Long term planning for a greener future

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Global Cooperation and System Analysis

Dedicated to the future of renewable energy

The Danish Energy Agency is an agency under the Danish Ministry of Energy, Utililites and Climate.

- Energy system planning and forecasting Policy and Legislation for the energy sector Danish efforts to reduce carbon emissions.
- Partnerships - GtG cooperation to support implementation of the Paris agreement of different governments
- Established in 1976
- 400 employees

Proven Domestic success

Over the last 40 years, the DEA has helped Denmark go from being 99% dependent on imported and largely fossil based energy to having the highest share of renewable energy in EU.

30%

The amount by which Denmark has reduced the adjusted greenhouse gas emissions since 1990 in 2015

56%

The contribution of non-hydro renewables to the electricity system in 2015 – the highest in the world.

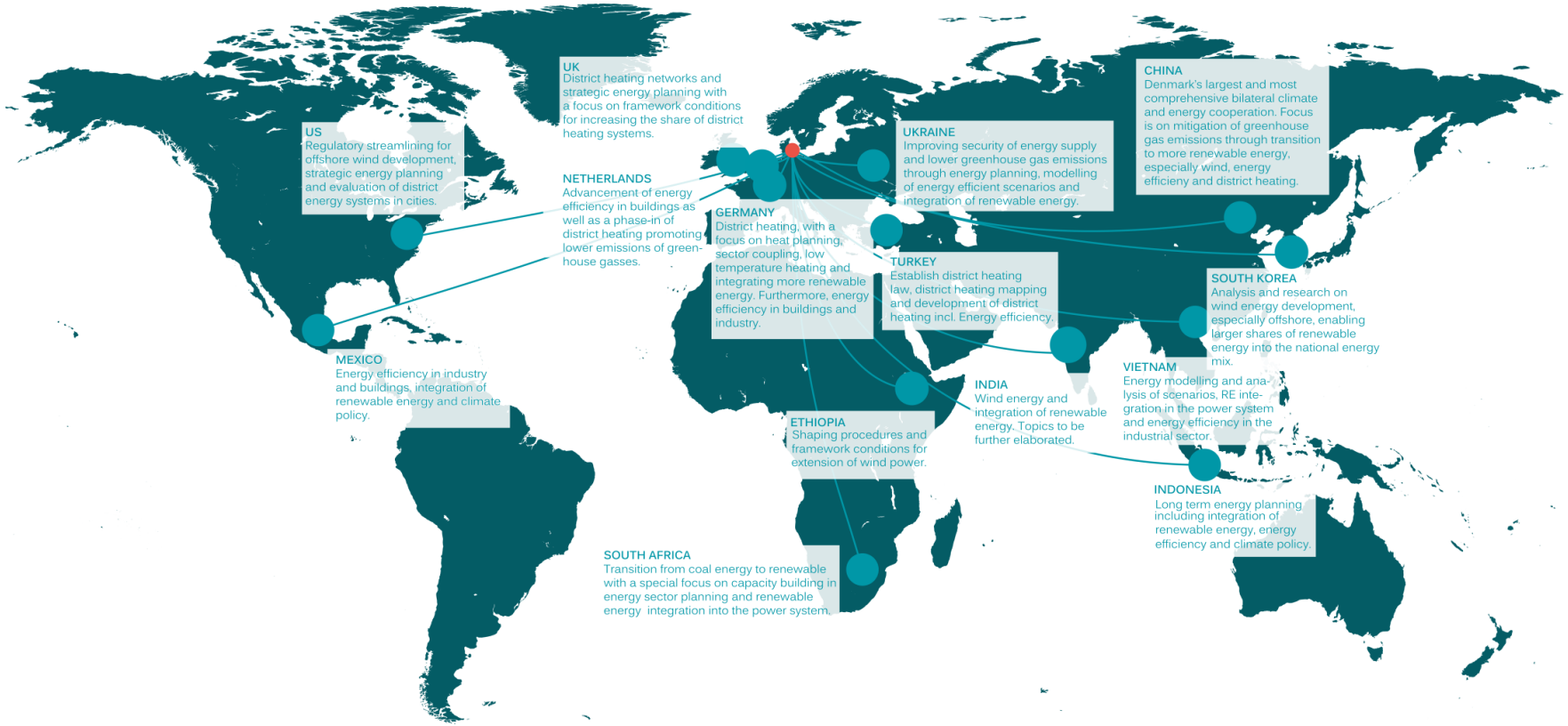
43%

The amount of wind based power used in Denmark in 2015.

Comprehensive expertise

This experience has allowed us to develop the following competencies

- **Electricity sector planning**
- **Heat sector planning**
- **Integrated analysis of the entire energy sector**
- **Model based long term scenario analysis for the energy sector**


UK
District heating networks and strategic energy planning with a focus on framework conditions for increasing the share of district heating systems.
US
Regulatory streamlining for offshore wind development, strategic energy planning and evaluation of district energy systems in cities.
NETHERLANDS
Advancement of energy efficiency in buildings as well as a phase-in of district heating promoting lower emissions of green-house gasses.
GERMANY
District heating, with a focus on heat planning, sector coupling, low temperature heating and integrating more renewable energy. Furthermore, energy efficiency in buildings and industry.
UKRAINE
Improving security of energy supply and lower greenhouse gas emissions through energy planning, modelling of energy efficient scenarios and integration of renewable energy.
CHINA
Denmark's largest and most comprehensive bilateral climate and energy cooperation. Focus is on mitigation of greenhouse gas emissions through transition to more renewable energy, especially wind, energy efficieny and district heating.
TURKEY
Establish district heating law, district heating mapping and development of district heating incl. Energy efficiency.
SOUTH KOREA
Analysis and research on wind energy development, especially offshore, enabling larger shares of renewable energy into the national energy mix.
MEXICO
Energy efficiency in industry and buildings, integration of renewable energy and climate policy.
INDIA
Wind energy and integration of renewable energy. Topics to be further elaborated.
VIETNAM
Energy modelling and ana-lysis of scenarios, RE inte-gration in the power system and energy efficiency in the industrial sector.
ETHIOPIA
Shaping procedures and framework conditions for extension of wind power.
INDONESIA
Long term energy planning including integration of renewable energy, energy efficiency and climate policy.
SOUTH AFRICA
Transition from coal energy to renewable with a special focus on capacity building in energy sector planning and renewable energy integration into the power system.

OUR MISSION

To support emerging economies in combining sustainable future energy supplies with economic growth

The Benefits of long term Energy scenarios

- 40 years experience of long-term energy planning
- Ensures that short-term policies do not conflict with long-term goals
- Scenario based analysis is the best basis for the realistic and cost-efficient transformation of energy systems
- Helps identify future challenges for either short term or long term goals
- Proven results in collaborations with in emerging economies

How we work

Why model based scenarios?

- The best way to form a solid base for decision on **policies** for energy system development
- A tool to identify long-term system **opportunities** and **challenges**
- Set up a **framework** towards green transition and a long-term, sustainable energy future
- Deliver **support** for strategic, operational and political decisions for the future energy systems

Capacity building in partner countries based on long term

Three commonly used models by DEA

	Balmorel	SISYFOS	Times
Sector Compromised	Electricity, CHP, transmission system	Electricity, CHP, heat, transmission system	Energy and environmental analysis of the whole sector
Model Characteristic	Deterministic Bottom up – Top down Partially equilibrium	Stochastic	Bottom up
International consultancy network	Limited	Limited	Global network of consultancies and universities
DEA's opportunity to support	Analytical and operational level	Analytical and operational level	Extensive: Support all types of programming, data managing and analysis

Balmorel

STREAM

LEAP

SISYFOS

DHAT

TIMES

LCoE

Model characteristics

- Used for future projections
- Can analyse energy sector, either as a whole or specific parts
- Collaboration between models in portfolio – many work in conjunction
- Emphasis on open, sharable models
- Support options from DEA and its partners in all models
- Different levels of analysis depth (and time required) possible

Balmorel

Specialised models

DHAT

- Cover specific sectors, specific subjects or smaller scale that is not normally analysed with system-wide models
- Provide much deeper analysis in the specific subject
- Subjects covered by models
  - Optimisation of electricity supply, system and grid (Balmorel)
  - Balmorel Lite tool – Scenario and RE integration
  - Average Lifetime Cost Analysis (LCoE)
  - Electricity security of supply
  - DHAT

LCoE

SISYFOS

STREAM

- Energy system simulation – small, but fast and easy
- Hourly resolution possible for supply, yearly of demand
- Easily accessible – built in Excel with VBA, can run from laptop
- Used in Denmark, multiple institutions
- Exists in multiple languages
- Good for screening of main policies
- Works on single regional/country level
- User friendly – immediate results from changes made

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DHAT

(District Heating Assessment Tool)

- Analyse local DH system and project scenarios
- Hourly resolution
- Simulation model
- Local level model – can as standard only model one DH grid
- Find the cost/benefit of implementing DH in a city (as standard)
- Local language versions in the works with improvements
  - Multiple existing grids in one city
  - Plans to reinvest or scrap
  - Needs to run multiple scenarios
- User friendly – for an energy model
- Used in Denmark, multiple institutions

Energistyrelsen

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Balmorel

- Covers electricity and DH sectors investments, transmission and dispatch
- Optimises investments for electricity and heat generation and transmission in different scenarios
- Simultaneously optimises hourly dispatch of electricity and heat generation and transmission utilisation
- Projects transmission between different nodes, regions or countries
- Hourly resolution through time slices
- Optimises the balance between heat and electricity supply (CHP and PP)
- Provides results on emissions, hourly power prices, system costs, etc.
- Requires specific expertise
- Used by multiple institutions in Denmark and as well as internationally

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SISYFOS

Energistyrelsen

- Security of Supply in the electricity system
  - What causes crisis events?
  - When to optimally stop power plants for maintenance?
  - What does wind and solar do for energy security?

- Simulation through stochasticity
  - Runs ~100K-100M times
  - Randomisation in outage occurrences for generation and transmission
  - Represents supply adequacy compared to the consumption in the hour

- Works on regional, national or international level
- Outage of power lines, powerplant and transformers analysed

- Used in Denmark, multiple institutions

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LCoE

(Levelized Cost of Energy calculator)

- Long-term investment decision analysis
  - Investments in new generation
  - Investments in new energy efficiency technologies
- Calculates and compares the average lifetime costs of providing or saving kWh
- Simulation model
- Compare and select the best technologies in future energy supply and demand on lifetime cost basis
- Socio-economic production costs including externalities
- Based in Excel, open code and desktop friendly
- Used in Denmark, multiple institutions

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Case study Mexico

Helping Mexico to realise its renewable energy potential

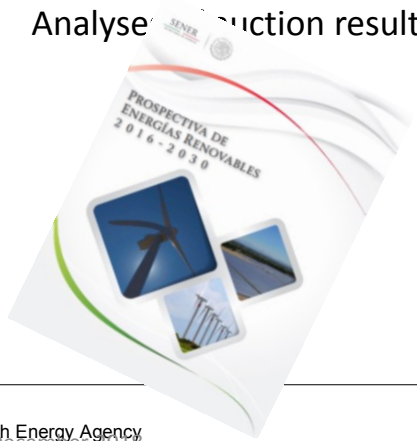
- **Mexico's challenge**
  The energy sector is characterised by limited use of renewable energy and a predominantly natural gas-based power supply.

- **Solution**
  Our cooperation focuses on climate change mitigation, renewable energy and energy efficiency and aims to develop capacity and knowledge in modelling and scenario development.

- **The result**
  Emissions will be reduced by **30% by 2020**. In **2024**, **35%** of Mexico's electricity production will be generated by green energy.

Balmorel in Mexico

- Balmorel scenarios for REO16, REO 2017 and 2018
- Training of Ministry of Energy experts (SENER)
- TSO studies with Balmorel on Business case of transmission) and System flexibility to help integrating
- Transmission system congestion
- Natural Gas studies with Balmorel (effect of import tax)
- Analyses of consequences of a reduced CO_2 cap for Mexico.
- Potentials for a more ambitious decarbonisation
- Analyse[illegible]uction results



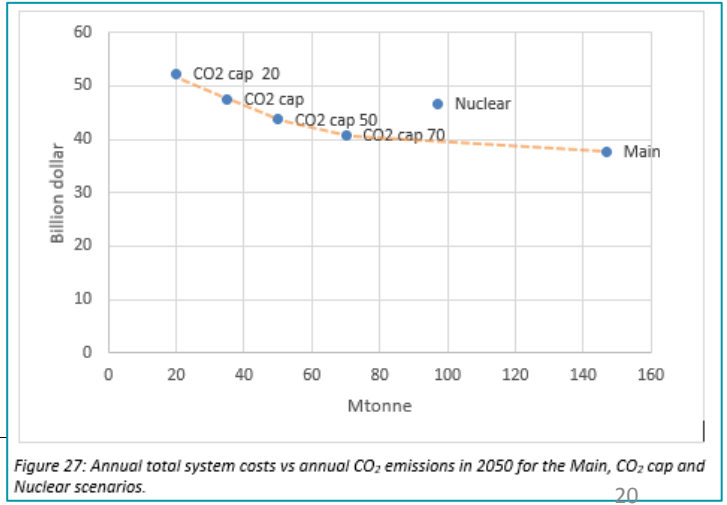
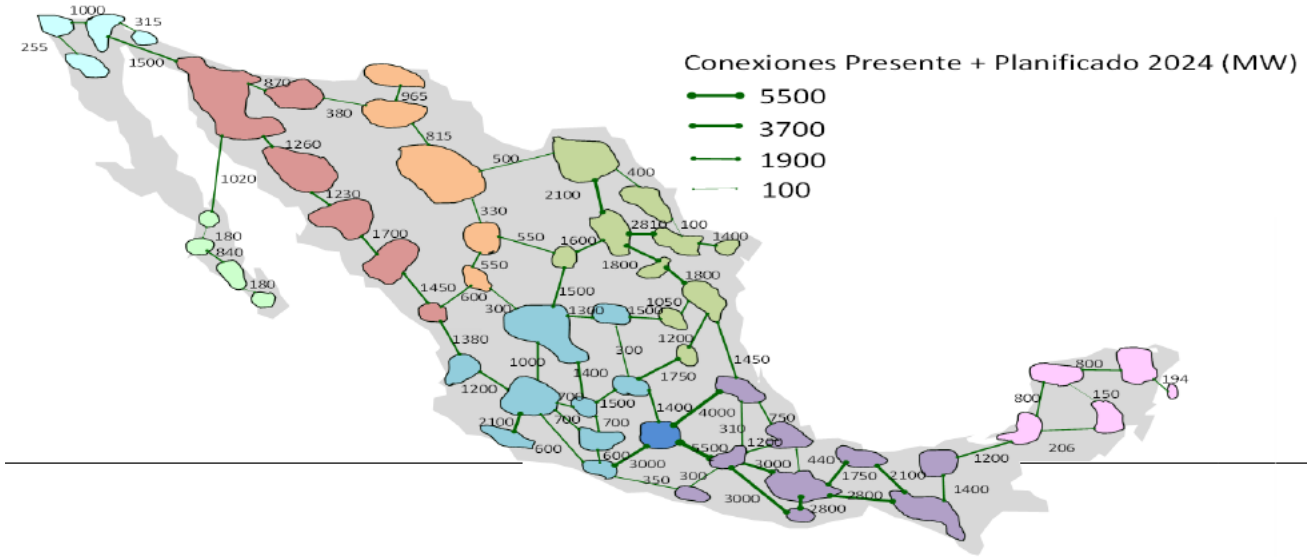


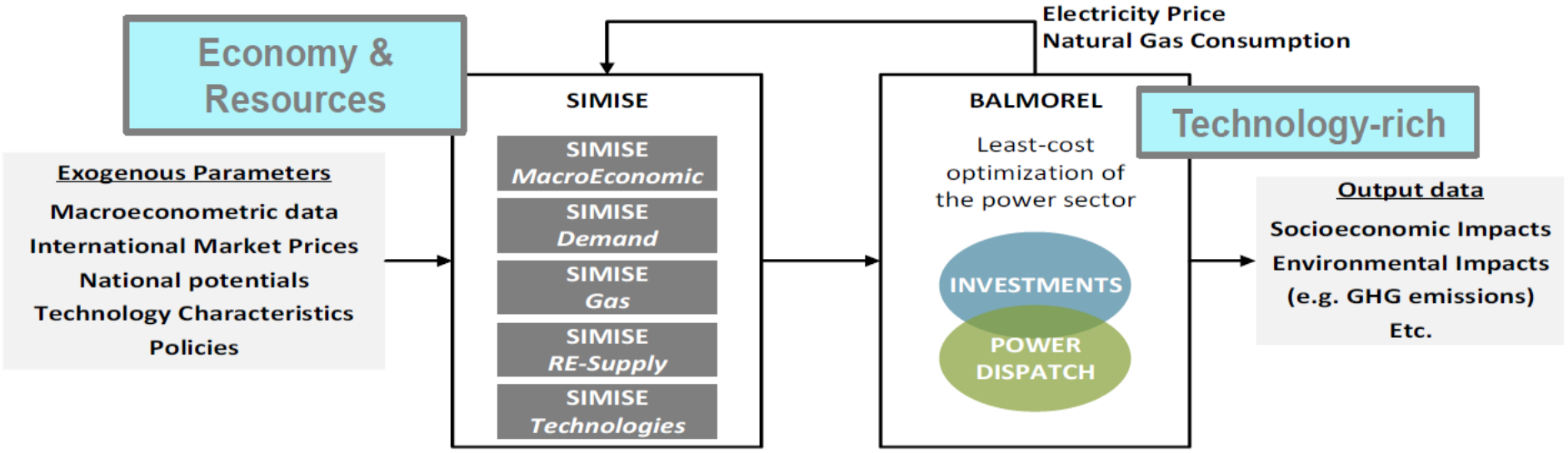
Figure 27: Annual total system costs vs annual CO_2 emissions in 2050 for the Main, CO_2 cap and Nuclear scenarios.

Balmorel for Mexico

53 power areas, exisiting and planned transmission infrastructure



Balmorel and SIMISE



Case study Indonesia

Supporting Indonesia to develop a greener outlook

- **Indonesia's challenge**
  Introducing a stronger planning tradition that can help to proceed from supply side planning to demand side planning.

- **Solution**
  The cooperation is focused on opportunities for integrating renewable energy into future electricity production. The DEA has been involved in the energy planning by providing technical assistance to Indonesia.

- **The result**
  Indonesia's National Energy Council will publish an energy outlook looking into the next five years.

Indonesian context

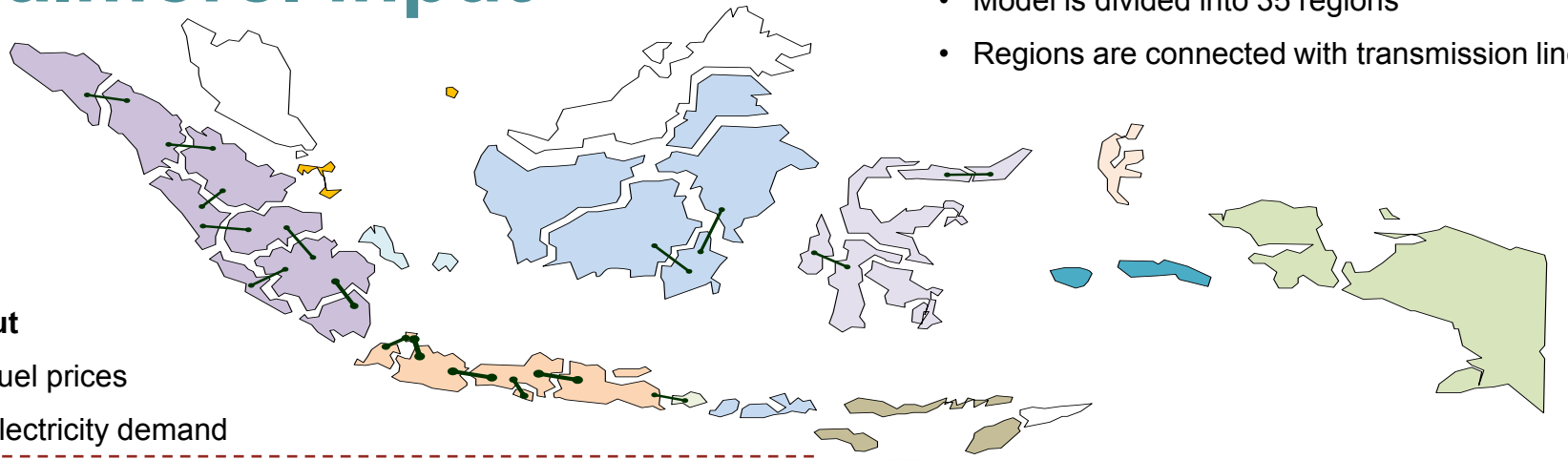
Capacity building of the Balmorel model in the NEC team.

- Implementing Balmorel as a complimentary model to the existing model setup at NEC.
- Develop a model setup together with the NEC team.
- Training and building up extra modelling skills in the NEC team.

Analysing the Indonesian power system.

Balmorel input

- Model is divided into 35 regions
- Regions are connected with transmission lines



Input

- Fuel prices
- Electricity demand
- Technical and economical characteristics of generator types
- Transmission limitations and bottlenecks
- Political goals and visions
- Wind speed profiles and solar capacity factors profiles

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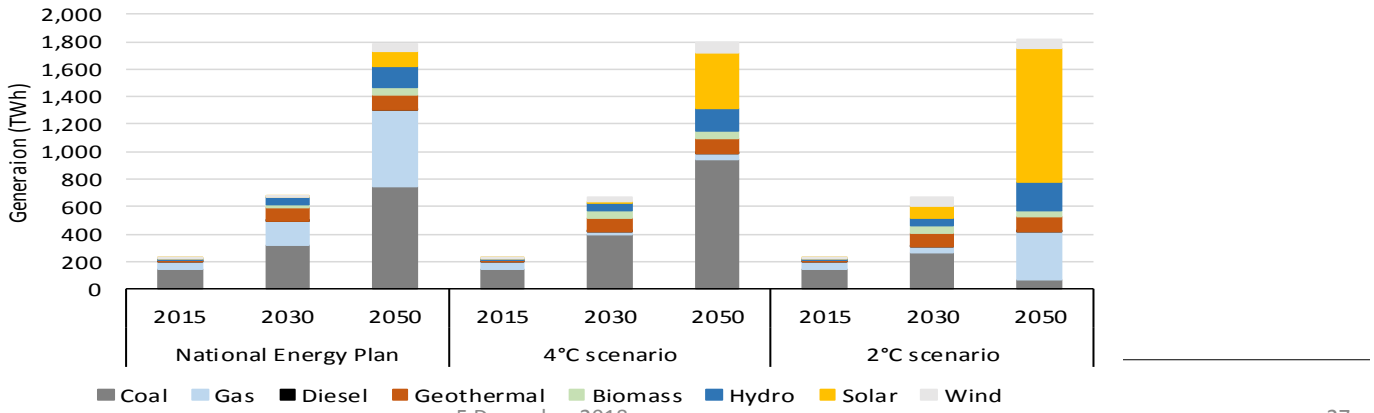
Indonesian 2050 scenarios

- **Reduce CO2** emission by substituting the use of fossil fuels with **renewables**, and/or **substituting coal with gas**.
- Achieving the CO2 reduction requirement in the 2°C scenario requires a very **ambitious integration of renewables** and almost complete **phase out of coal**.
- By 2050 there is almost **700 GW of solar PV** installed in Indonesia, and 130 GW **(520 GWh) of storage** to help integrate fluctuating production
- The 4°C scenario and the National Energy Plan exhibits the lowest electricity costs when **externalities are not considered**. When externalities are considered, Now the **2°C scenario has the lowest electricity cost**



Case study Vietnam

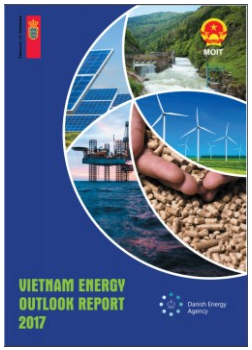
Supporting Renewable Energy And Energy Efficiency In Vietnam

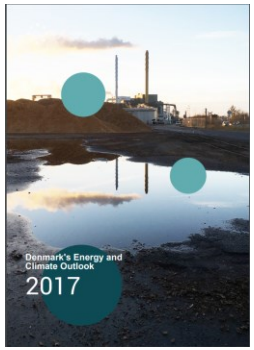
- **Vietnam's challenge**
  As a fast growing economy Vietnam experiences a rapid growth in energy consumption with double digit growth rates for electricity consumption.

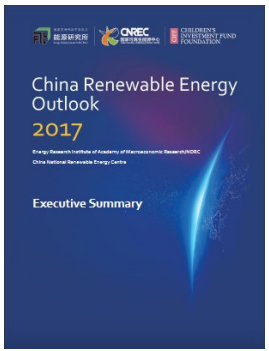
- **Solution**
  Our cooperation focuses on power sector scenario modelling, integration of renewable energy and energy efficiency.

- **The result**
  In September 2017 MOIT and DEA have jointly published the Vietnamese Energy Outlook Report 2017. It is expected a new EOR to be jointly published by 2019.

Want to learn more?







Download the Danish Energy Model leaflet

https://ens.dk/sites/ens.dk/files/contents/material/file/the_danish_energy_model.pdf

Access Balmorel Lite tool

https://ens.dk/en/our-responsibilities/global-cooperation/balmorel-lite

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