



# RE Expansion and Integration Possibilities in Vietnam: Future Perspectives

*- Insights from long-term power system development  
scenario study using the Balmorel model*

**November 29 / December 1, 2016**  
**HaNoi / HCMC, VietNam**

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**Ea Energy Analyses**

# Ea Energy Analyses



- Private company
  - Started in 2005
  - Background in the Danish Transmission System Operator, TSO
- Models
  - Balmorel: Economic expansion of large electricity systems (investment and dispatch, perfect foresight)
  - SisyfosR: Security of supply (stochastic)
- A number of power system development and RE integration projects internationally
  - China, EAPP (12 countries), Europe, Mexico, US (NE US and Eastern Canada), Vietnam

# THE PROJECT: A BRIEF OVERVIEW

# Goals of the project

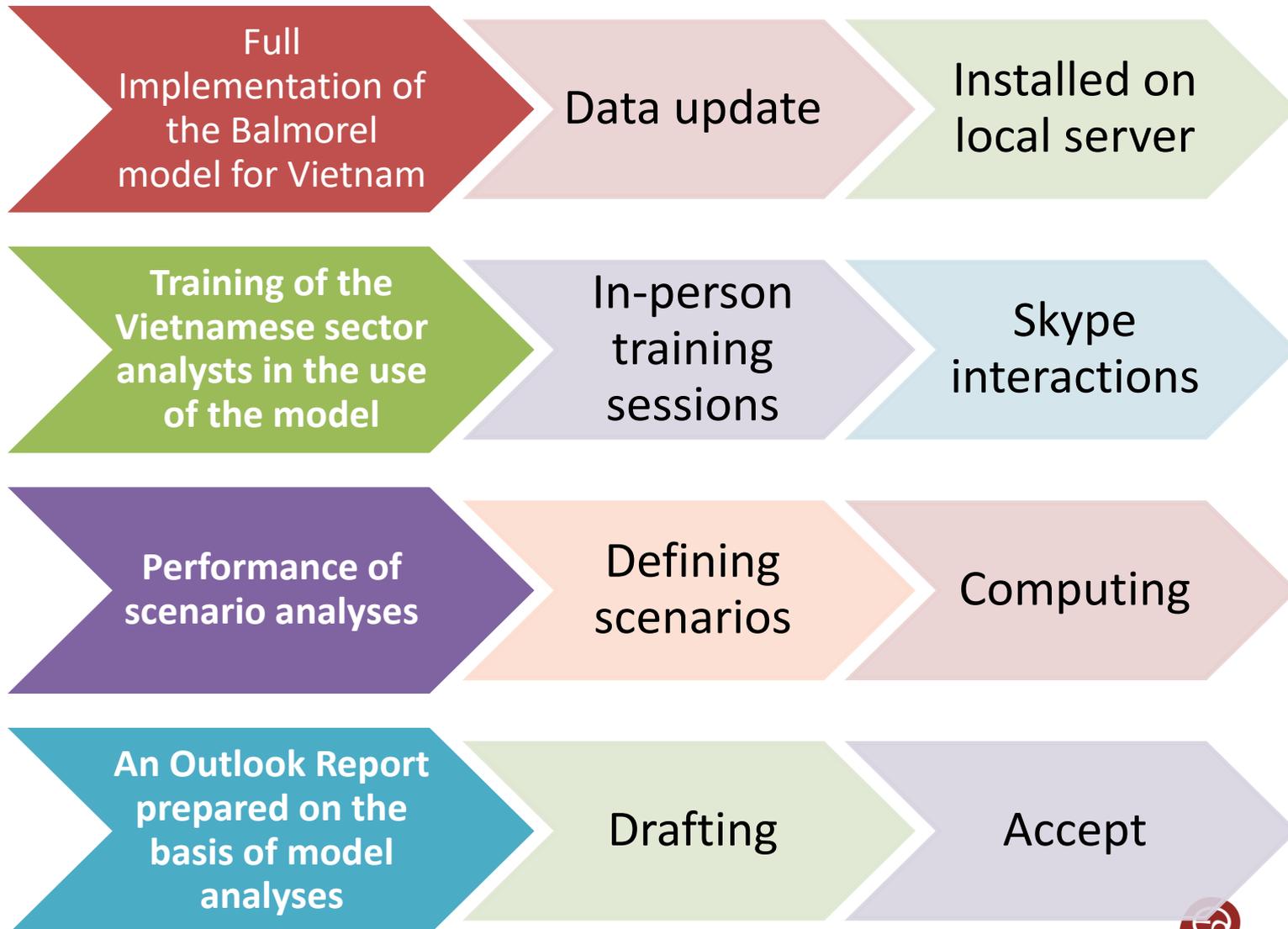
- Develop long-term energy scenarios for the Vietnamese electricity system
  - 2016 – 2050
  - Many alternative scenarios: provide insights into multiple ‘possible futures’ and address uncertainties
  - Model-based investments
  - Focus on costs and benefits and integration of renewable energy
  - Demonstrate that the approach can be used for PDP8
- Deliver ‘Outlook Report 2016-2050’ based on the modelled scenarios
- Knowledge sharing and capacity-building

# Project composition

- Steering group
  - MOIT
  - Danish Energy Agency
  - Danish Embassy
- Consultants
  - Ea Energy Analyses (international consultants)
  - Institute of Energy (local consultants)



# The project on one page



# Project status

- Fully functional Balmorel model set-up for Vietnam has been completed
  - Selected data refinements and final review in progress
  - Estimates and assumptions used for RE resource potential representation
    - RE resource quantification study (supported by GIZ) awaiting approval
- Local training sessions of the Vietnamese experts in the use of the Balmorel model carried out
- Local access and operation of the Balmorel model at the IE fully established
  - Server with full Balmorel model and database functionality set up at IE
- Set of scenarios for the Outlook Report selected
- **NB!** Preliminary results as project is still in progress!

# OUTLOOK REPORT

# Outlook Report: Background



- Vietnamese power system facing significant opportunities and challenges
  - Rapid demand growth expected
  - Reliance on (imported) fossil fuels and their prices – with the associated CO2 emission growth
- Decisions made today will have long-lasting consequences
  - Uncertainty regarding a number of key drivers (future power demand, fuel and technology costs and availability etc.)
- Investigating the system-wide outcomes of a number of possible ‘futures’ can assist in making informed decisions today
  - Model-based scenario analyses provide an objective and impartial research framework

# Outlook Report: Concept



- Provide a number of alternative scenarios alongside PDP 7
  - Addressing the sources of future uncertainties (fuel prices, power demand)
  - Analysing the system-wide effects of alternative policies (e.g. different RE goals, CO2 prices, alternative support schemes)
- Illustrate and quantify the possible alternative futures
  - System capacity, generation, transmission
  - Power prices, fuel use, CO2 emissions
- Provide informed insight on the potential alternatives and give inspiration / support to the next PDP development process

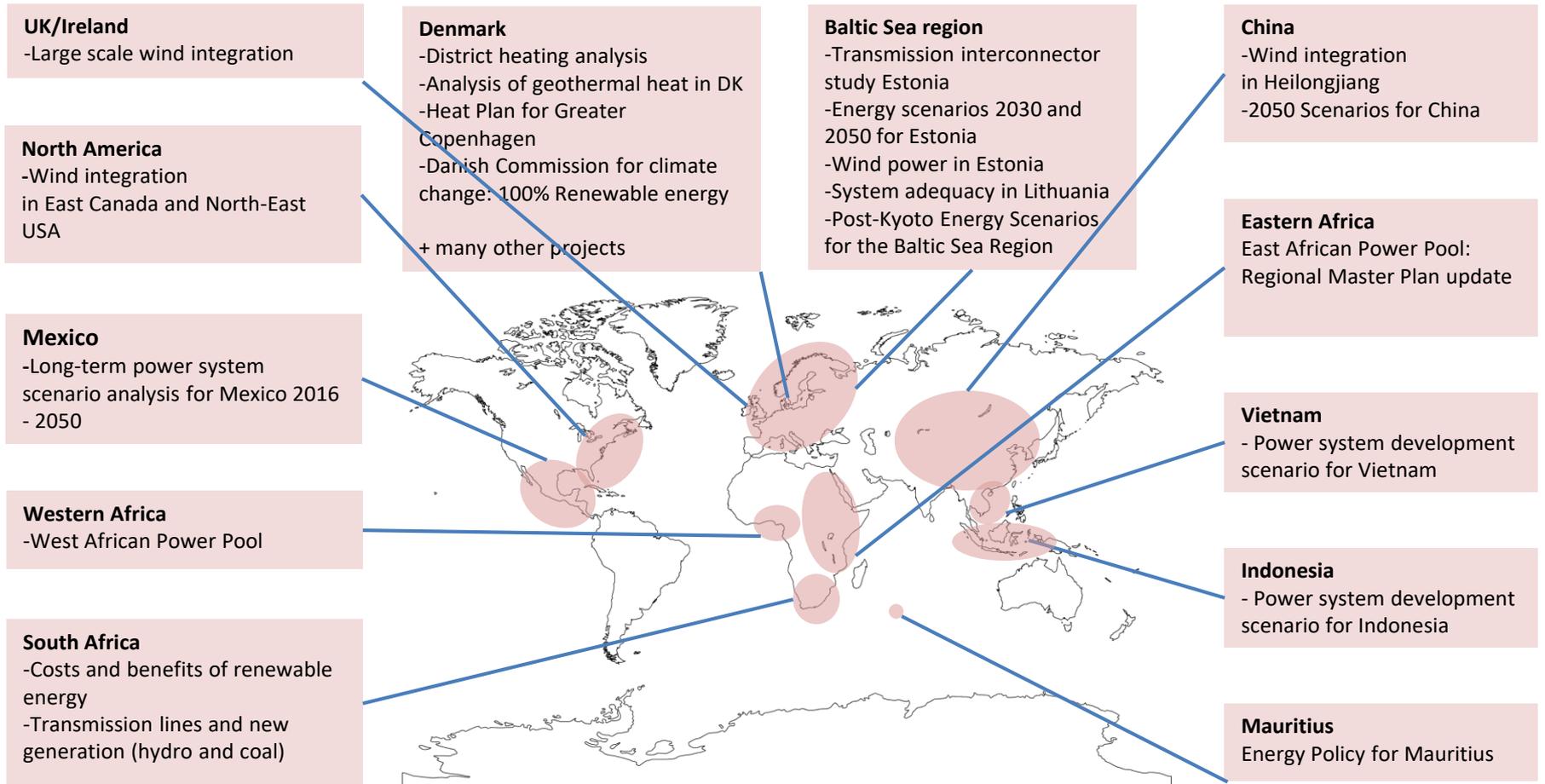
# THE BALMOREL MODEL: A BRIEF OVERVIEW

# Balmorel model



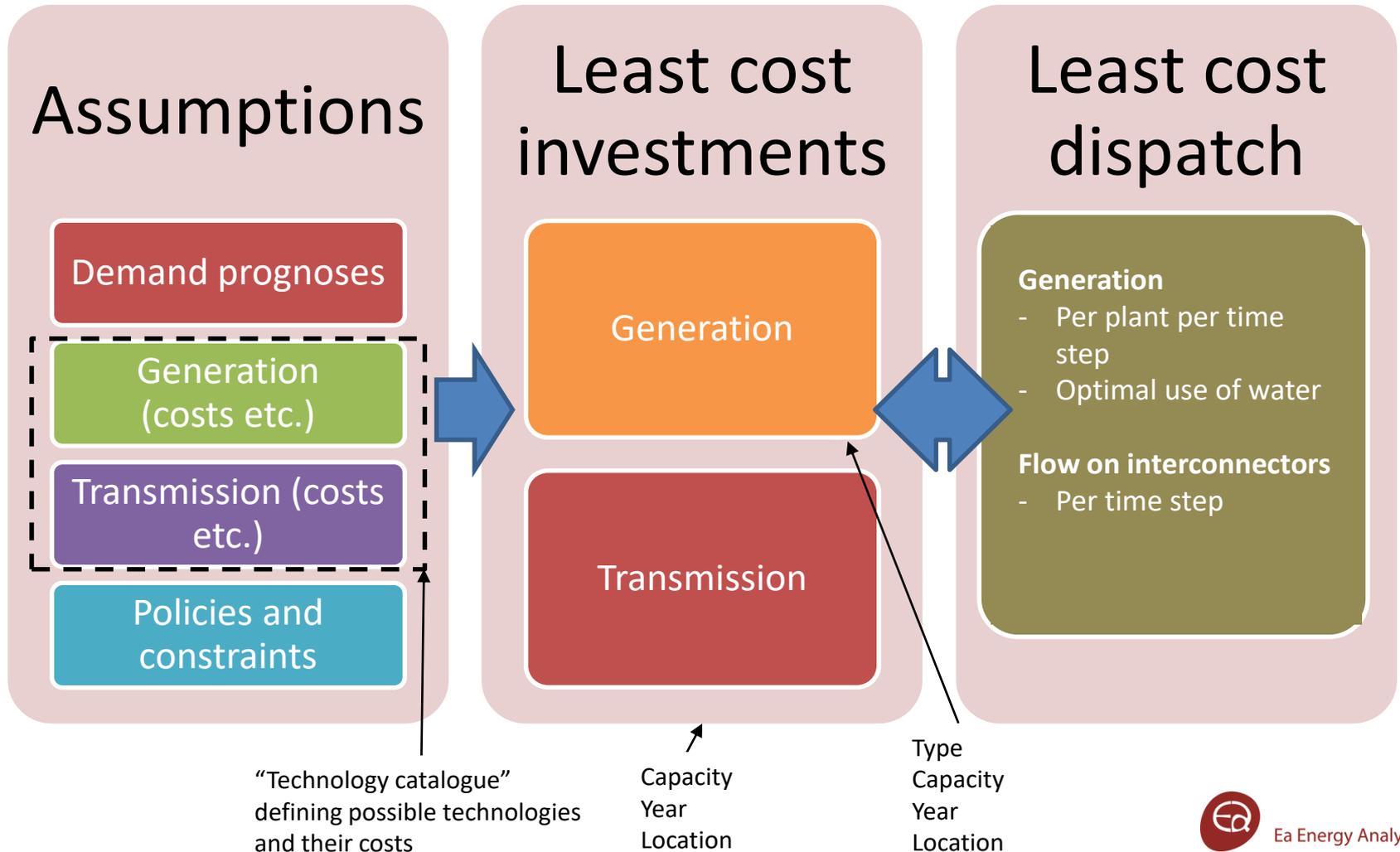
- Least-cost optimization model
  - Investment optimization for generation and transmission
  - Economic dispatch
  - Covers power, heat and transmission, as well as storage
- First version developed in 1999-2001
  - Continuous improvements
- Transparency
  - Open source: [www.balmorel.com](http://www.balmorel.com)
  - Requires a commercial solver: GAMS
    - GAMS = General Algebraic Modeling System, a high-level modeling system for mathematical programming problems ([www.gams.com](http://www.gams.com))
- Flexibility
  - Possible to implement new policies, policy objectives, technologies and other considerations
- Transferability
  - Adaptation with local data

# The Balmorel model



See: [www.eaea.dk/themes/111\\_theme\\_modelling\\_of\\_energy\\_systems.html](http://www.eaea.dk/themes/111_theme_modelling_of_energy_systems.html) for project description and reports

# The Balmorel model



# Baltimore VietNam model

- Process started in July 2015
- Draft model development and training commenced in October 2015
- Continuous data and model updates and operator training
  - July 2016: Data update and Baltimore operator training
    - PDP7 data implemented, further updates
  - October 2016: Data and model update and Baltimore operator training Local server setup completed
    - PDP 7 final data updates and scenarios

# INPUT DATA AND SCENARIOS

# VietNam Balmorel model: Input data

- The Balmorel VietNam model is fully functional
  - Populated with the best data available
  - Estimates and assumptions used where accurate data not available / pending
- Key input data categories in the model:
  - PDP VII Revised generation expansion plan per individual units
  - Large hydro reservoir plants represented individually, along with their reservoir storage capacity
  - Existing regional transmission - and committed expansion plans
  - Power demand projections as per PDP VII Revised – and extrapolation towards 2050
    - Gradually decreasing demand growth rate towards 2050
    - Regional hourly load profiles
  - Domestic coal and natural gas resource potentials and costs
  - Fuel costs: existing and projections towards 2050

# VietNam Balmorel model: Input data (2)

- Technology 'catalogue' with the characteristics and costs of existing and projected power generation technologies towards 2050
  - Learning curves for cost / performance most notably represented for wind and solar PV
- RE resources represented
  - Small hydro regional potentials, large hydro individual investment candidates and the respective inflow profiles
  - Biomass national potential estimates per type and technology, main feedstock costs
  - Wind speed / solar PV production hourly profiles for wind and solar PV per location / region
  - Wind and solar PV national resource potentials currently based on estimates

# Core scenario descriptions

## PDP 7

- PDP 7 capacity exogenous until 2030
- No investments
- Runs in 5-year periods until 2030
- No RE goals
  - The current results indicate RE goals cannot be met in 2030

## Main

- PDP 7 capacity exogenous until 2020
- Investments allowed
  - Generation from 2020
  - Transmission from 2030
- Runs in 5-year periods until 2050
- RE goals in line with RE Strategy

# Scenarios: Overview



- PDP 7 generation and expansion plan represented until 2020
- Model given 'freedom to optimize' thereafter



- PDP 7 generation and transmission expansion plan represented in its entirety
- Dispatch model run only

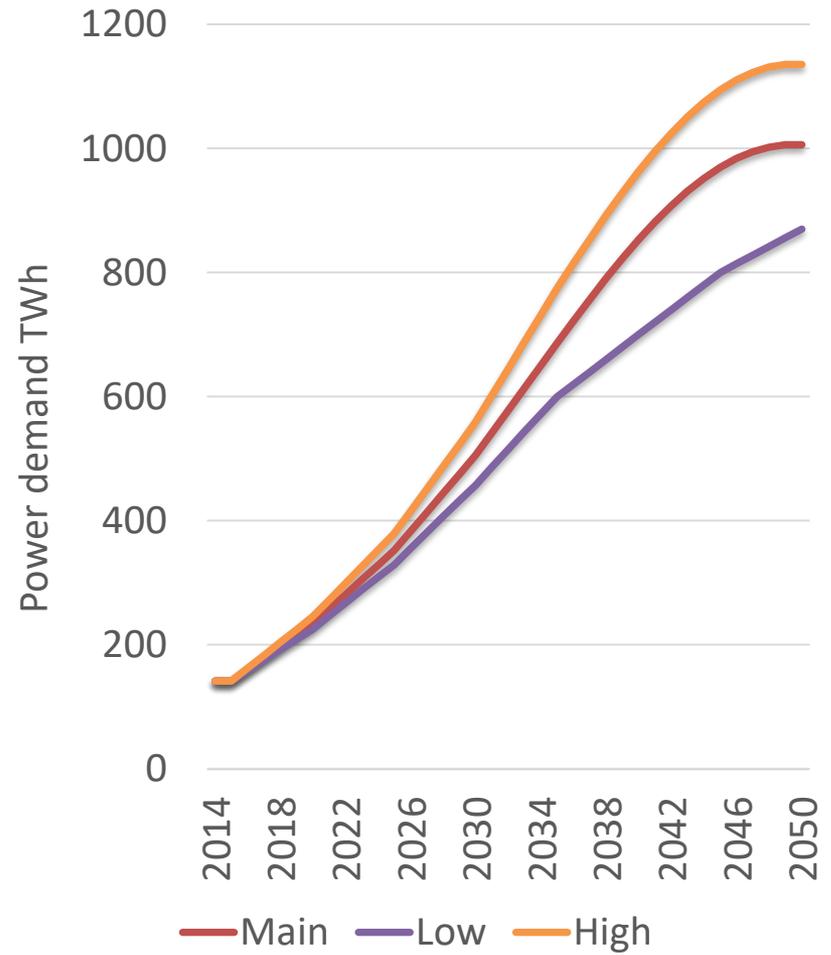
# Scenarios: Overview

Alternative scenarios based on the Main scenario simulated investigating 'alternative futures', parameter variations and different policy options.



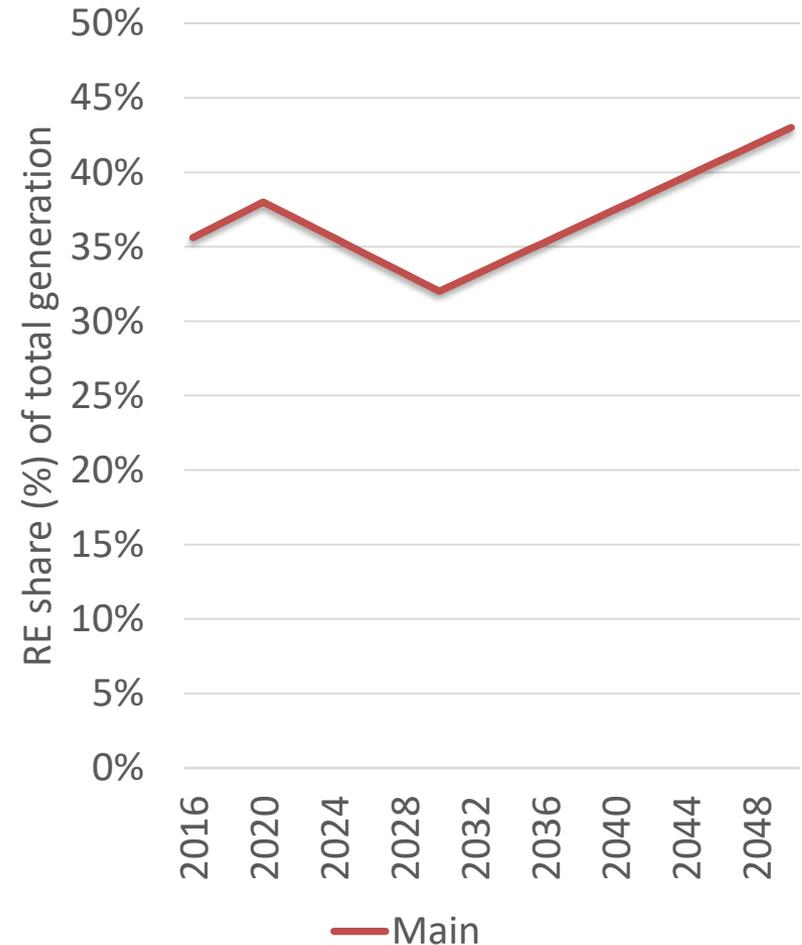
# Demand projections in the scenarios

- Main
  - PDP 7 revised until 2030
  - Gradually decreasing growth rate thereafter (reaching 0% in 2050)
- High Demand
  - As per PDP 7 revised
  - Gradually decreasing growth rate thereafter (reaching 0% in 2050)
- Low demand
  - Based on WWF / IES study
  - BAU projection



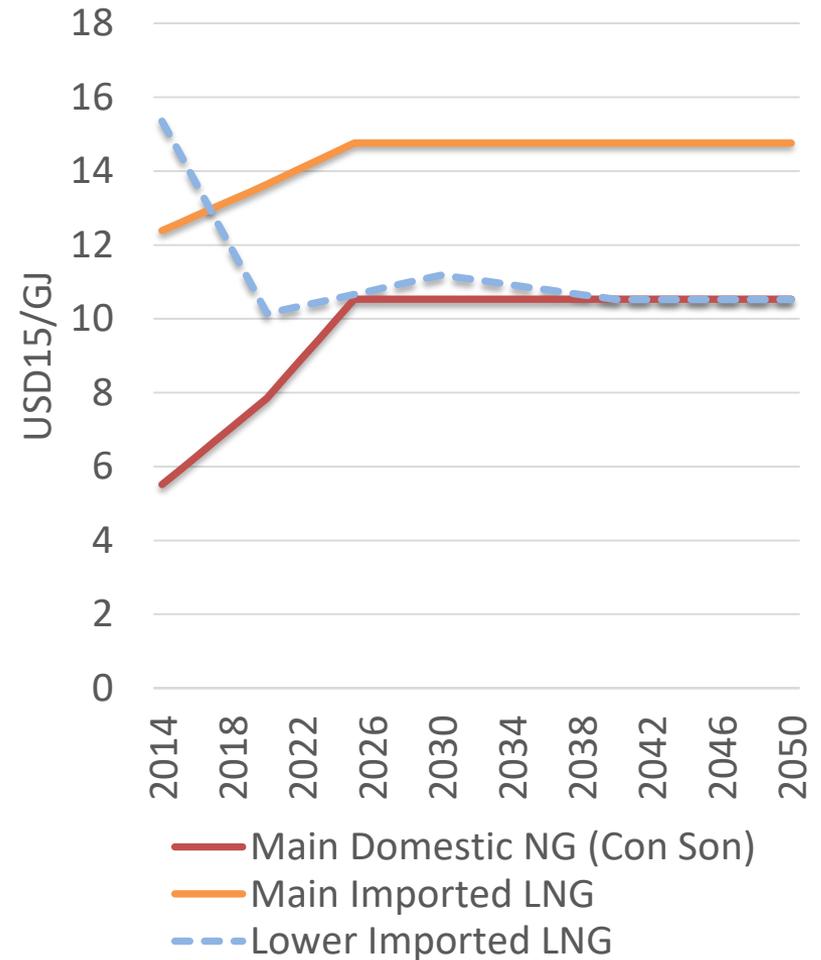
# RE goals in the scenarios

- Main
  - RE goals in line with the RE Strategy
- Unrestricted
  - No RE goals
  - The BAU scenario



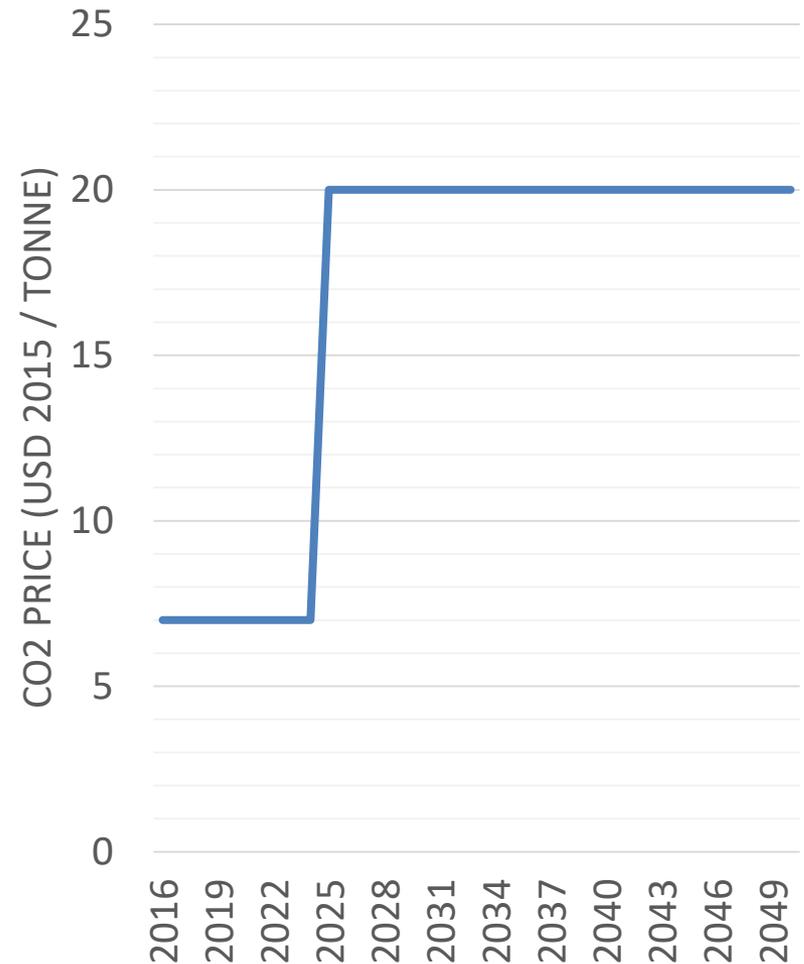
# Fuel price and policies in the scenarios

- Low NG price
  - Natural gas price (LNG imports) follow the IEA WEO 2015 450 PPM scenario
- No Coal
  - No investments in coal-fired technology allowed as of 2035



# CO2 price in the scenarios

- CO2 price
  - 7 USD/tonne in 2020, 20 USD/tonne thereafter
  - No RE goals as CO2 price is a policy alternative



Based on preliminary work-in-progress results

## **KEY TAKE-AWAYS**

# Balmorel scenario analysis: Key take-aways

- PDP VII Revised might not be able to meet the RE Strategy goals in 2030
- Importance of the planning assumptions for the development of the power system – and assessment of what is ‘feasible’
  - Natural gas price
  - Demand growth
  - RE resource potentials
- Importance of transmission capabilities in RES integration
- Following the RE Strategy targets will achieve the Green Growth Strategy (GGS) goals in the long-term
  - GGS goals not met in the short- to medium-term

## Balmorel scenario analysis: Key take-aways (2)

- Implications of different policy choices
  - RE targets do not affect the rest of the system -> more limited impact on CO2 emissions
  - Policies addressing CO2 emissions / costs directly could more efficiently achieve both RE and CO2 emission reduction ambitions
  - Intuitively, ‘No Coal’ scenario identifies the most critical driver of CO2 emissions
- Economic results indicate RE goals could be achieved at a relatively modest additional cost compared to the BAU scenario (‘Unrestricted’)
  - Higher CapEx outweighed by lower fuel expenditure
- Current results indicate that the Vietnamese power system could successfully integrate very significant shares of RES generation

# NEXT STEPS

# Next steps

- Complete data refinement and review, most importantly:
  - RE resource potentials
  - Demand projections towards 2050
- Produce the final set of modelled scenario results
- IE / local experts to continue use of the Balmorel model to achieve independent operational proficiency
- Outlook Report to be published in May 2017

# RE resource mapping study

- Supporting activity aimed at quantifying the wind resource potential in Vietnam supported by GIZ
  - Scheduled to commence shortly
- Outcomes of this study to be used in the current project
  - Wind resource potential estimates per region and area-specific wind power investment costs
  - Solar PV resource potential estimates per region and area-specific solar PV investment cost, as well as hourly production time series
    - Based on the outcome of the World Bank's study to be completed by December 2016
- Expected project completion: April 2017



## Thank you!

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