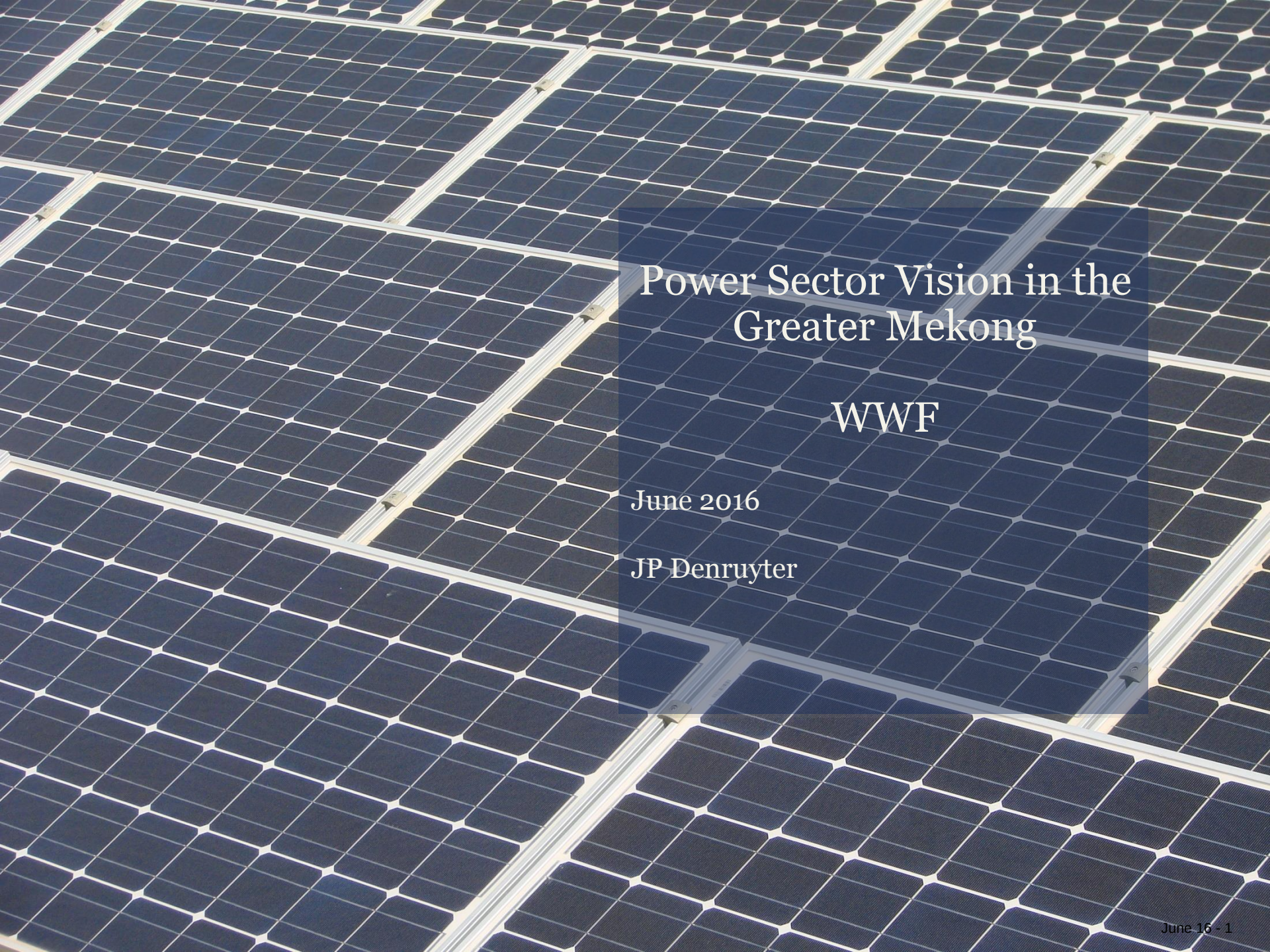
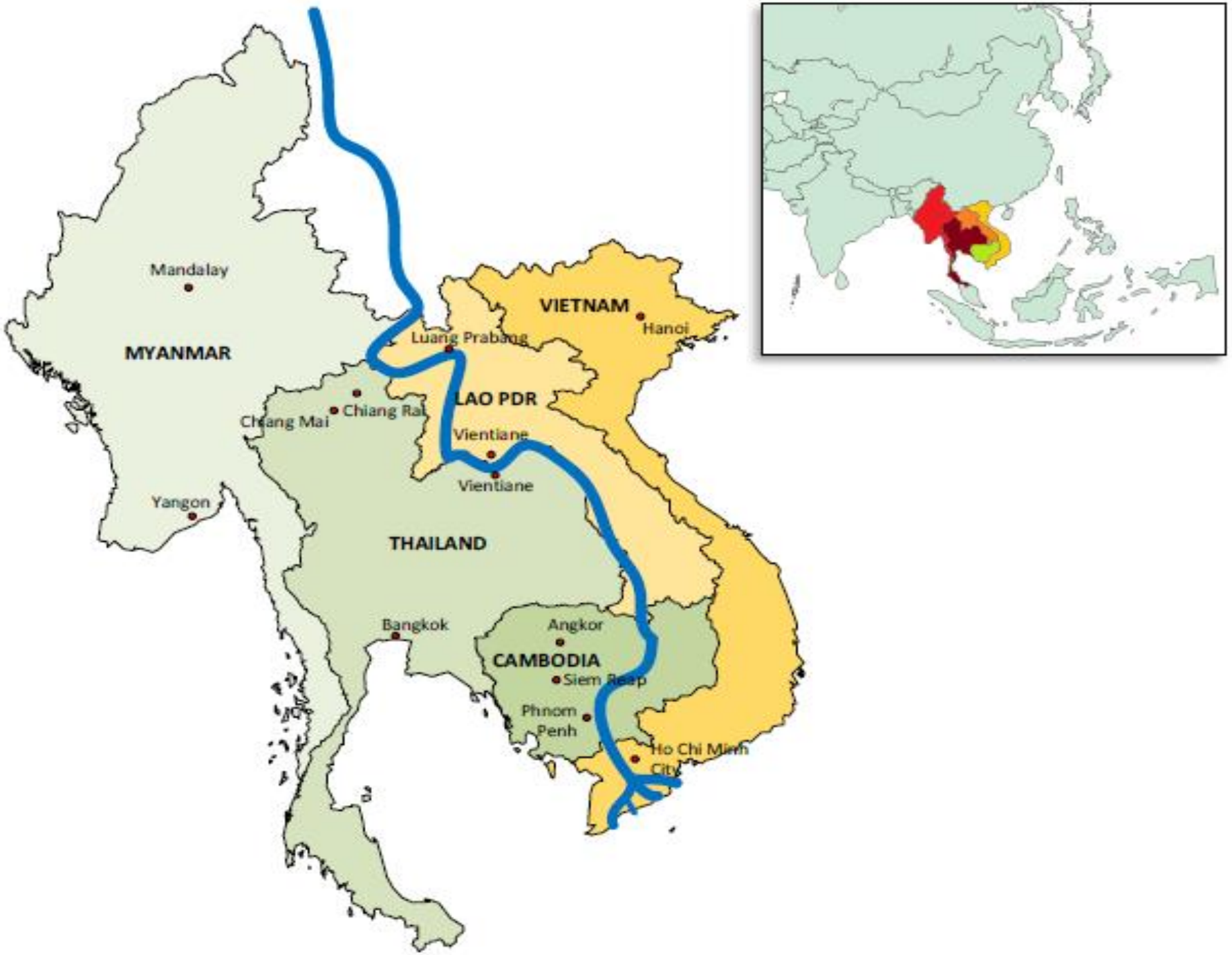


Power Sector Vision in the Greater Mekong

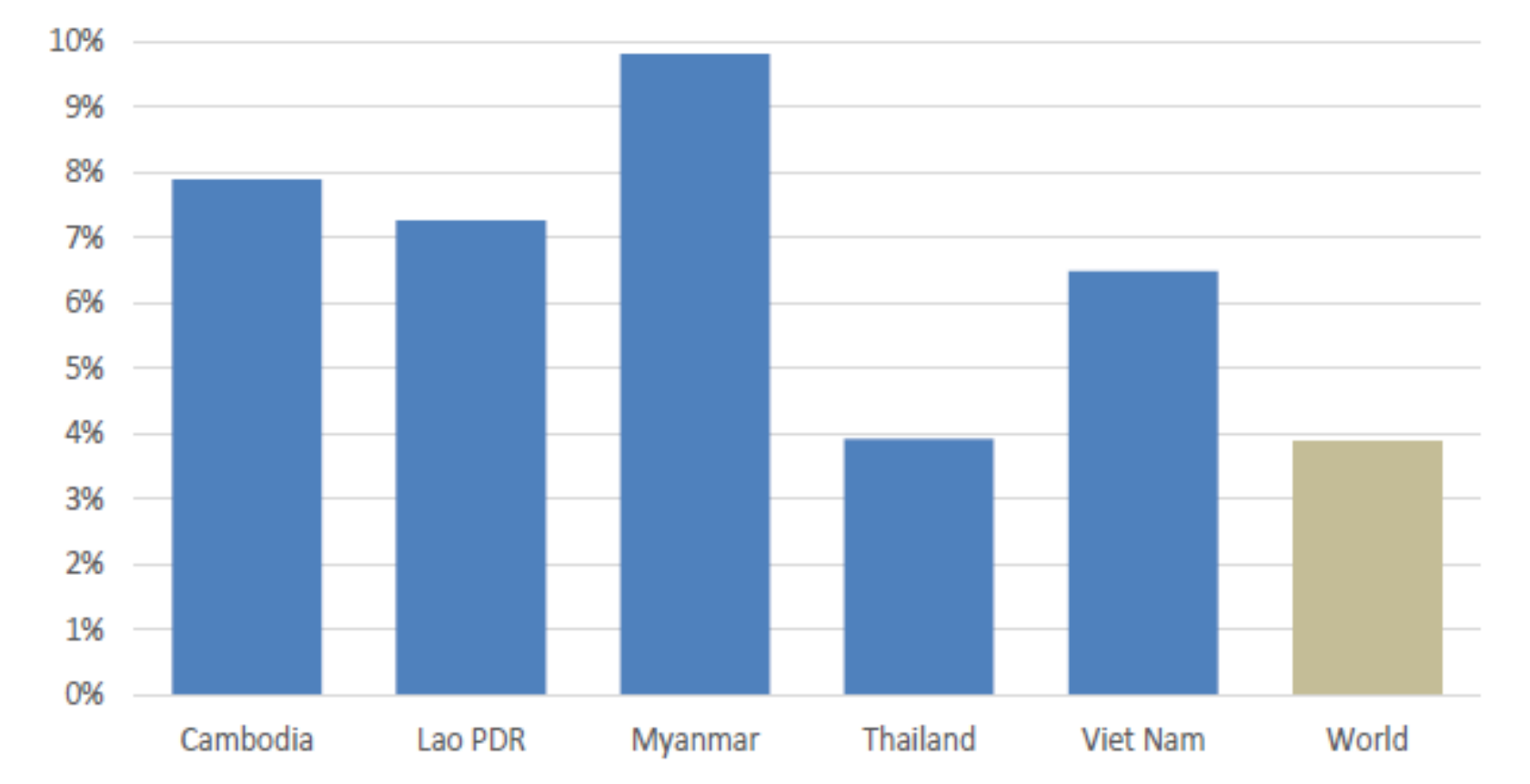
WWF

June 2016

JP Denruyter


Mandalay
MYANMAR
VIETNAM
Hanoi
Luang Prabang
LAO PDR
Chiang Mai
Chiang Rai
Vientiane
Vientiane
Yangon
THAILAND
Bangkok
Angkor
CAMBODIA
Siem Reap
Phnom Penh
Ho Chi Minh City

Average real GDP growth 2000 - 2014



Electricity demand and growth rates

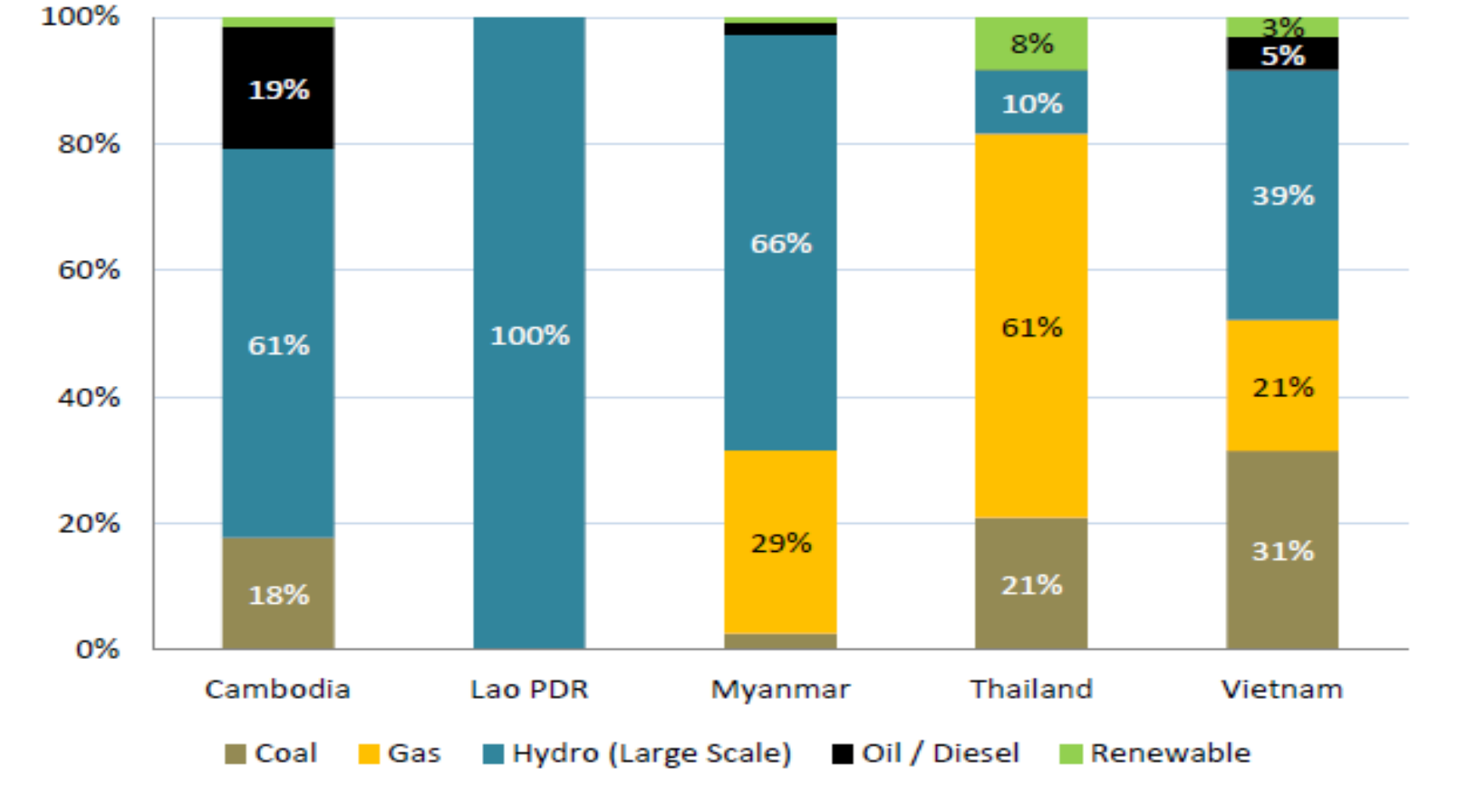
Country	Electricity Consumption		Peak Demand	
	TWh	CAGR[3], %	MW	CAGR[4], %
Cambodia	4.2	19.4%	687	16.0%
Lao PDR	3.4	14.5%	748	12.5%
Myanmar	9.6	15.7%	2,235	16.2%
Thailand	168.2	4.4%	26,942	2.9%
Viet Nam	142.3	12.7%	22,100	10.2%

- CAGR for electricity consumption is for the last ten years for Cambodia, Lao PDR, and Viet Nam, last five years for Myanmar and twelve years for Thailand.
- CAGR for peak demand is for last five years for Cambodia, Myanmar, and Thailand, ten years for Lao PDR and Viet Nam.

Electrification rates (2014)

Country	Population without Access to Electricity (millions)	Electrification Rate[5] (%)	Urban Electrification Rate (%)	Rural Electrification Rate (%)
Cambodia	9.2	39%	90%	24%
Lao PDR	0.8	89%	98%	83%
Myanmar	38.1	26%	40%	20%
Thailand	0.2	100%	100%	99%
Viet Nam	1.9	98%	100%	97%

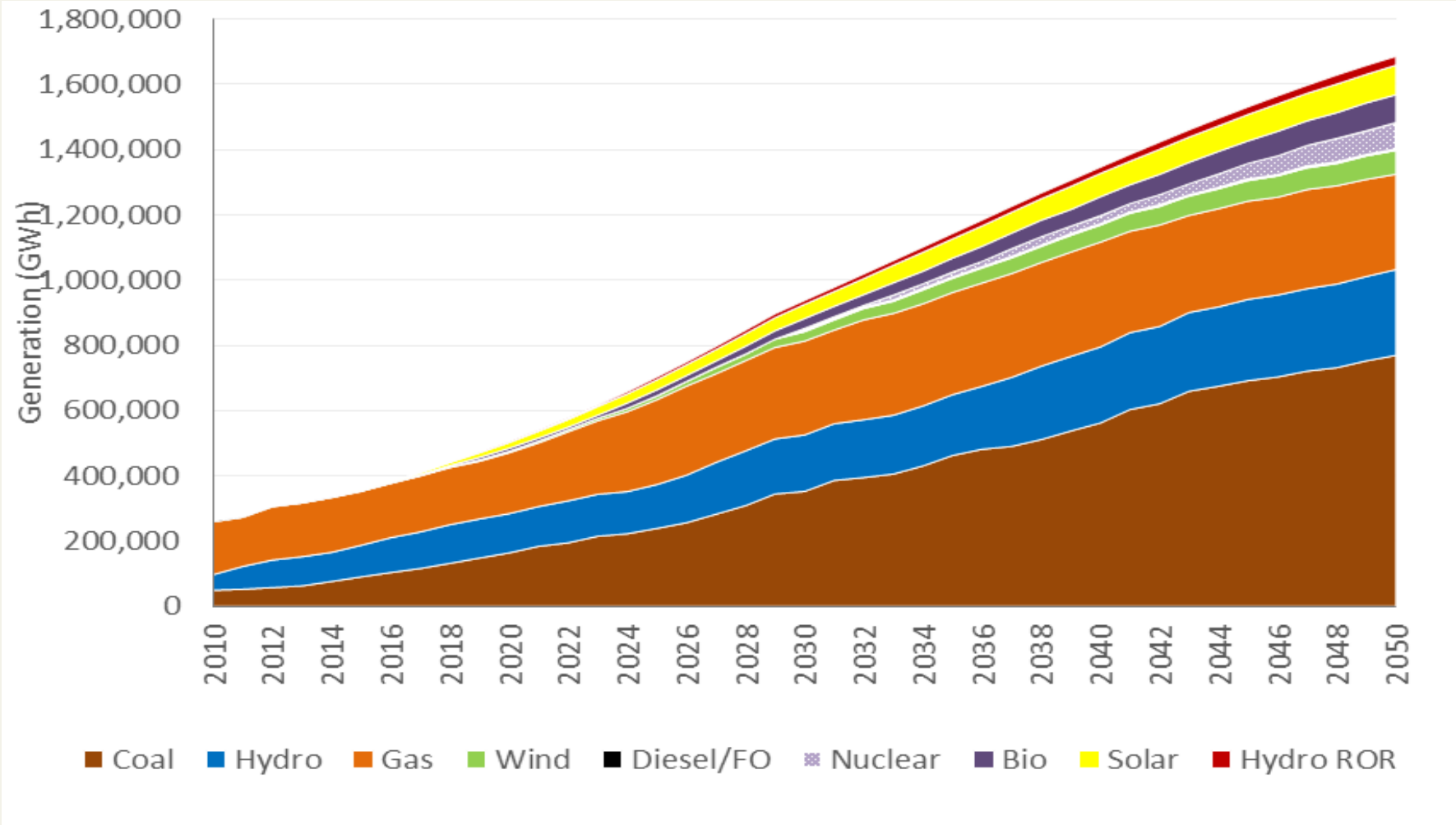
Installed capacity by technology/fuel (2014)



The future for the power sector in the Greater Mekong

- Huge electricity consumption growth
- Hydro – not much potential left in Thailand and Viet Nam but large potential in Cambodia, Lao PDR and Myanmar – high environmental and social impacts
- Coal – available but poor quality and difficult locations. Imports planned.
- Gas – over 1000 Bcm in region.
- Great wind, solar and biomass potential

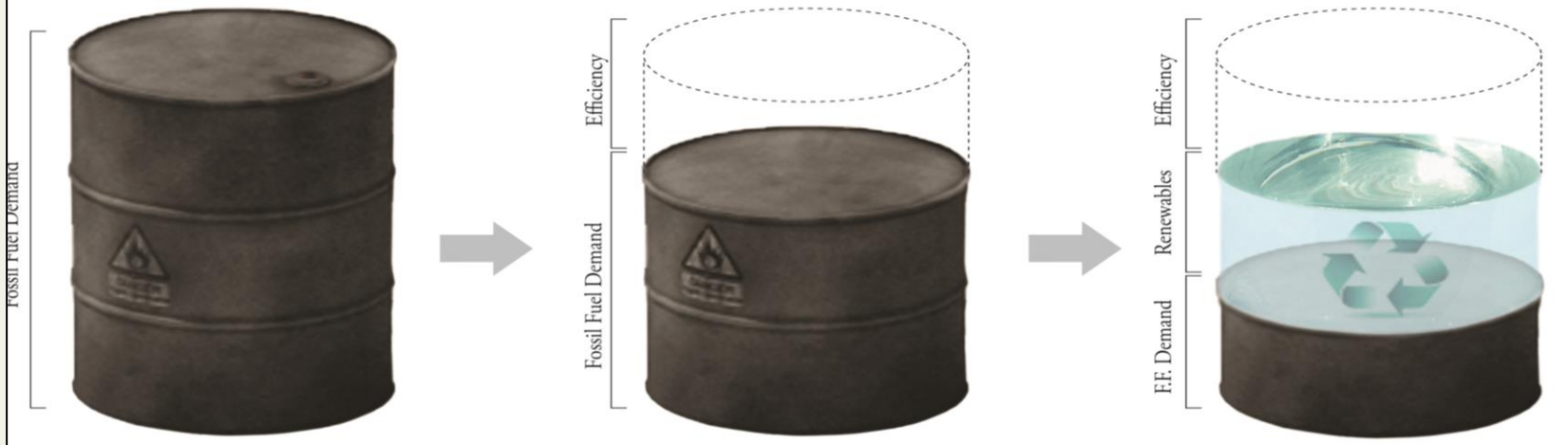
Greater Mekong future generation mix (BAU)



Is that a good future?

- Health Impacts - $0.014 - $0.17/kWh (Buonocore et al., 2015)
- Over 780 million tonnes of CO2eq emissions per year in 2050
- 50% of electricity produced with imported fuel (outside of Mekong region) by 2050

Alternative for the region?



ENERGY DEMAND

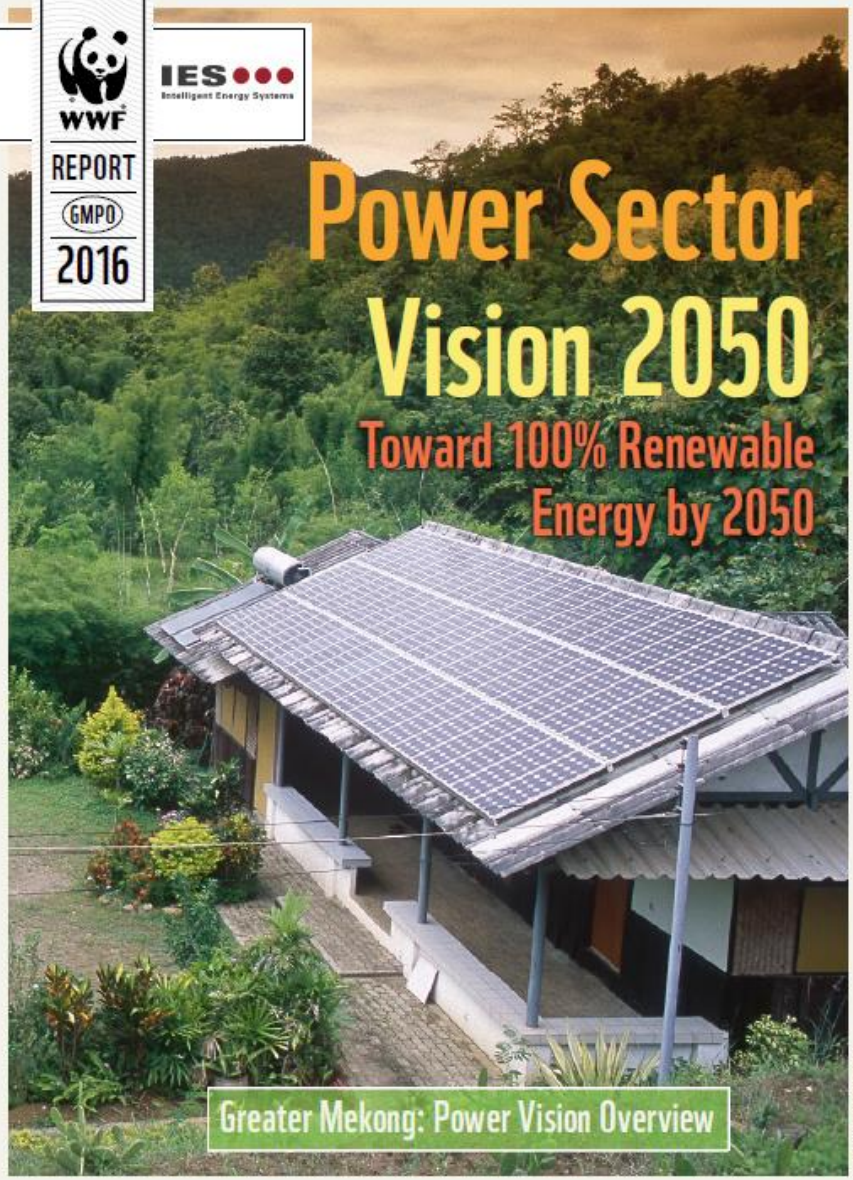
2010

LIMTED ENERGY DEMAND THROUGH RATIONAL USE

2020

USE RENEWABLES TO OFFSET REMAINING DEMAND

2030

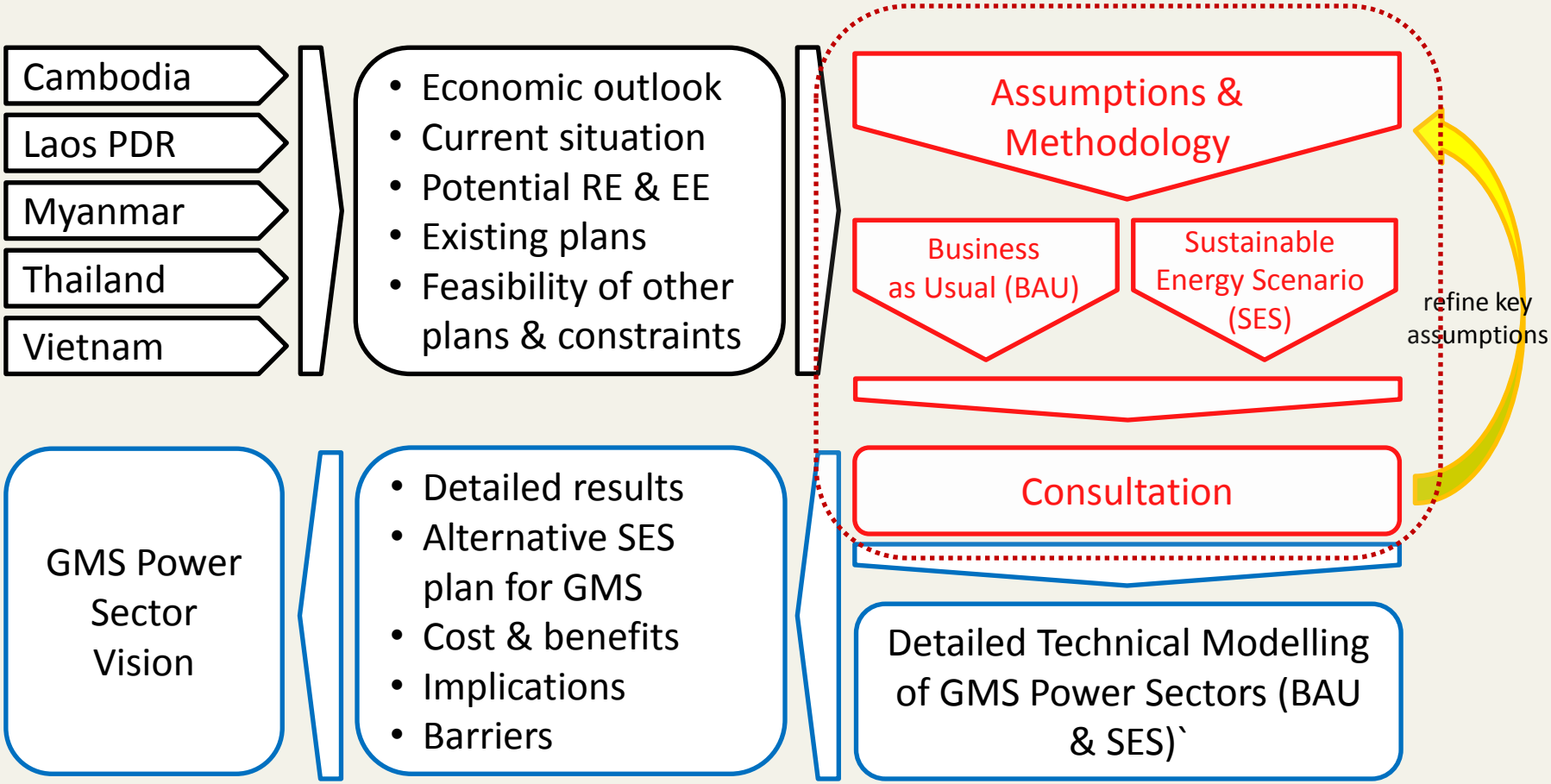


Analyse technically and economically whether the power sector can shift to a power mix largely based on renewables and efficiency.

Multi-stakeholder project with consultations.

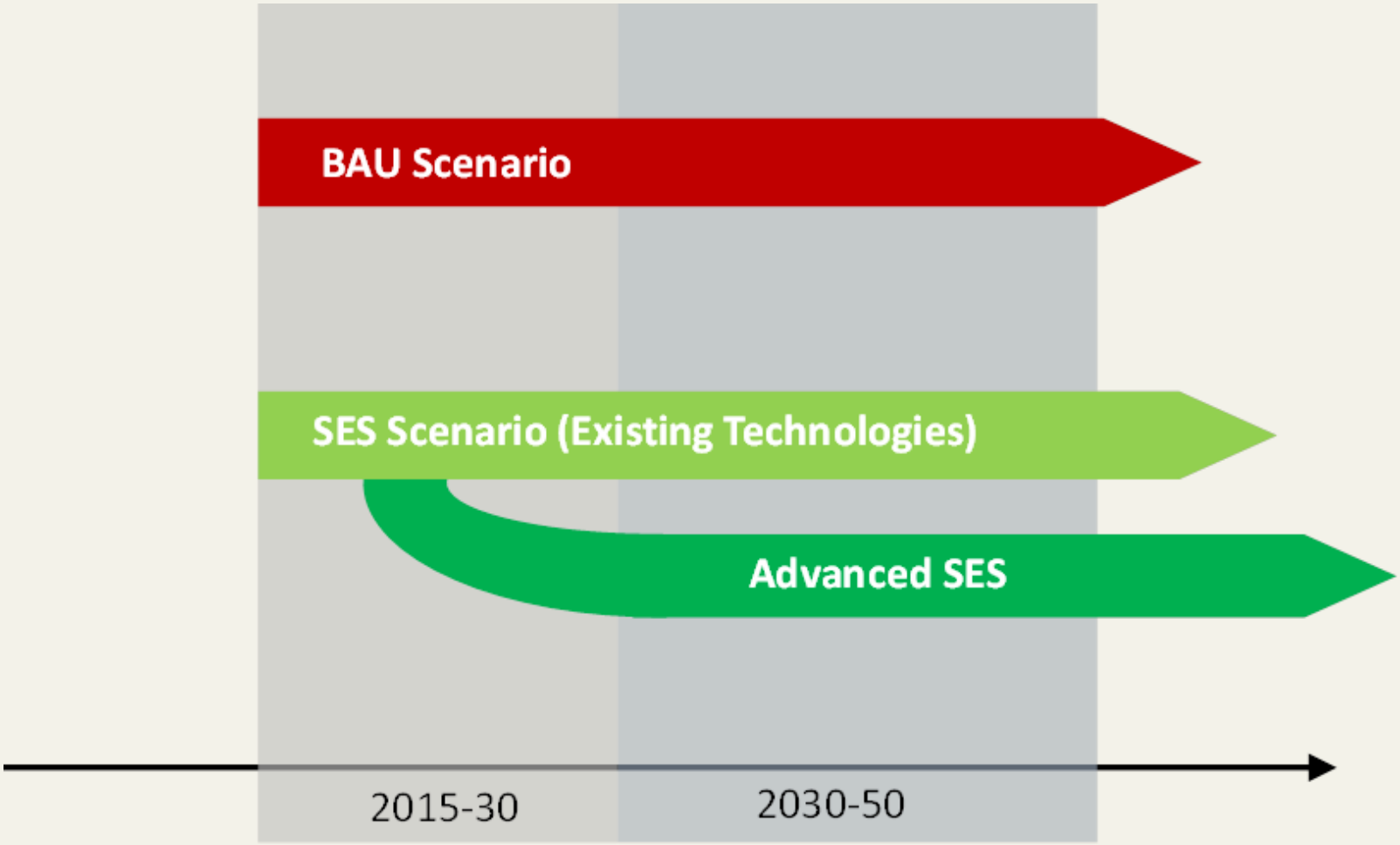
Contribute to debate on power development plan and future of power sector.

Project Stages & Current Status



Modelling

- On an hourly basis to balance supply and demand
- Optimisation based on least cost
- Transparent assumptions on fixed and variable costs of various technologies


BAU Scenario
SES Scenario (Existing Technologies)
Advanced SES
2015-30
2030-50

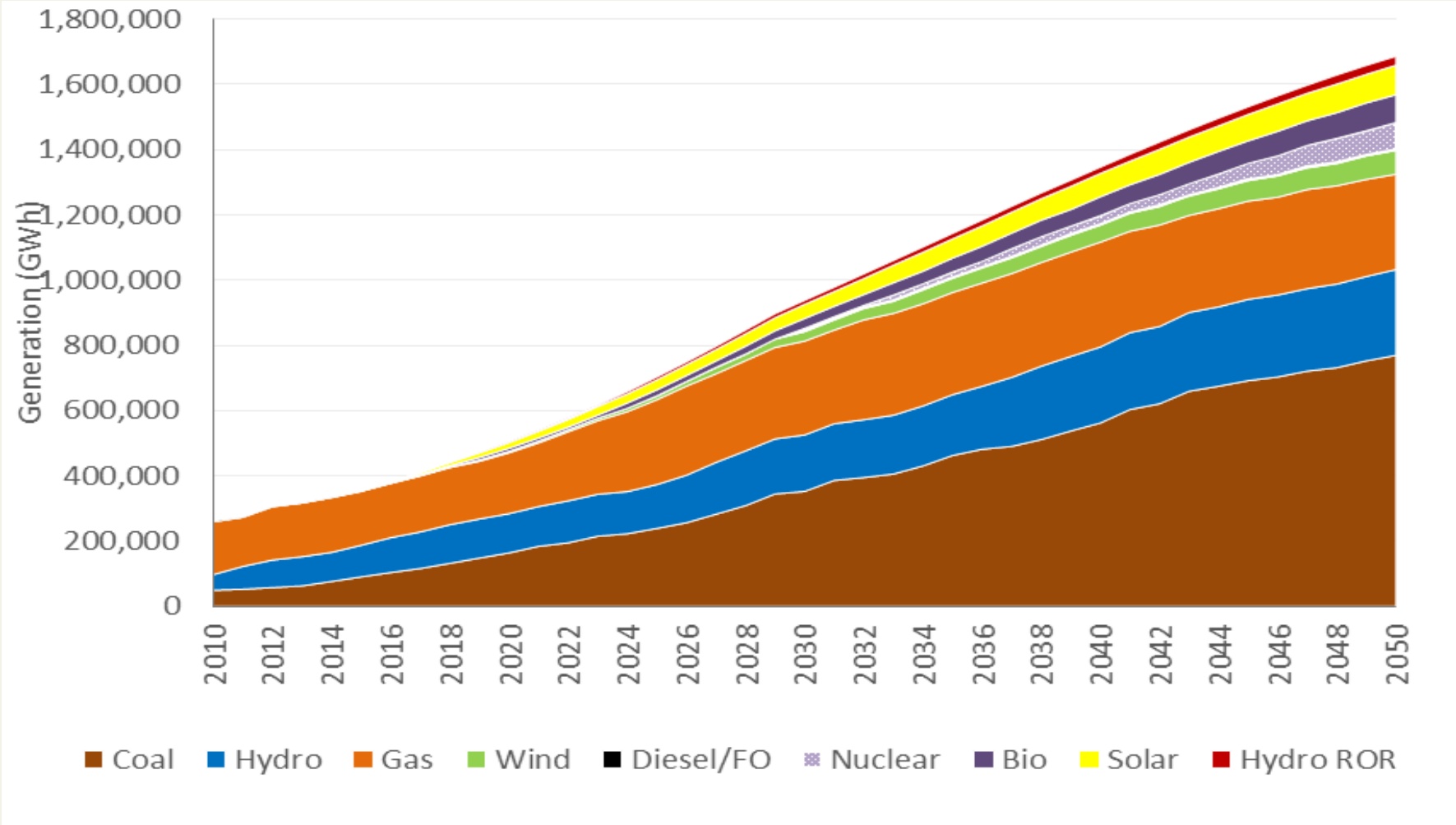
Assumptions for Scenarios

- Use of official GDP and population growth forecasts
- Conservative assumptions on technology and fuel costs for fossil fuels and renewable energy
- Energy efficiency assumptions based on other Asian countries – huge potential!
- Sustainable Energy Scenario gives preference to solar, wind and biomass technologies

Our Partners for the Power Sector Vision project

- IES for technical modelling
- Vietnamese Sustainable Energy Alliance
- Renewable Energy Association Myanmar
- Spectrum Myanmar
- Healthy Public Policy Foundation Thailand
- Mekong Strategic Partners in Cambodia
- Laos – consultants

Greater Mekong future generation mix (BAU)



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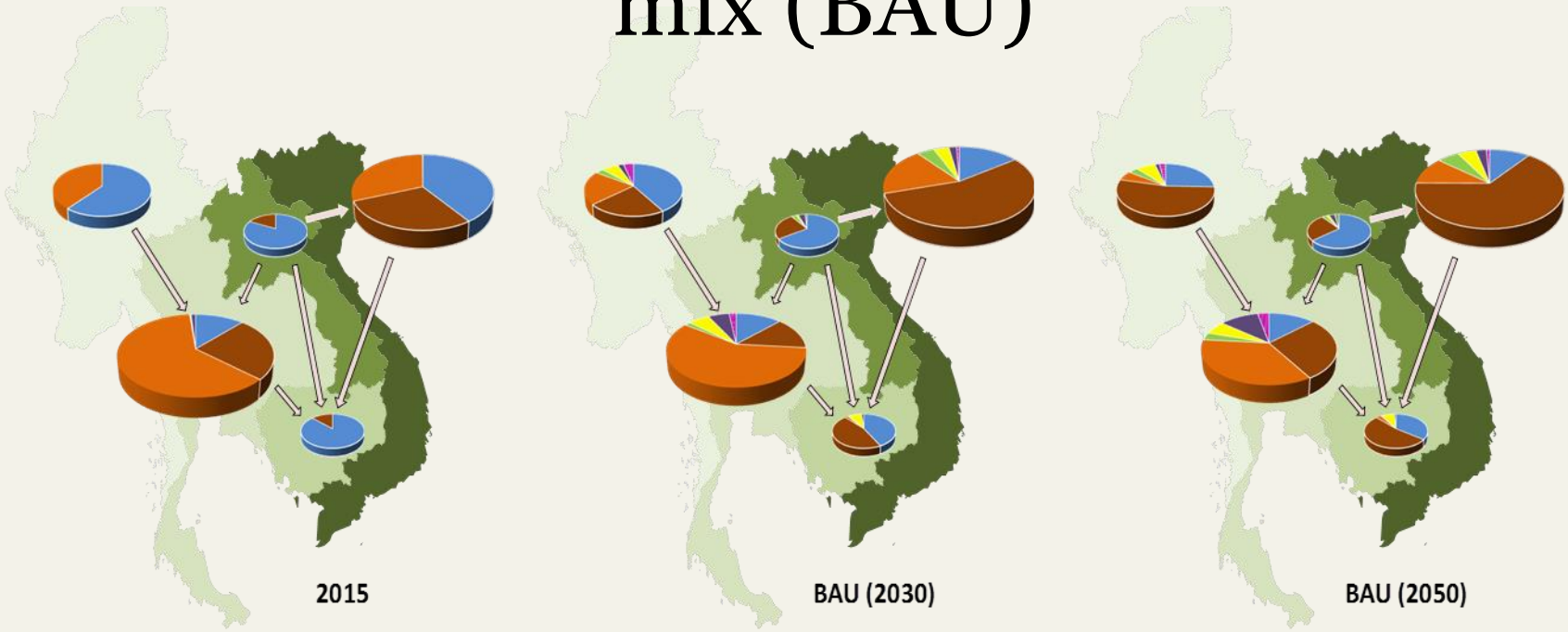


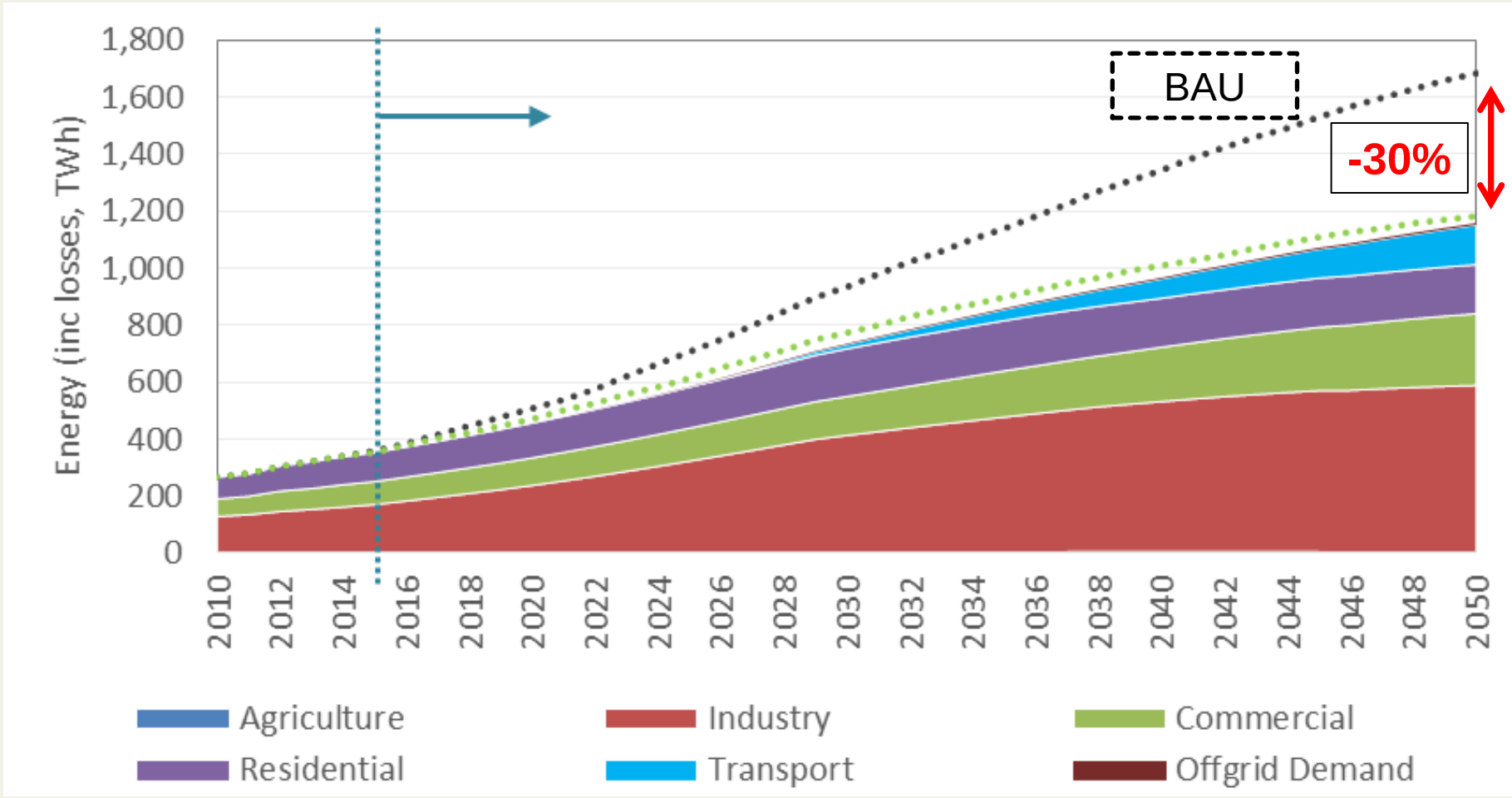
Resource

- Coal, Diesel, Fuel Oil, Nuclear
- Gas
- Large Hydro
- Wind
- Solar, Battery, CSP
- Biomass and Biogas
- Other Renewables

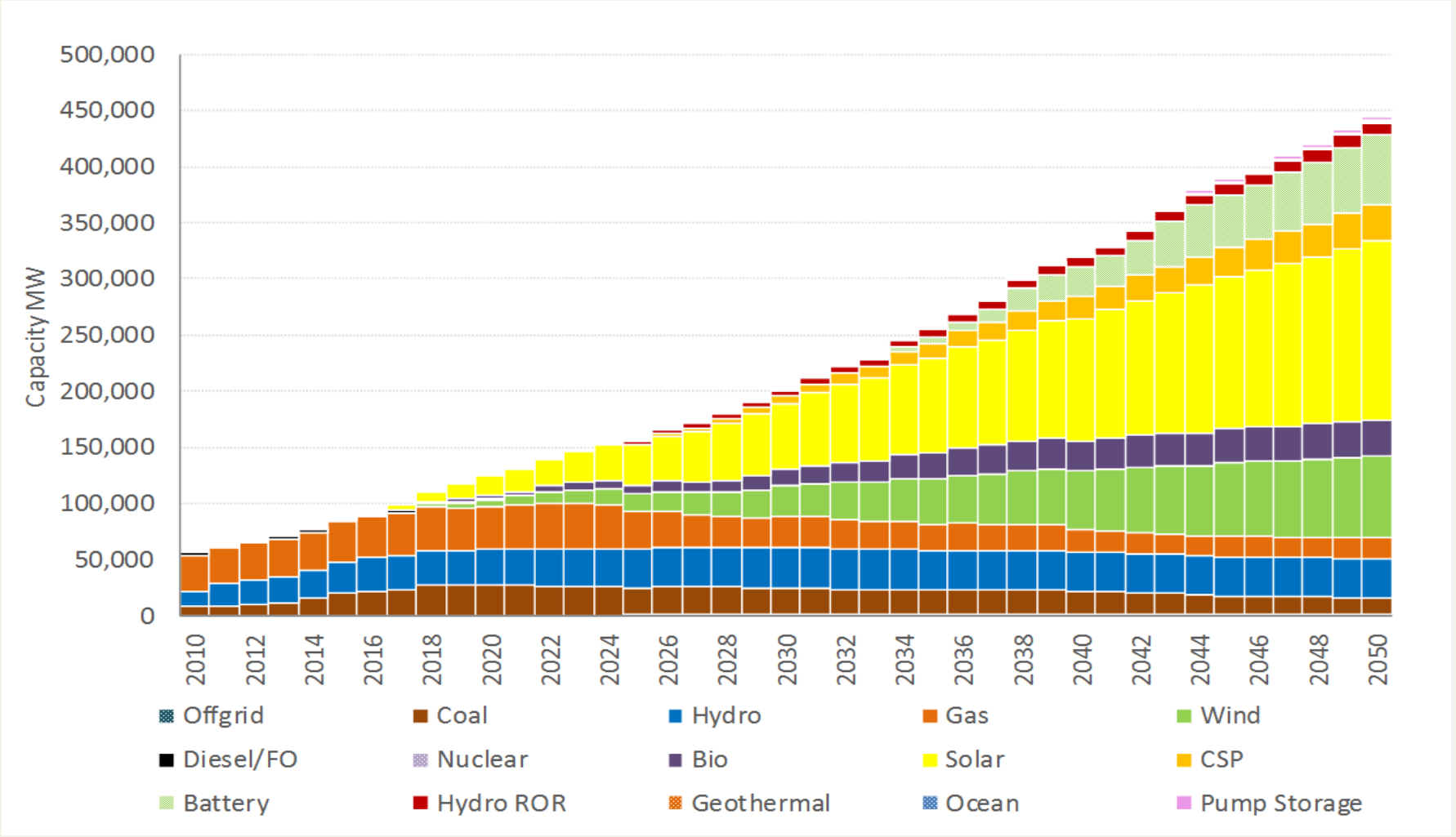
Flows

- Below 10,000 GWh
- 10,001 - 20,000 GWh
- Above 20,000 GWh

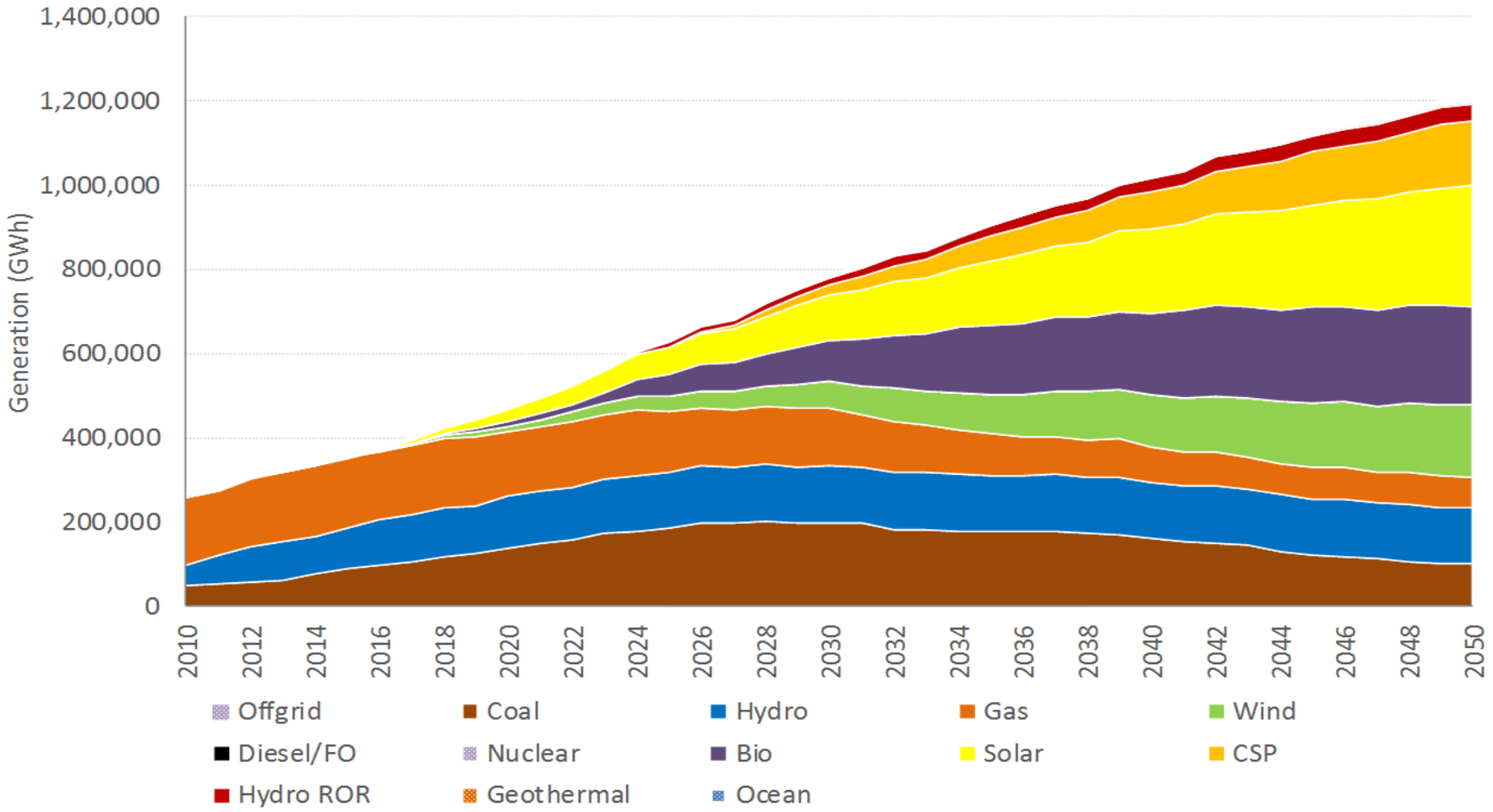
Sustainable Energy Scenarios Electricity Demand



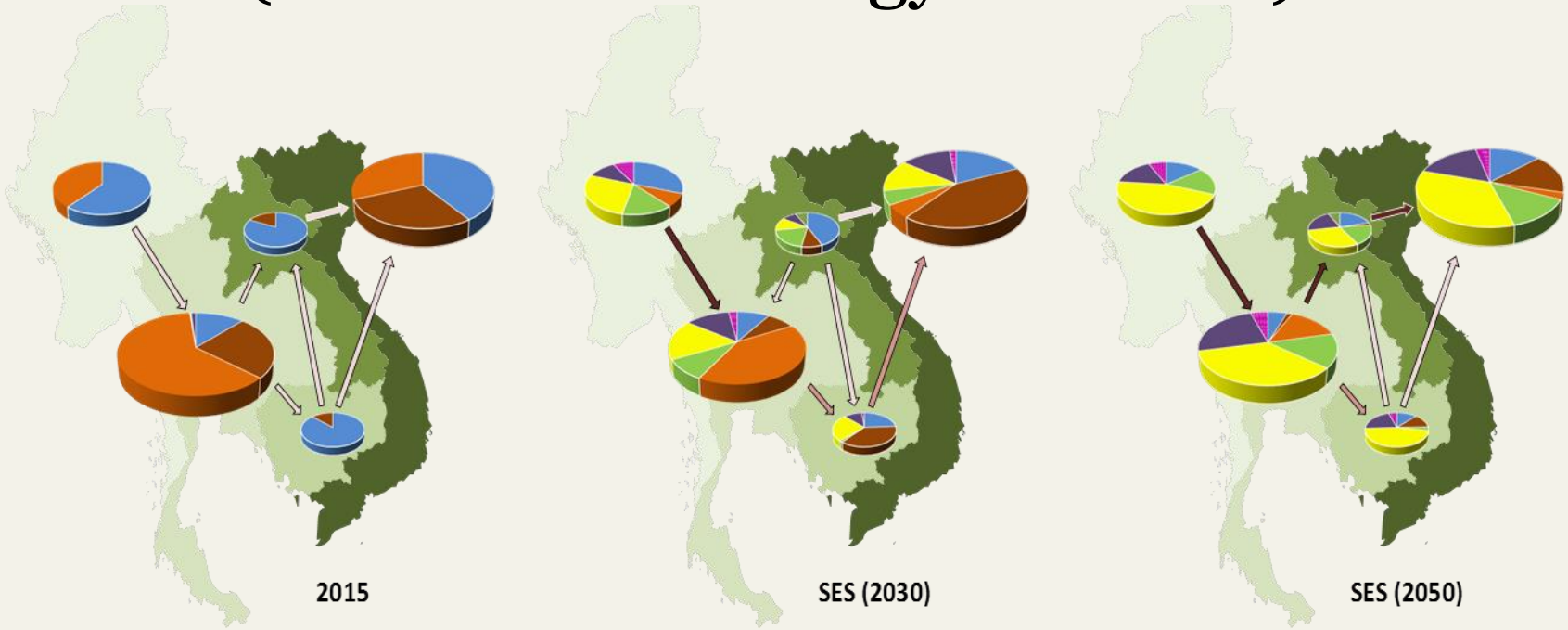
Greater Mekong future capacity mix (Sustainable Energy Scenario)



Greater Mekong future generation mix (Sustainable Energy Scenario)



Greater Mekong future generation mix (Sustainable Energy Scenario)



Resource

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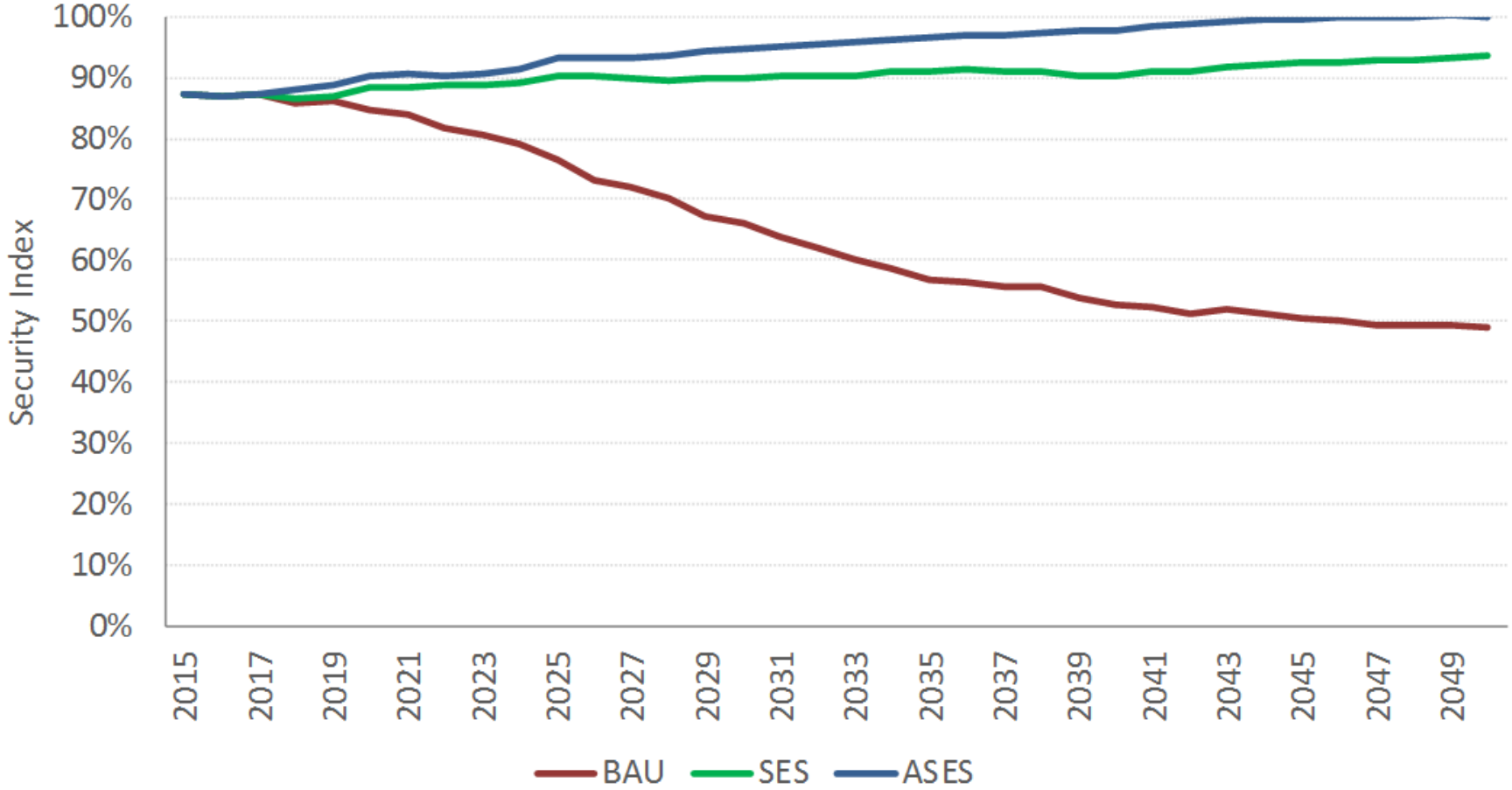
- Other Renewables

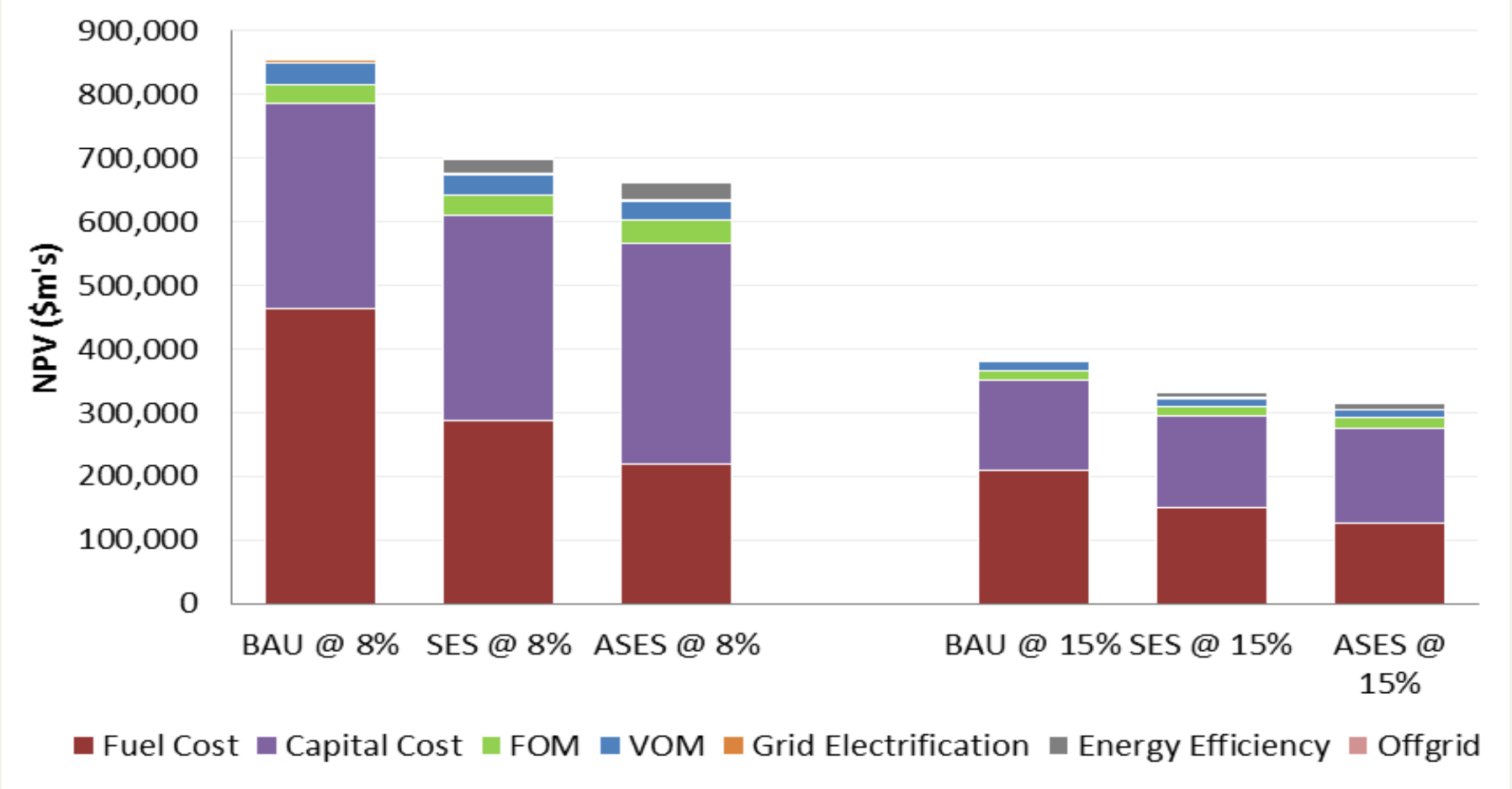
Flows

- Below 10,000 GWh
- 10,001 - 20,000 GWh
- Above 20,000 GWh

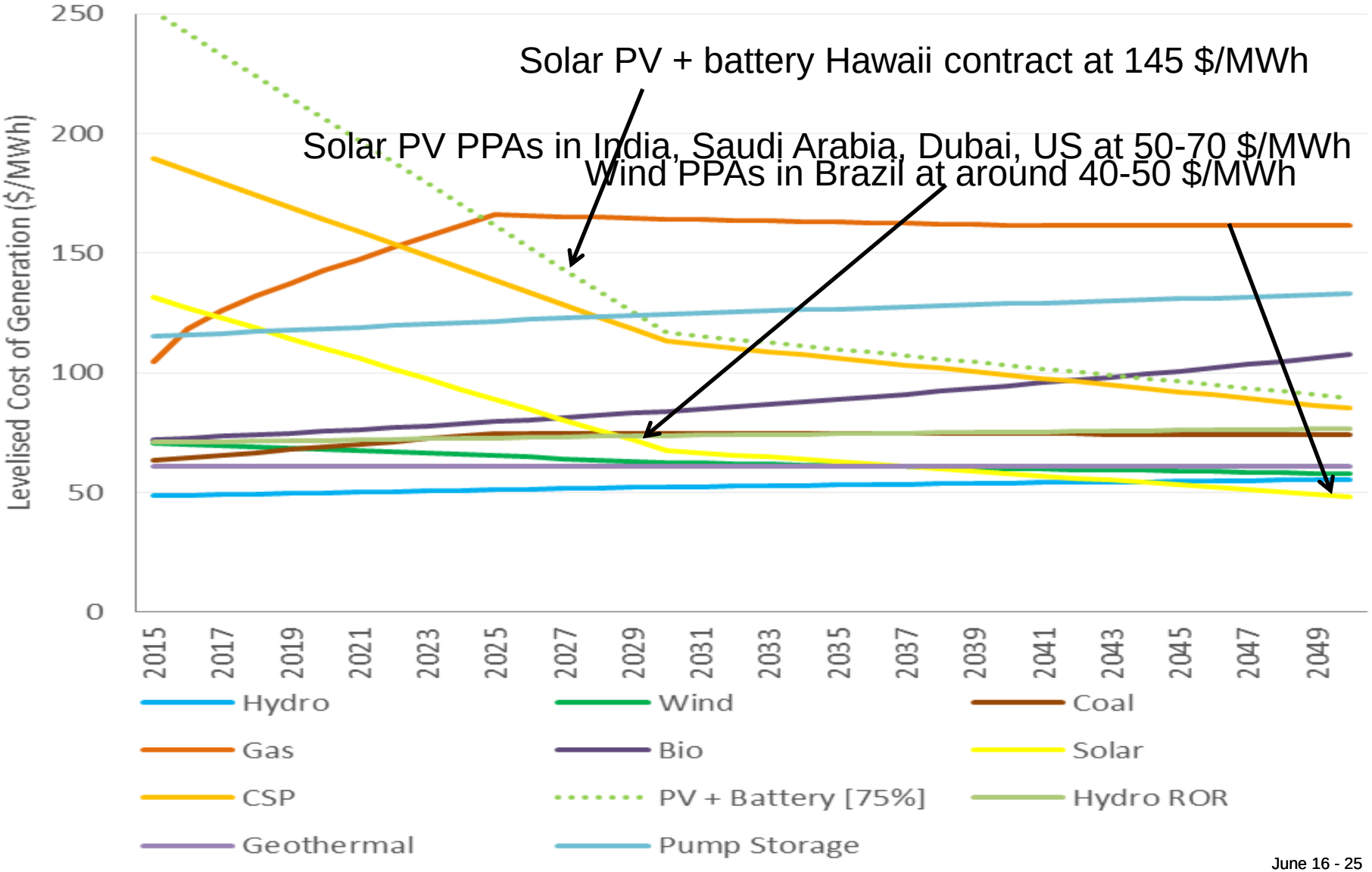
Supply security : % of electricity generated at home



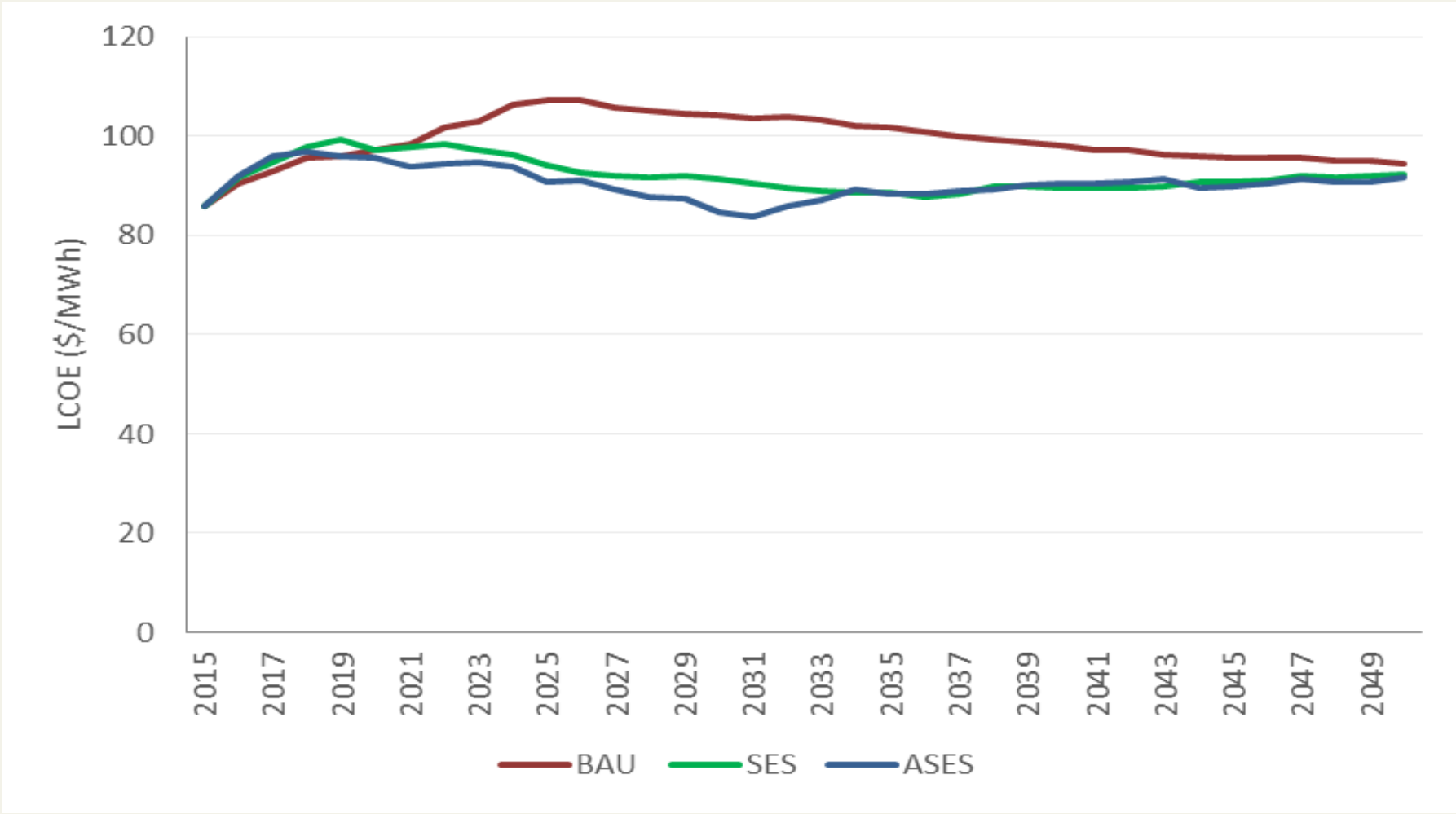
Net Present Cost of power sector OPEX & CAPEX until 2050



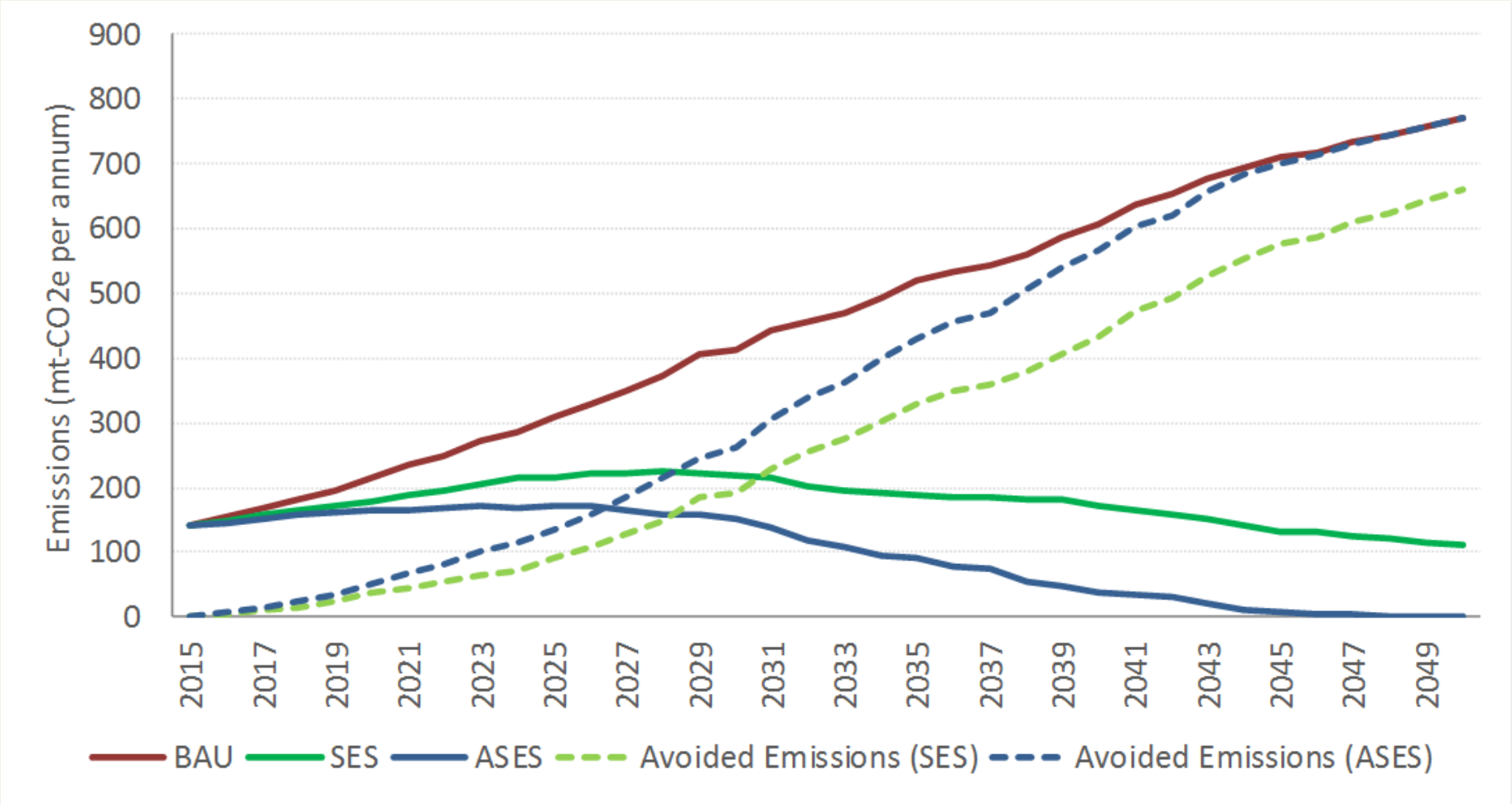
Are the cost assumptions realistic?



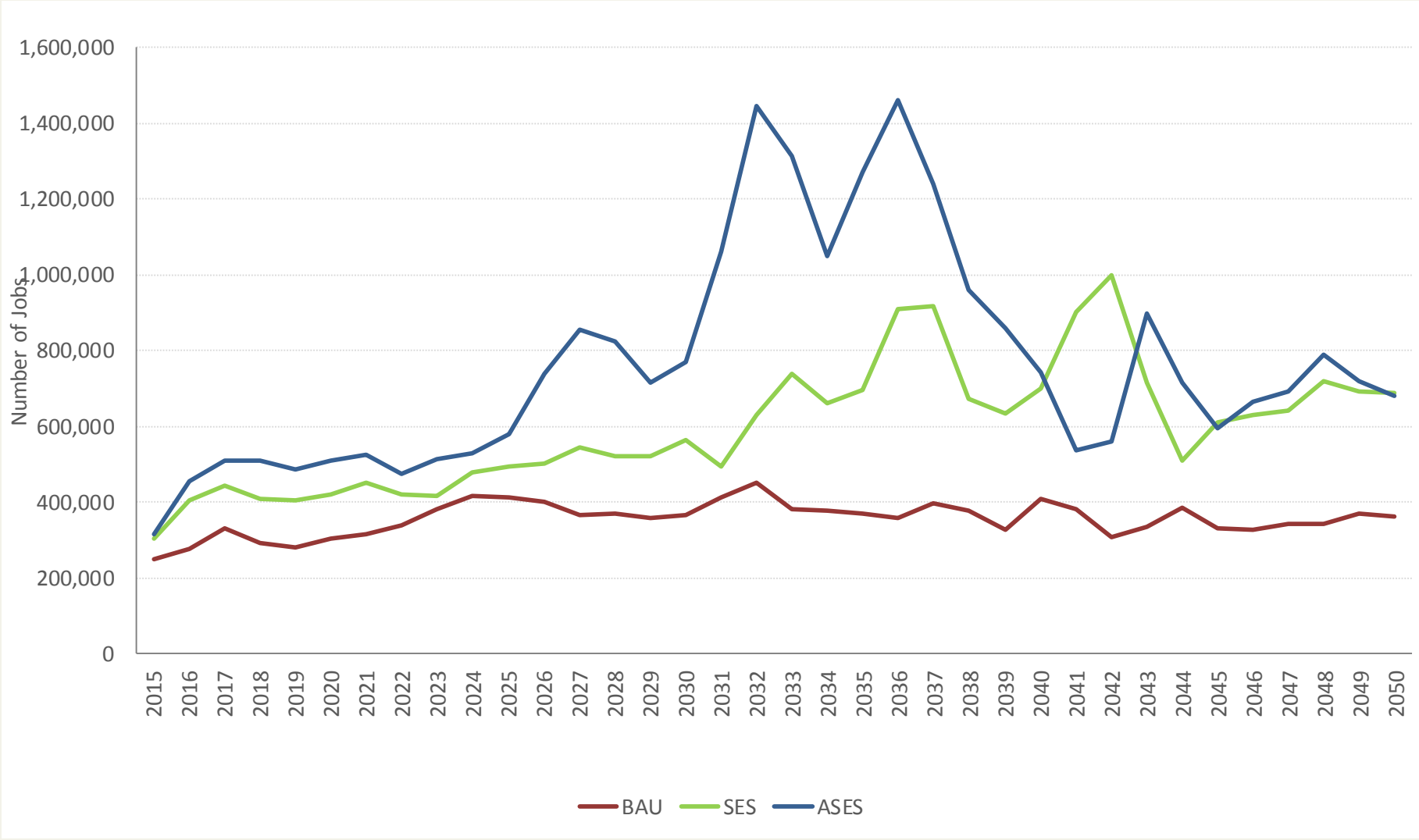
Levelised cost of electricity



Avoided CO2eq emissions

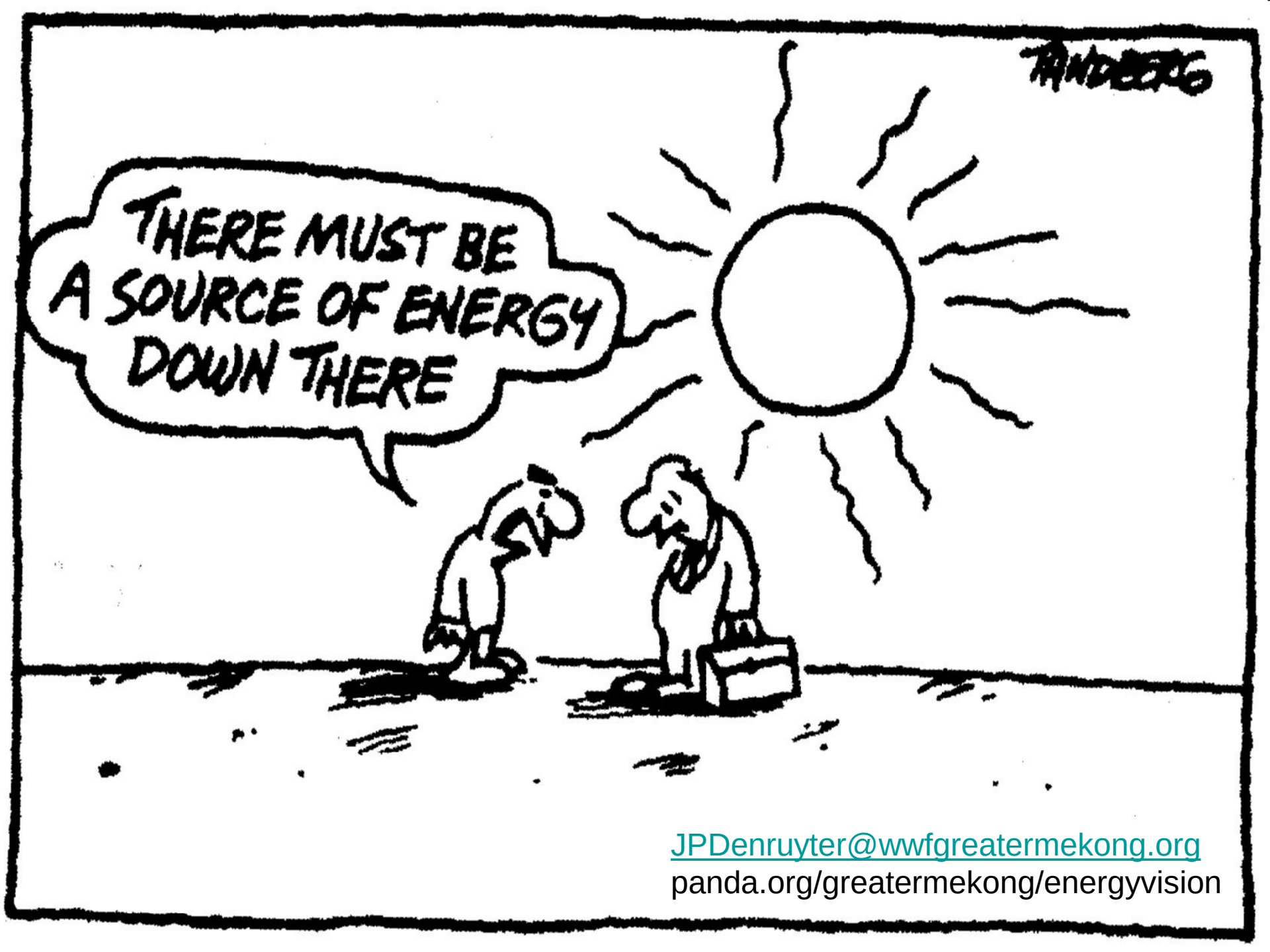


Job creation



Scenario Conclusions

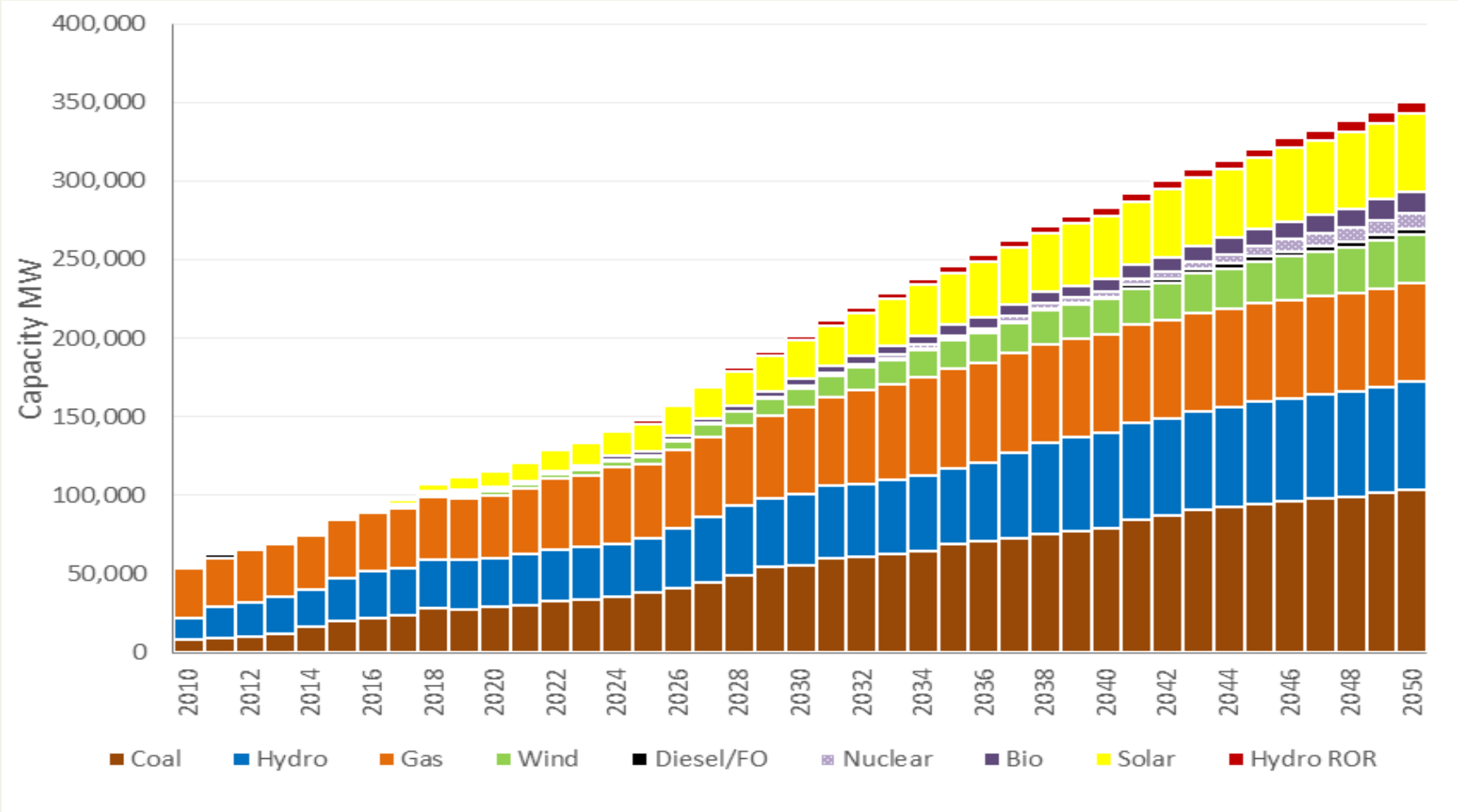
- RE range is between 86% and 100% by 2050
- Carbon emissions reduced by minimum 83%
- SES Hydro increase limited to plants under construction or last phases of planning
- Additional cost to society? Higher capital costs (50% higher) but lower fuel costs turn the energy transition into a win-win scenario
- This does not take into account social and environmental benefits – a just and sustainable energy transition has many more benefits



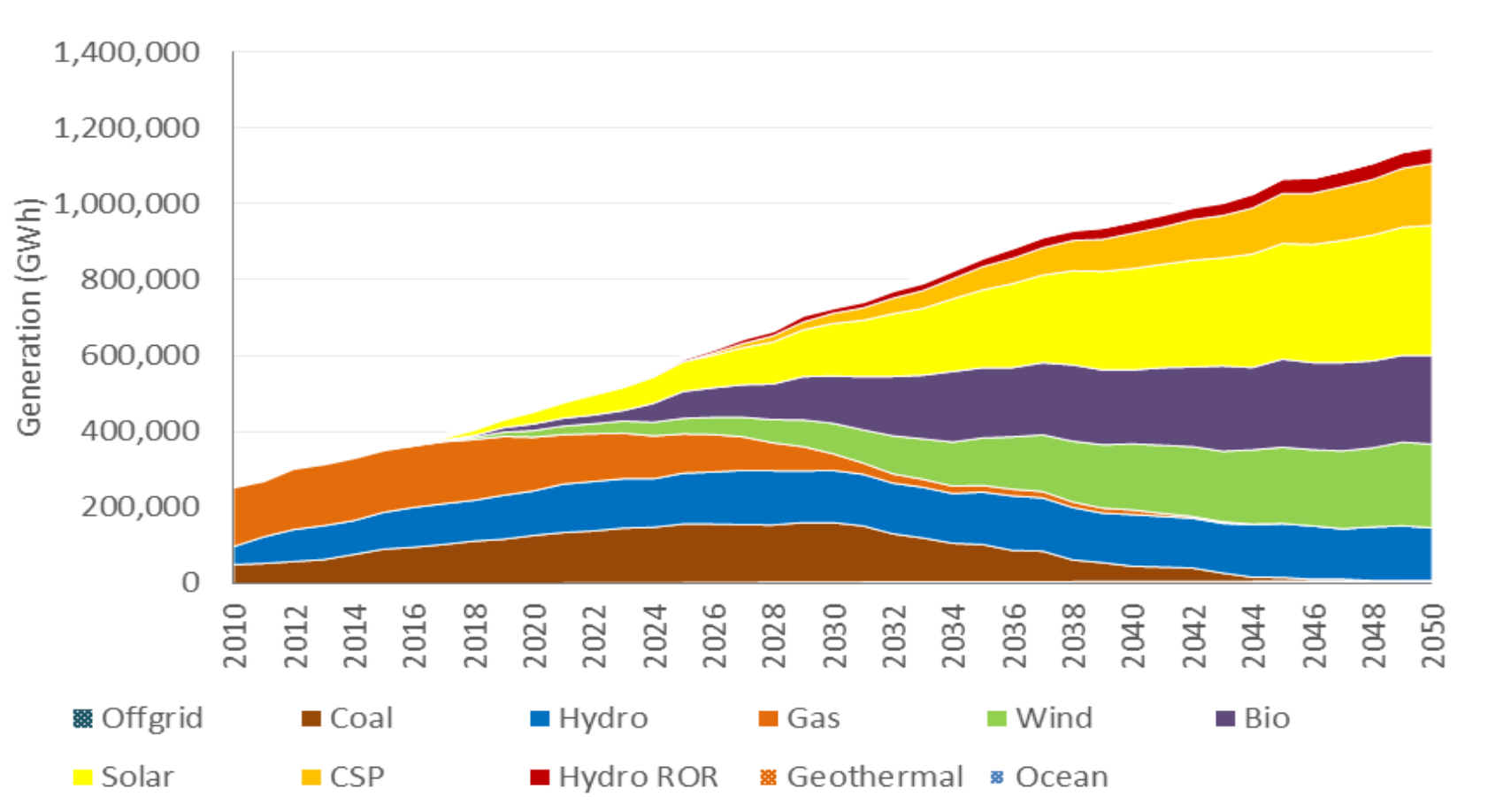
JPDenruyter@wwfgreatermekong.org
panda.org/greatermekong/energyvision

Back up slides

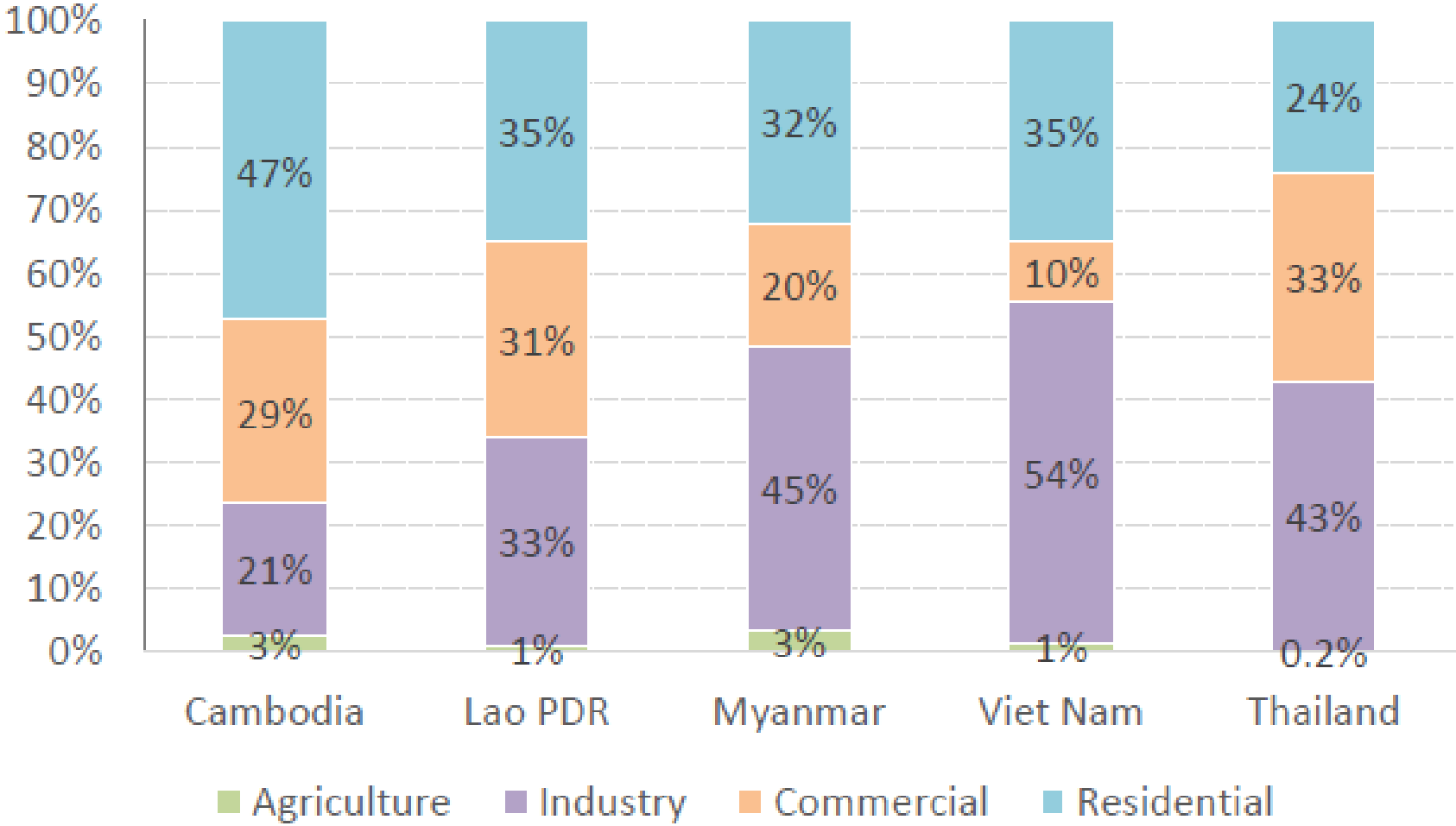
Greater Mekong future capacity mix (BAU)



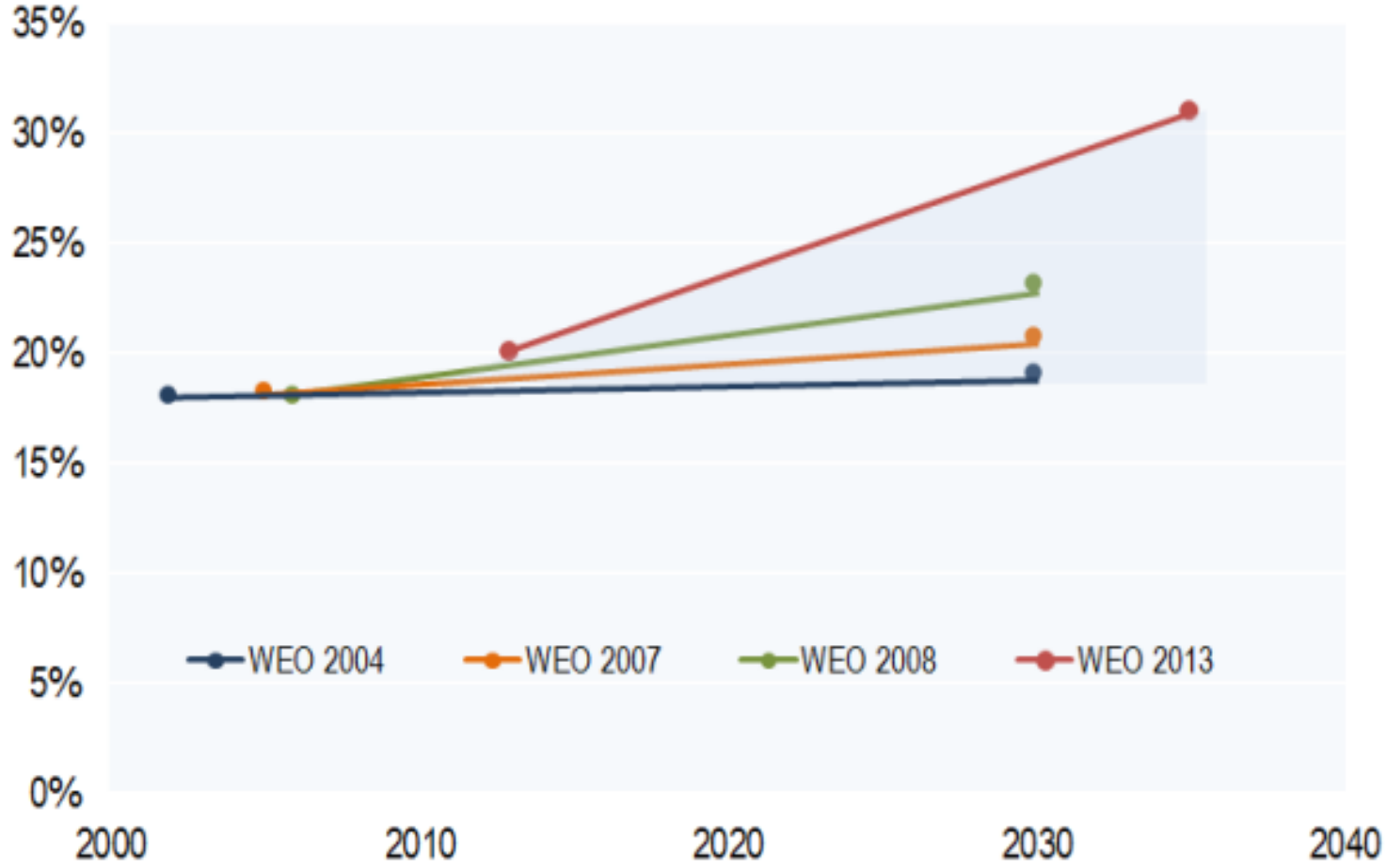
Advanced Sustainable Energy Scenario (ASES)



Electricity demand by sector 2014

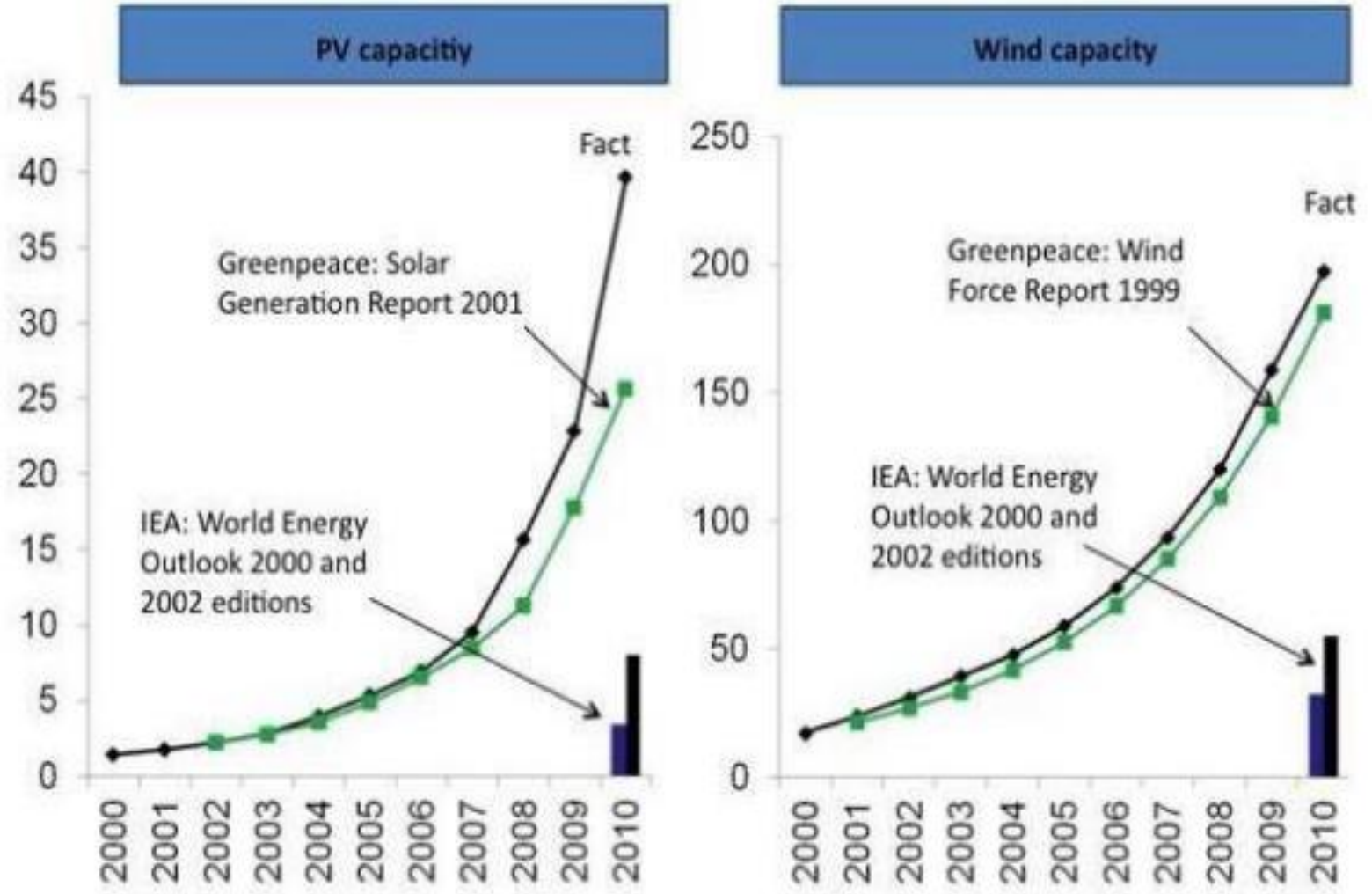


Global share of renewables in electricity generation

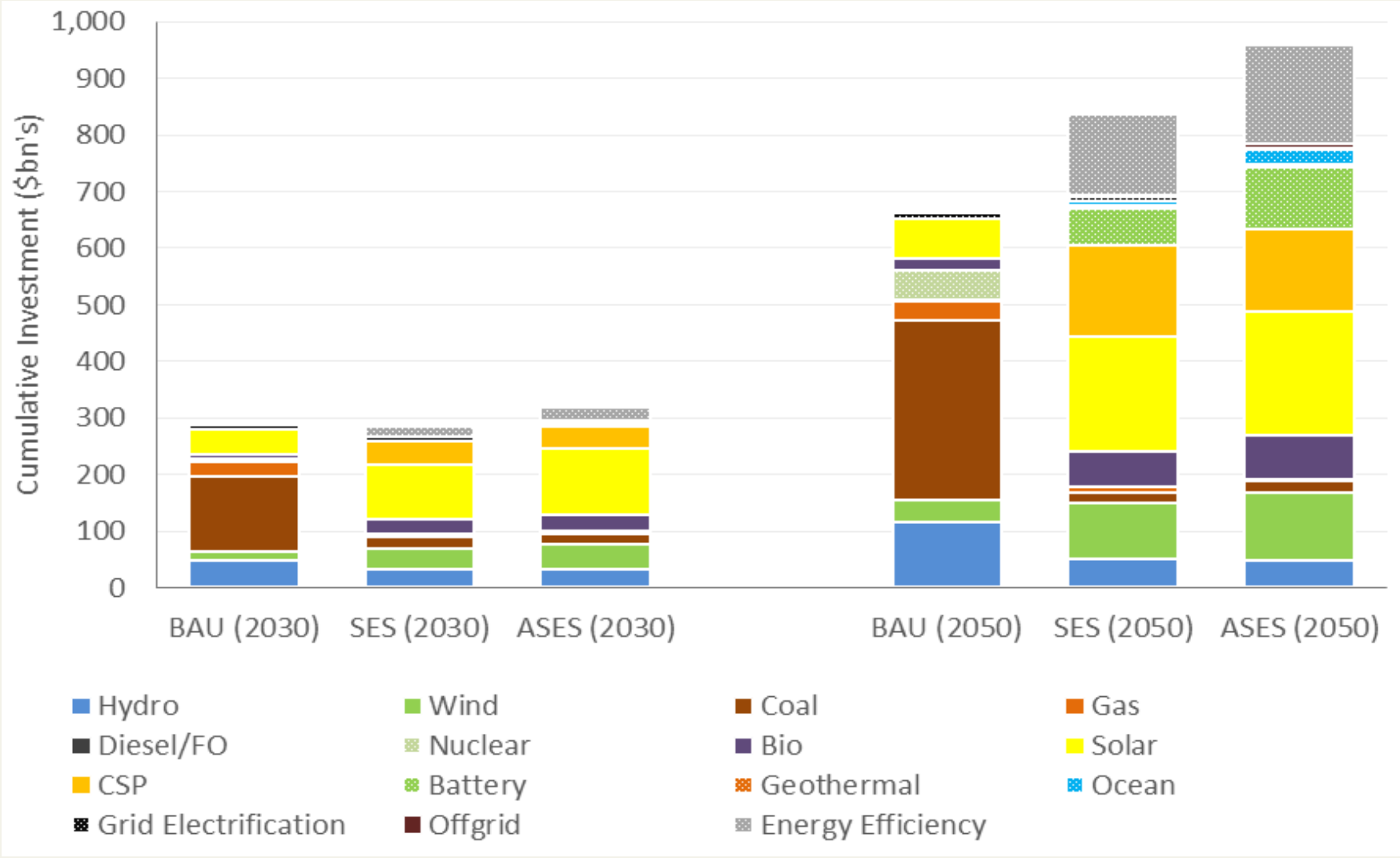


Source: Based on projections of IEA World Energy Outlooks in Reference Scenarios of WEO 2004, 2007 and 2008, and New Policies Scenarios in WEO 2013.

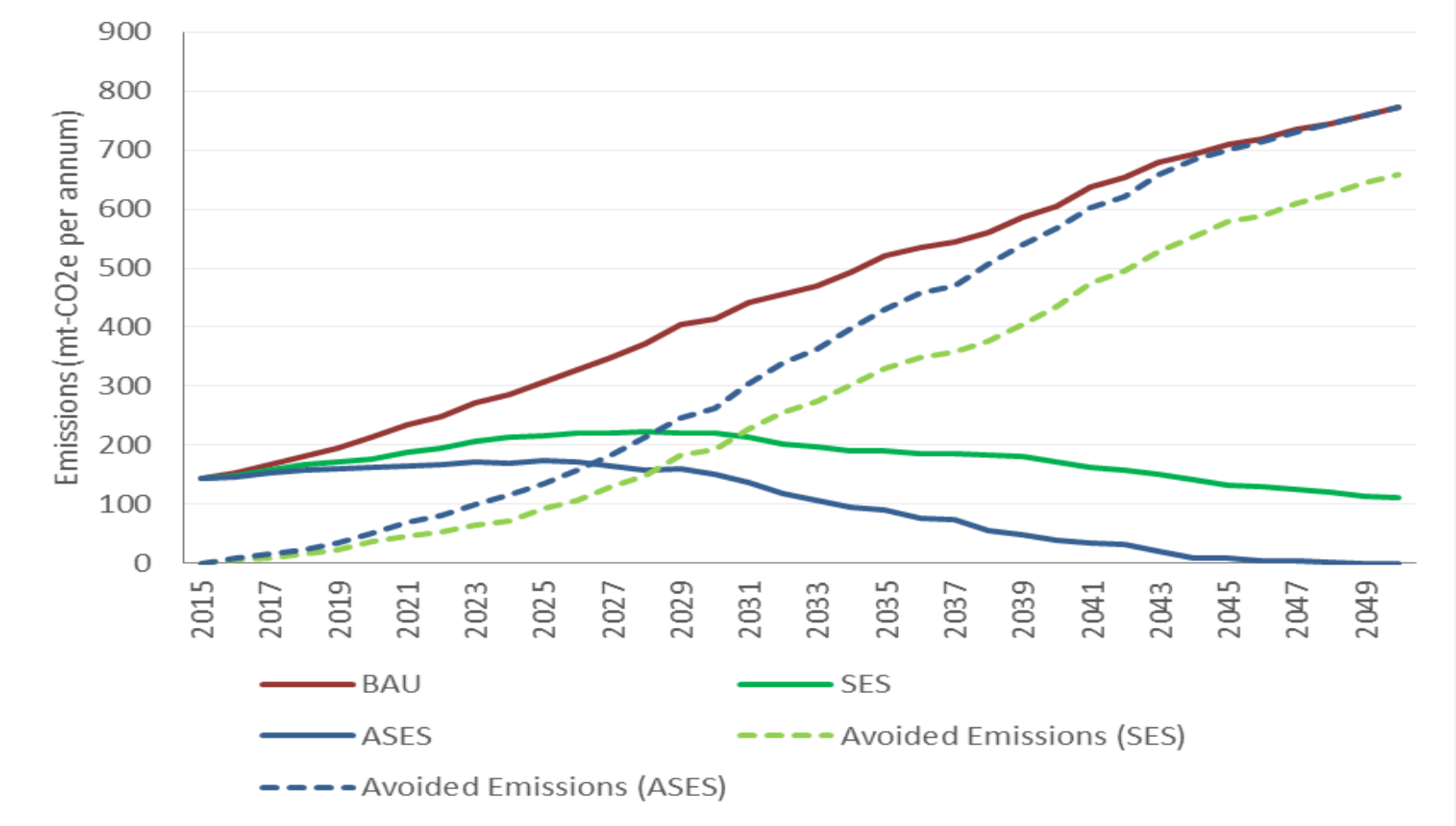
Greenpeace Forecasts vs. IEA´s and Facts



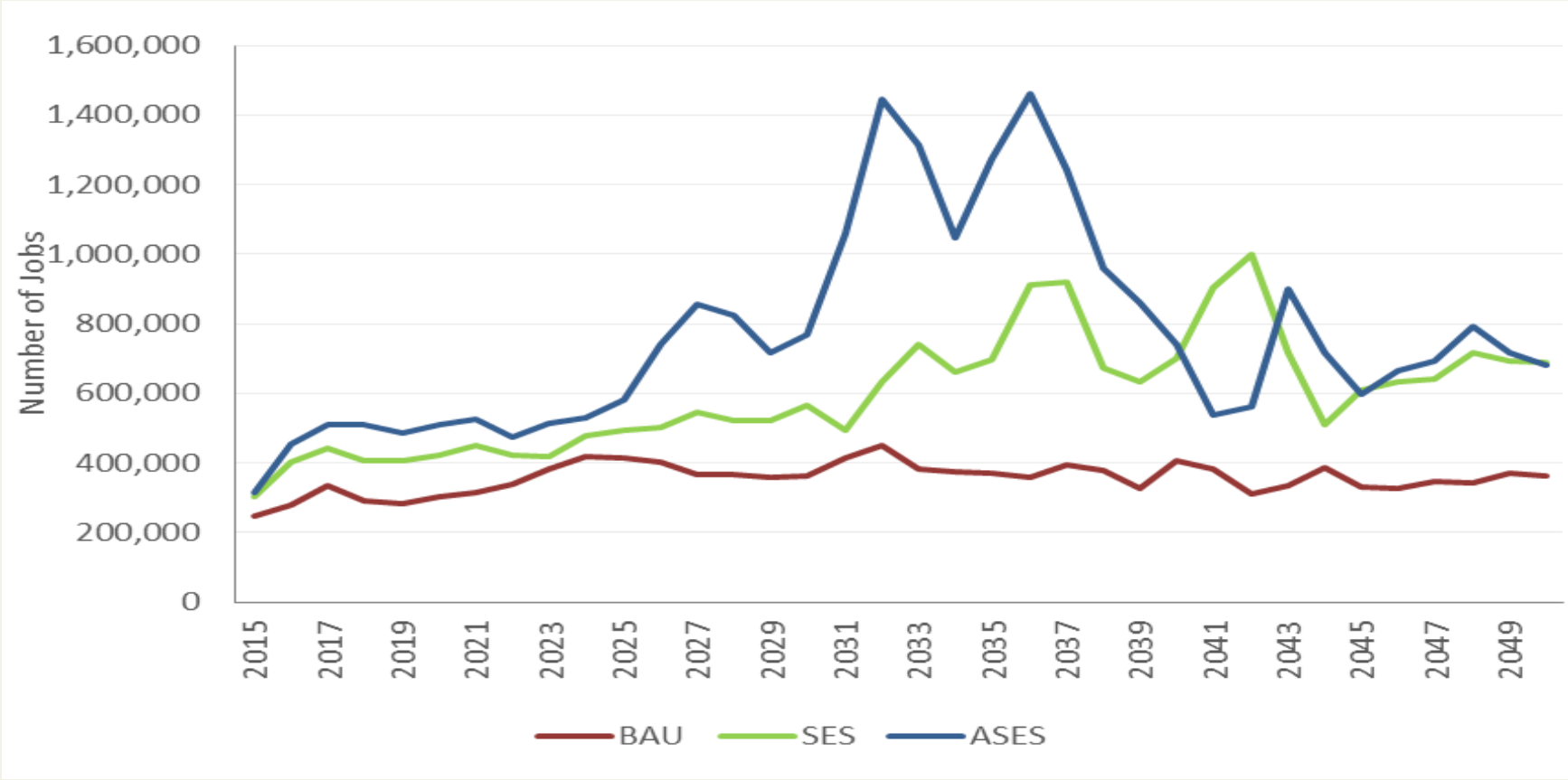
Cumulative investments



Carbon Emissions



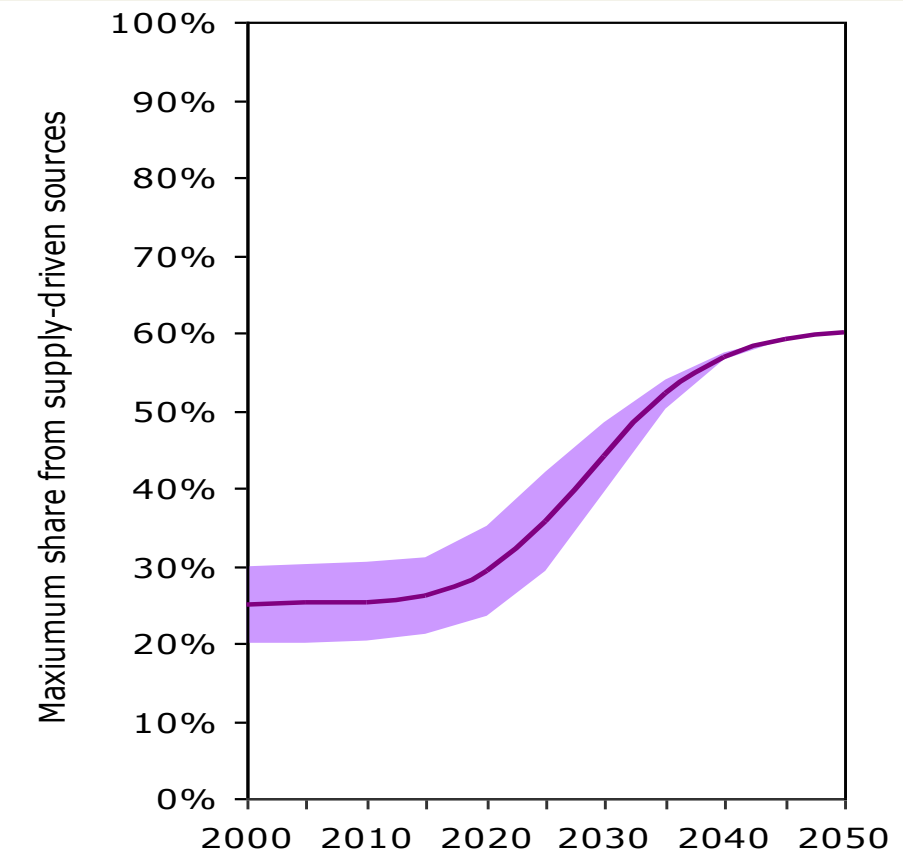
Job creation



Hydro

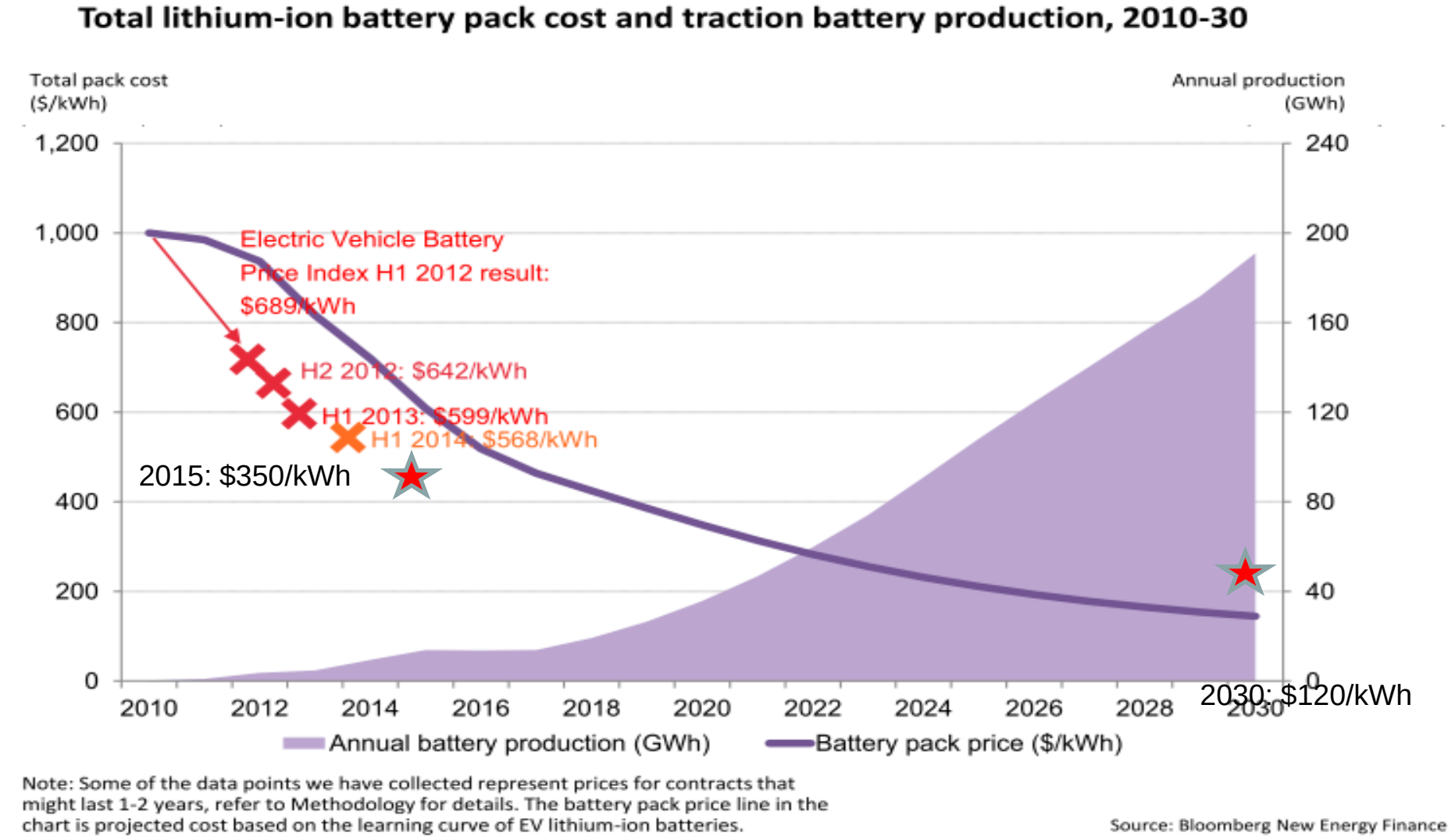
“The fact that current hydro power projects are included in the SES does not mean that WWF or its partners condone any specific existing dam. But since they have been built, they are part of the suggested power mix in the SES. It may well be that some of those dams will be decommissioned early to make way for more sustainable solutions.”

Technical potential: 60% of variable electricity



(WWF and Ecofys, 2011)

Why batteries?



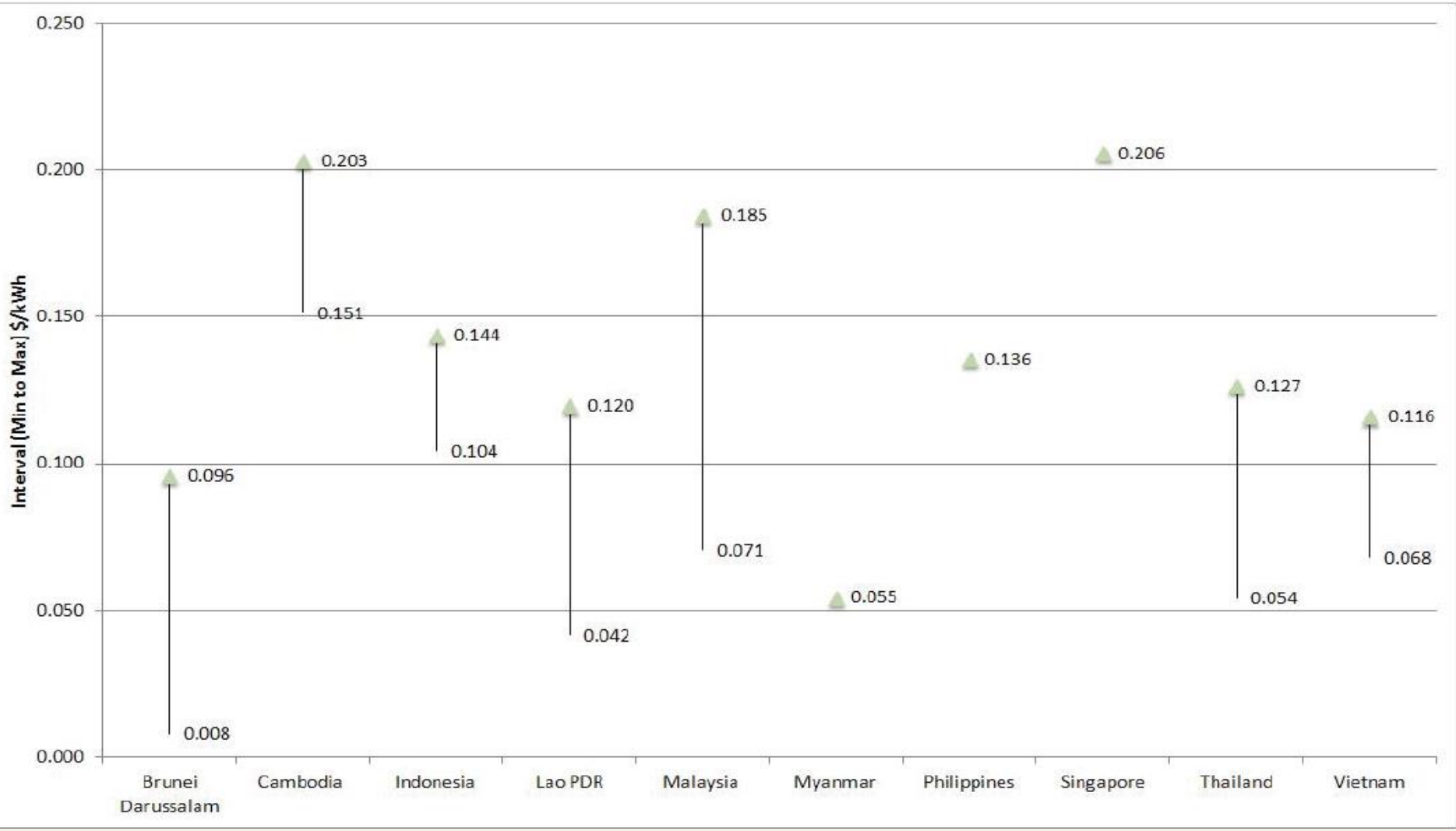
Why batteries?

- UBS study recently showed that solar and batteries are already cost effective in Australia (Reneweconomy, 2014).
- Project in Hawai: *“The combined solar and energy storage system is designed to give KIUC, the Kaua‘i Island Utility Cooperative, dispatch-able electricity in the evening, and after the sun goes down. KIUC has a 20-year contract with SolarCity to buy the solar-generated electricity at a competitive price of 14.5 cents per kilowatt hour.”*
- *Estimate of amount of EV conservative (25% in Thailand by 2050 – compared to expert projections of 50-60%)*

Efficiency – why this method?

- No bottom-up approach possible without data
- Simply assuming a percentage of EE is not satisfactory
- Assuming future energy intensity levels by comparing with other countries – ok, not perfect.
- Quite conservative: we compare energy intensity in 2050 with today's energy intensity in reference countries

Electricity tariffs



(ASEAN Centre for Energy)

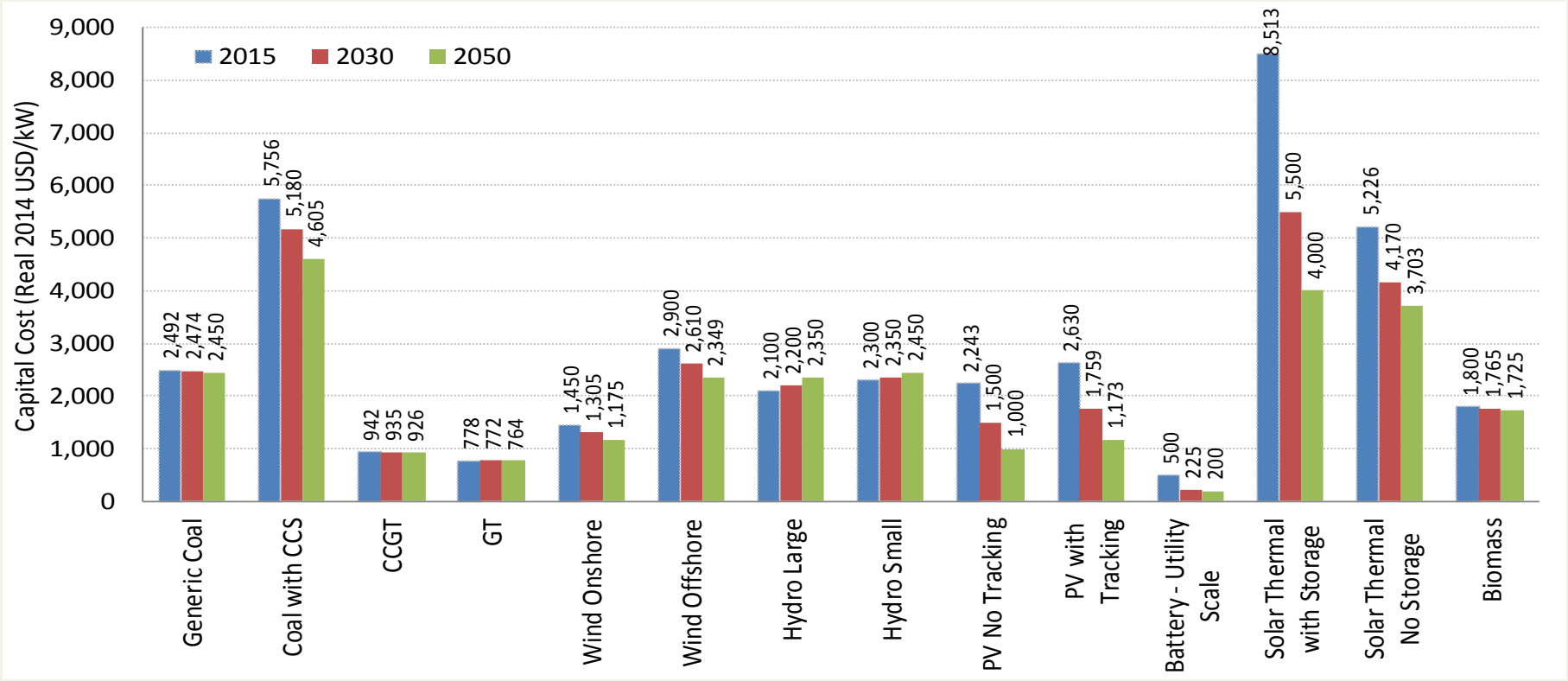
Main assumptions
Demand

- BAU: government plans, with extrapolation based on GDP growth per economic sector, population growth and electrification rates.
- SES: GDP growth, population growth, electrification rates (access to electricity + car electrification), energy intensity from other countries (Japan, South Korea, Hong Kong, Singapore)
- Energy efficiency costs from McKinsey, Berkeley

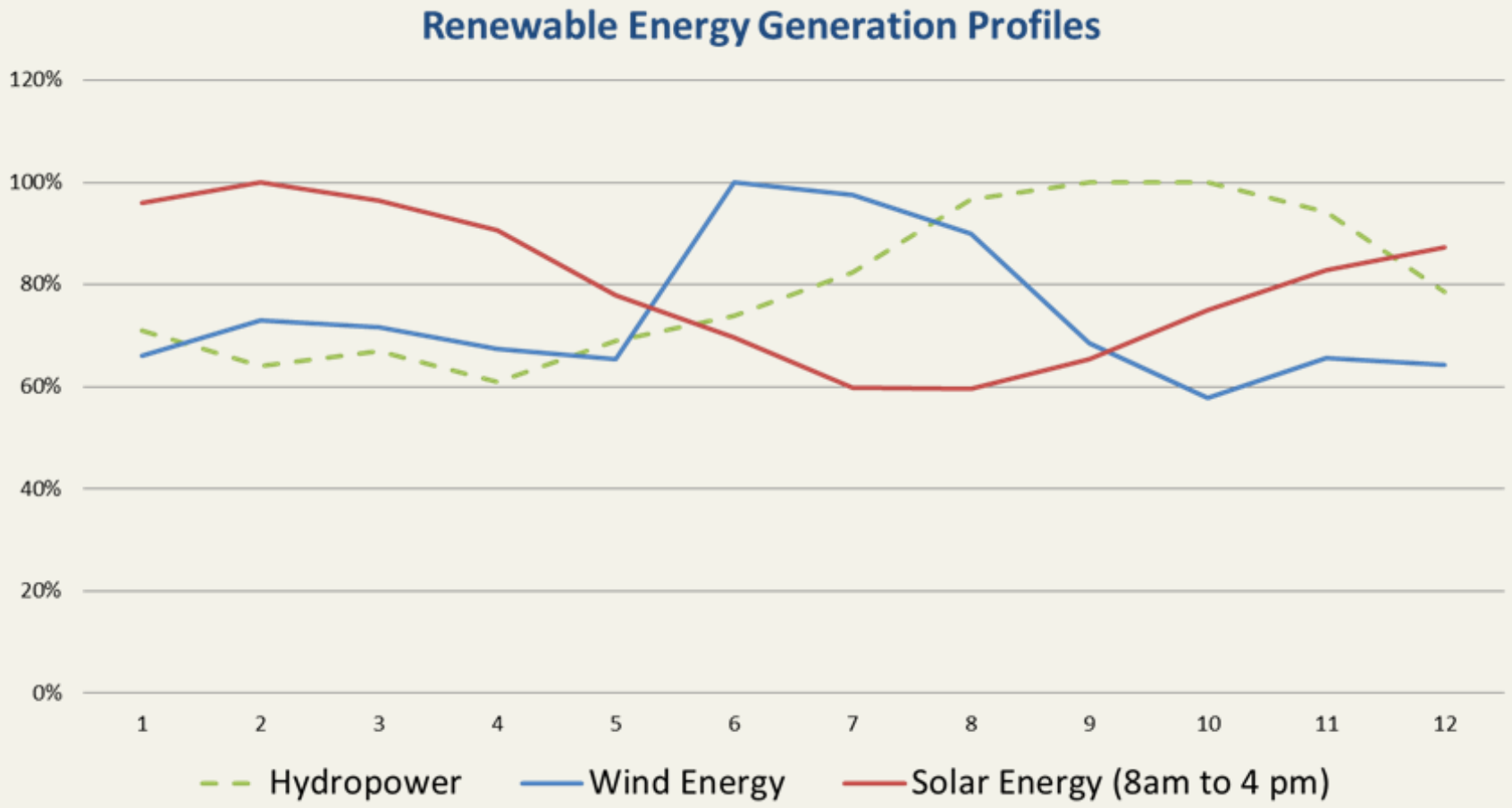
Main Assumptions
Supply

- CAPEX and OPEX assumptions on RE and FF (incl. nuclear) for BAU and SES
- Cost assumptions on storage (batteries mainly)
- Reasonable speed of technology development

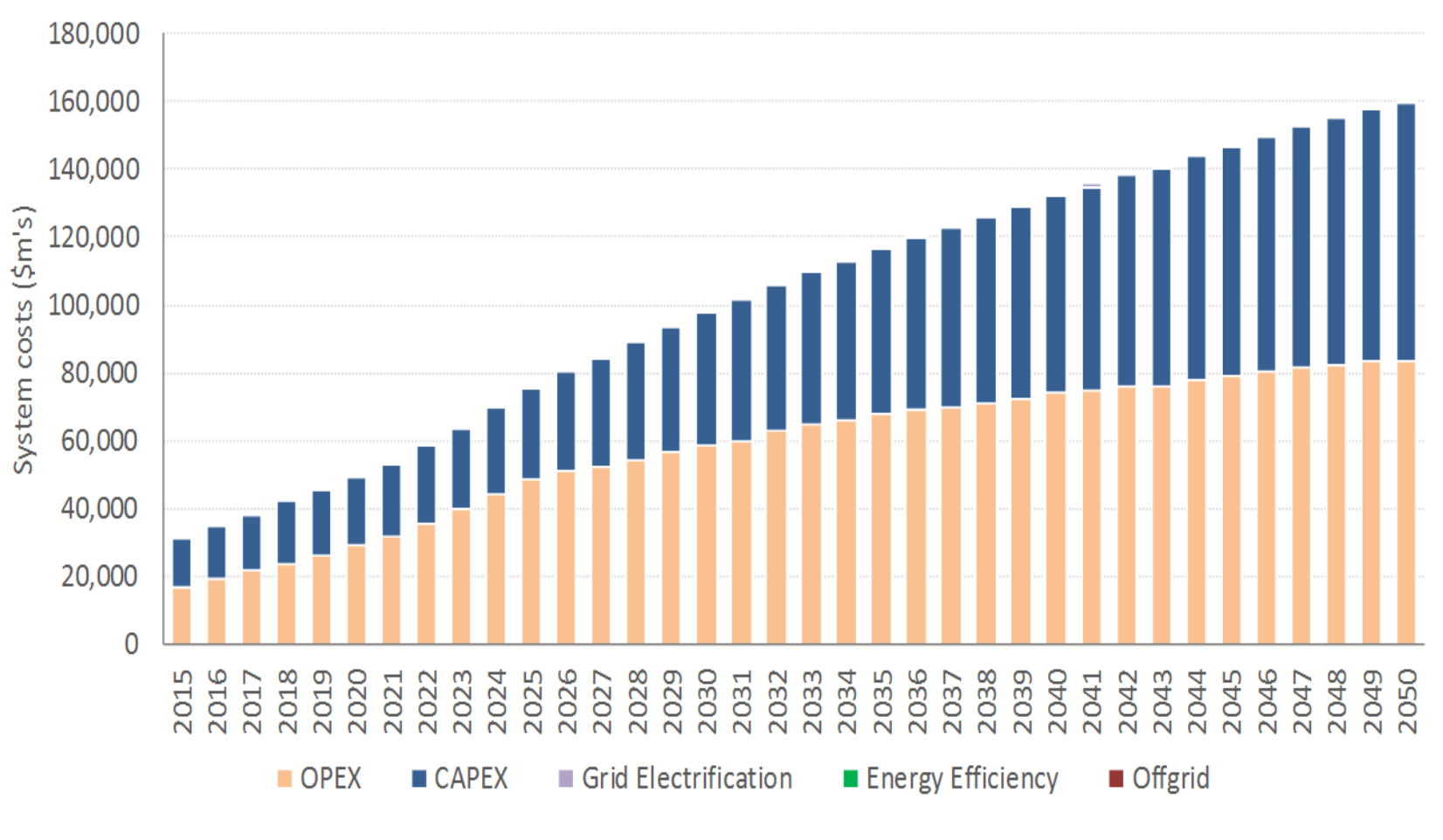
Capital costs



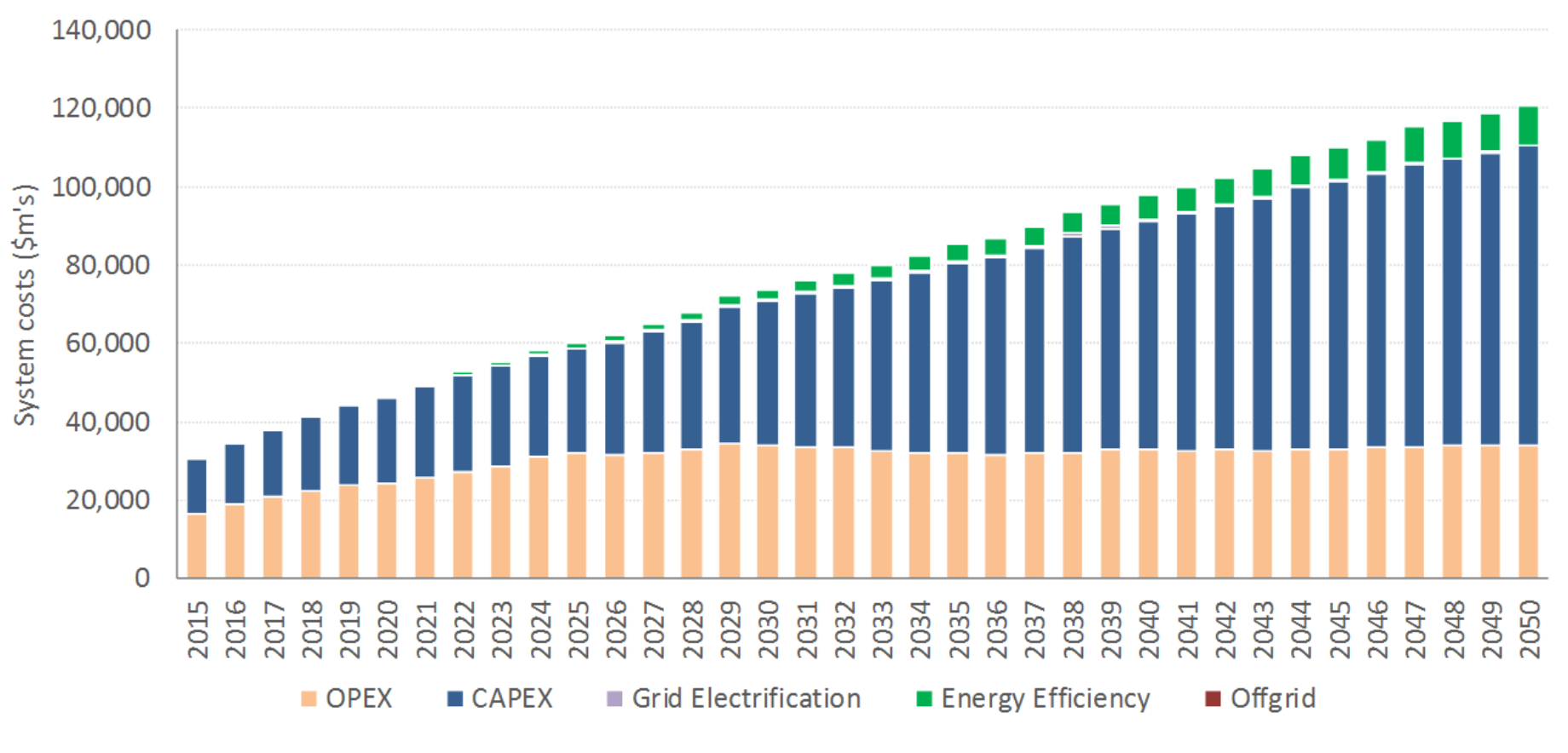
Grids - Myanmar



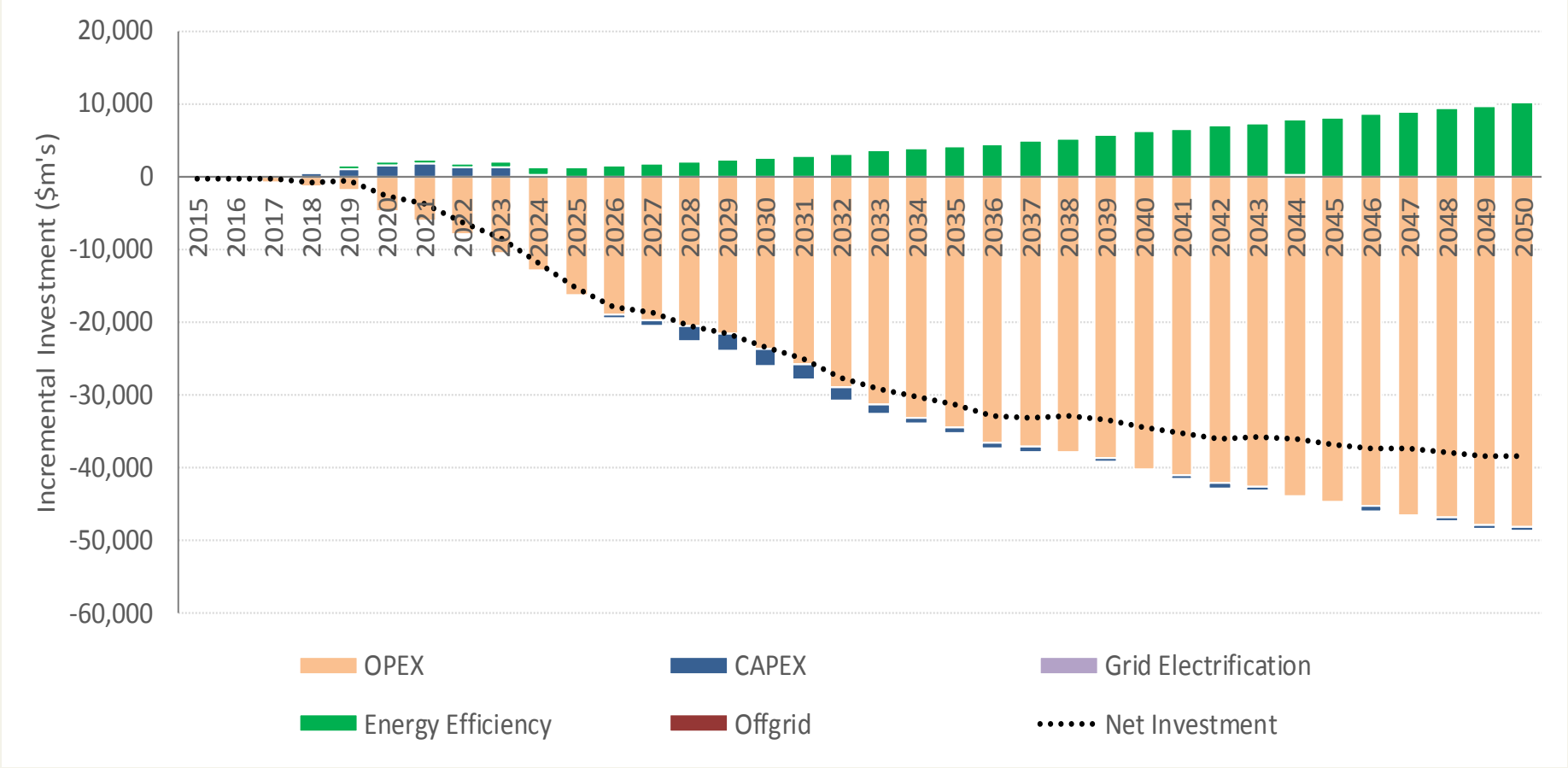
Cost of scenarios
BAU



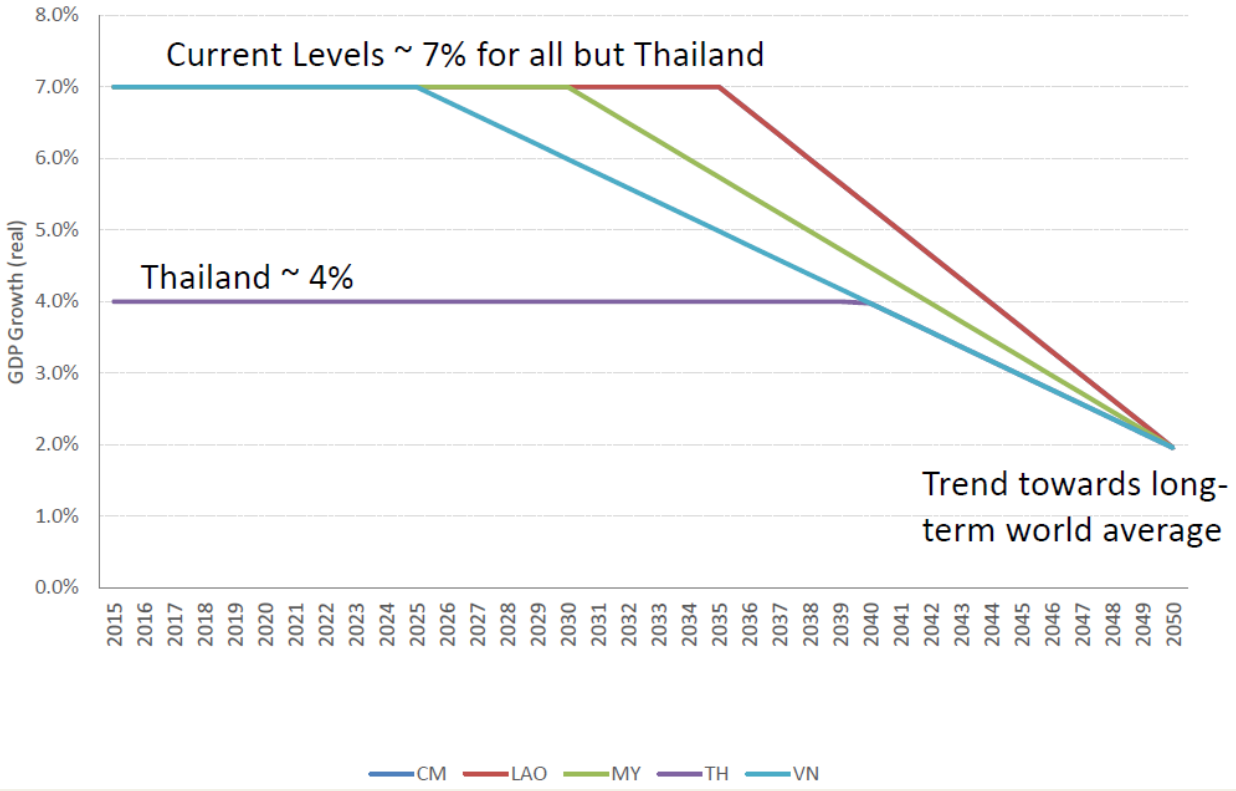
Cost of scenarios
SES



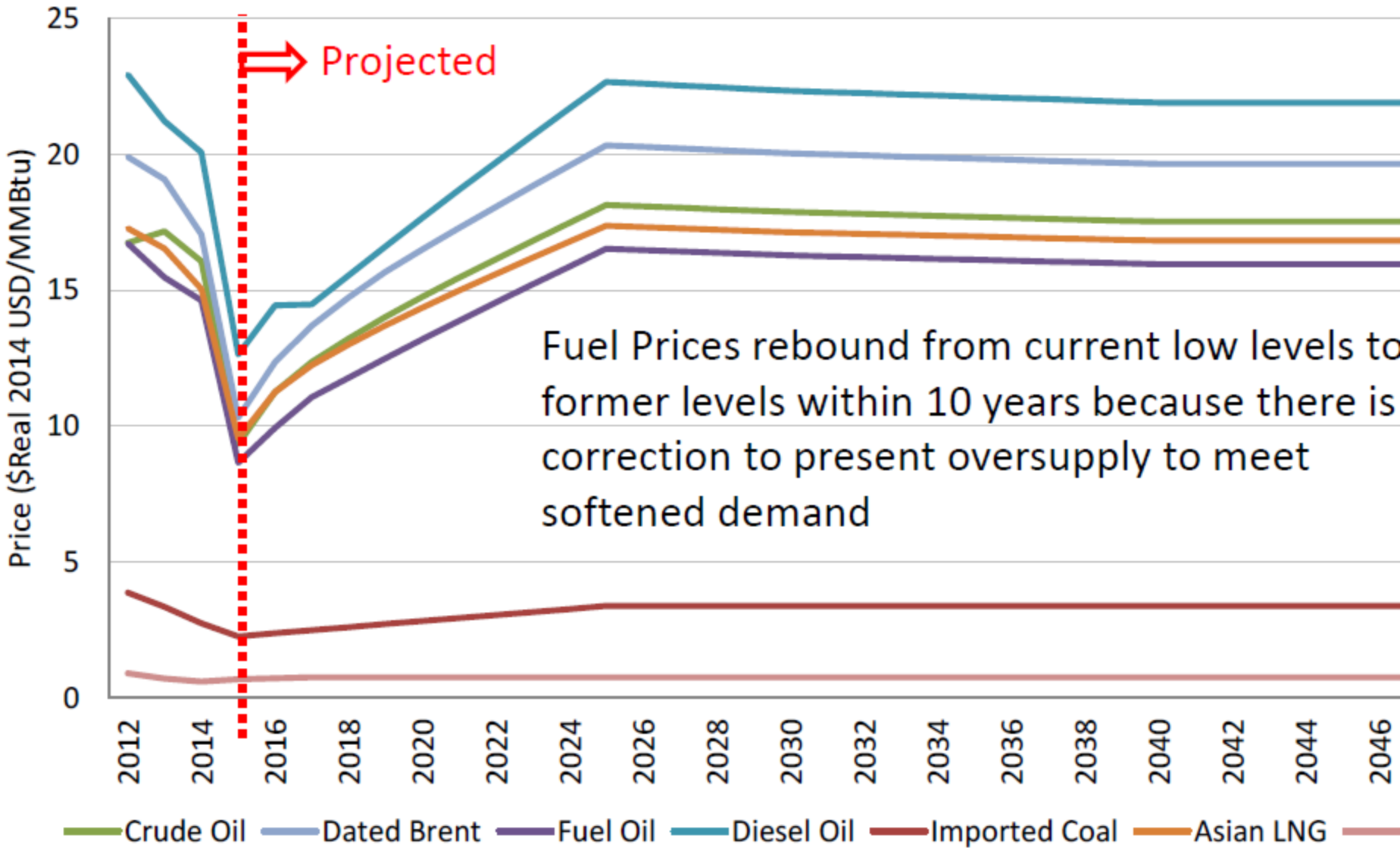
Cost of scenarios
Difference between BAU and SES



GDP – Same in All Scenarios



Fuel Prices – Same in All Scenarios



Type	FOM ($/MW/yr)	VOM ($/MWh)
Hydro	15,124	0.00
Wind	11,784	10.00
Coal	24,036	3.69
Gas	12,023	6.31
Diesel	29,870	15.20
Uranium	34,400	13.77
Fuel Oil	13,283	8.73
Bio	30,435	4.48
Solar	11,331	5.00
CSP	51,359	5.00
Battery	10,000	0.00
Hydro ROR	12,861	0.00
Geothermal	51,359	0.00
Pump Storage	6,216	0.00
CCS	48,724	8.29
Ocean	140,000	0.00