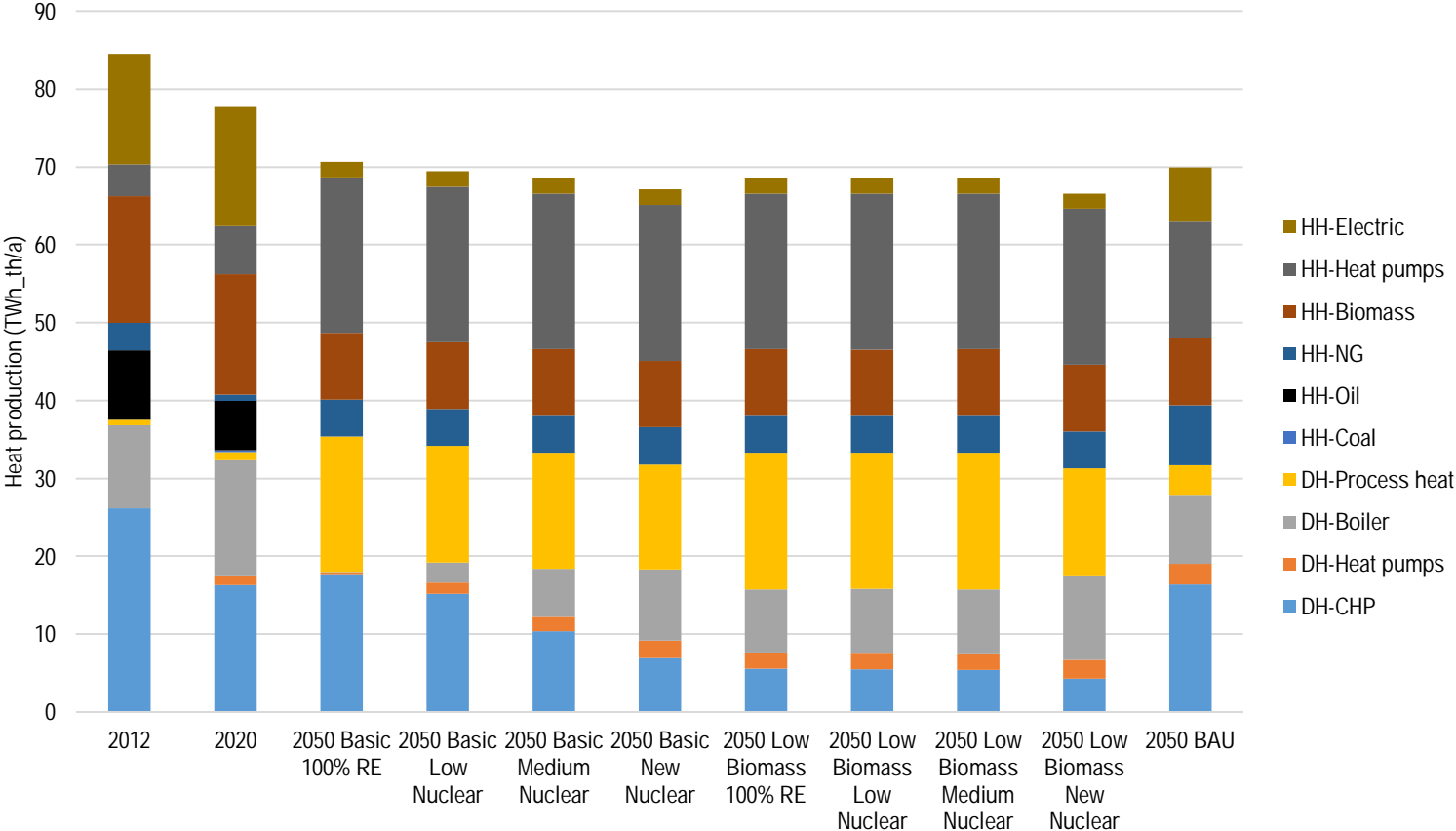
**NEO  
CARBON  
ENERGY**

# Electricity production



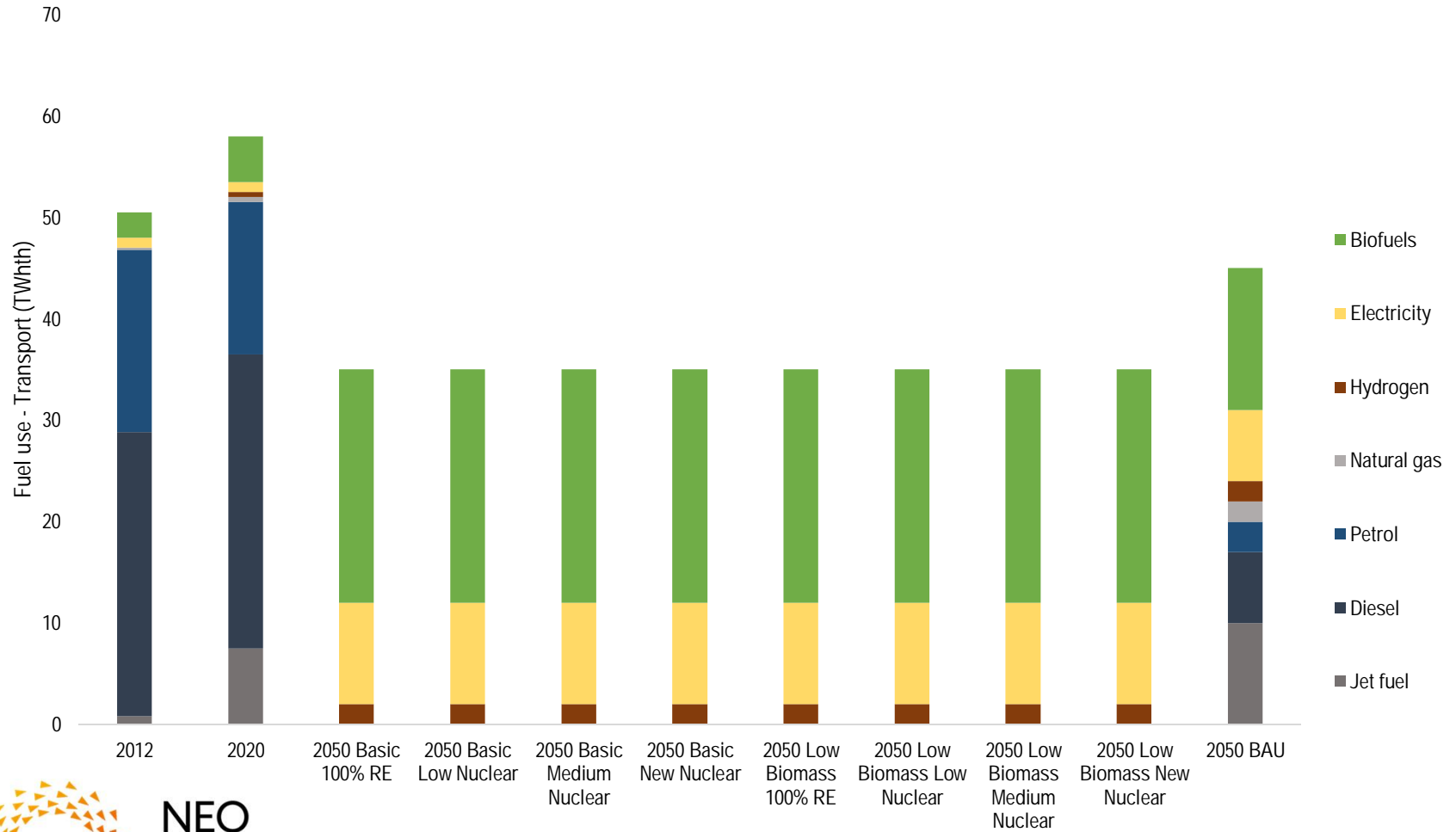
**NEO  
CARBON  
ENERGY**

# Heat production



**NEO  
CARBON  
ENERGY**

# Transport



**NEO  
CARBON  
ENERGY**

# Special Issues

- Fuel use in industry assumed 40% bio or synthetic gas and 60% biomass
- Steel industry expected to utilise arc furnaces and Direct Hydrogen Injection
- No role for CCS
- Strong roles for a variety of energy storage solutions
  - Power-to-gas plays prominent role for seasonal storage
  - Storage of bio and synthetic gas significant
  - Thermal storage has seasonal role, but is not expanded greatly from current situation
  - Batteries (Li-ion) play prominent role in daily and short-term storage
    - V2G connections have greater role by far (over 80%) than stationary batteries
- Role of storage could be reduced with higher imports/exports of electricity
- Electrification of light transport has significant impact on energy system
  - Biofuel and synthetic fuel use for aviation, shipping, heavy transport, military, emergency services



# Interpretation and recommendations

- A 100% renewable energy system seems possible for Finland
- High level of energy independence seems achievable
- Prominent roles of RE and energy storage should be considered in all future energy policy discussion
- Opportunities exist for increased domestic investment and RE-based employment and improved national trade balance
- Flexibility should be a defining feature of future energy systems
- 100% RE should be an equal partner in future energy discourse

# Additional information

- Two publications:
  - [M. Child and C. Breyer, “Vision and initial feasibility of a recarbonized Finnish energy system,” \*Renewable and Sustainable Energy Reviews\*, vol. 66, no. 1, pp. 517-536, 2016.](#)
  - [Supplementary materials to above publication](#)
  - [M. Child and C. Breyer, “The role of energy storage solutions in a 100% renewable Finnish energy system,” \*Energy Procedia\*, in press, 2016.](#)
- One publication pending:
  - [Child, M.; T. Haukkala C. Breyer, The role of solar photovoltaics and energy storage solutions in a 100% renewable energy system for Finland in 2050, in \*31st European Photovoltaic Solar Energy Conference and Exhibition, Hamburg, September 14-18, 2015.\* – Final version submitted to journal has been expanded and updated](#)

