APEC Workshop on Filling the Gap to Reach the Goal of Doubling Renewable Energy in the APEC Region

SESSION 3:

Renewable Power Modelling for APEC Energy Demand and Supply Outlook 6th Edition

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Introduction

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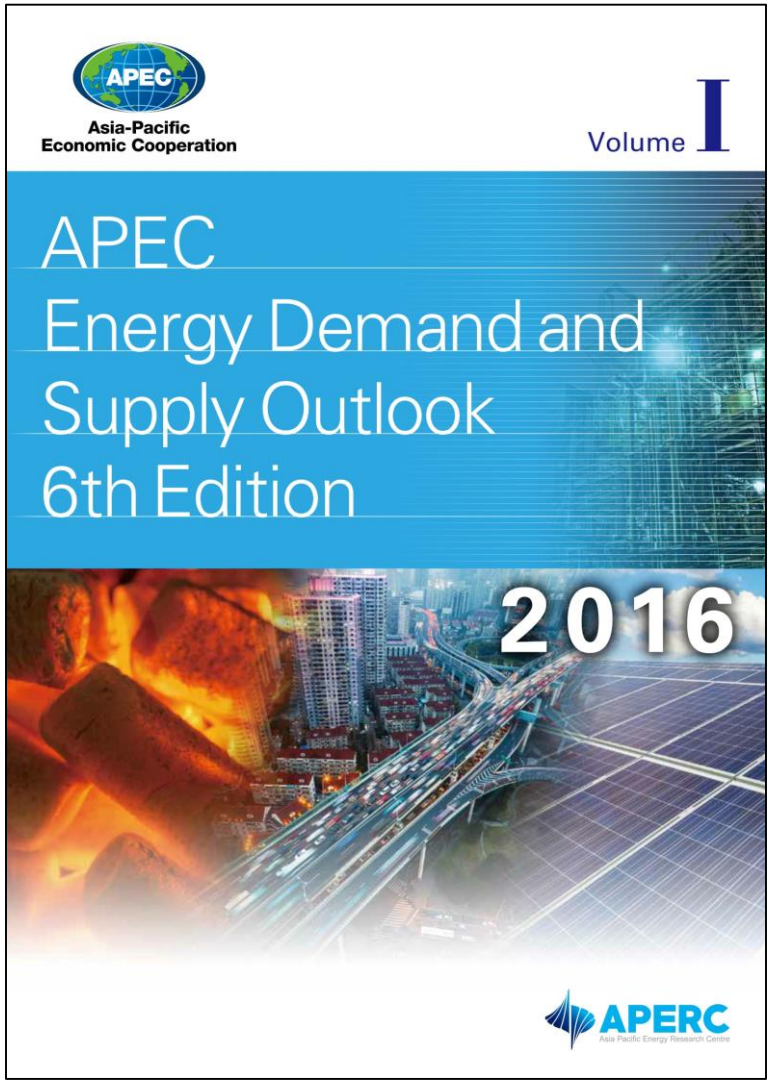
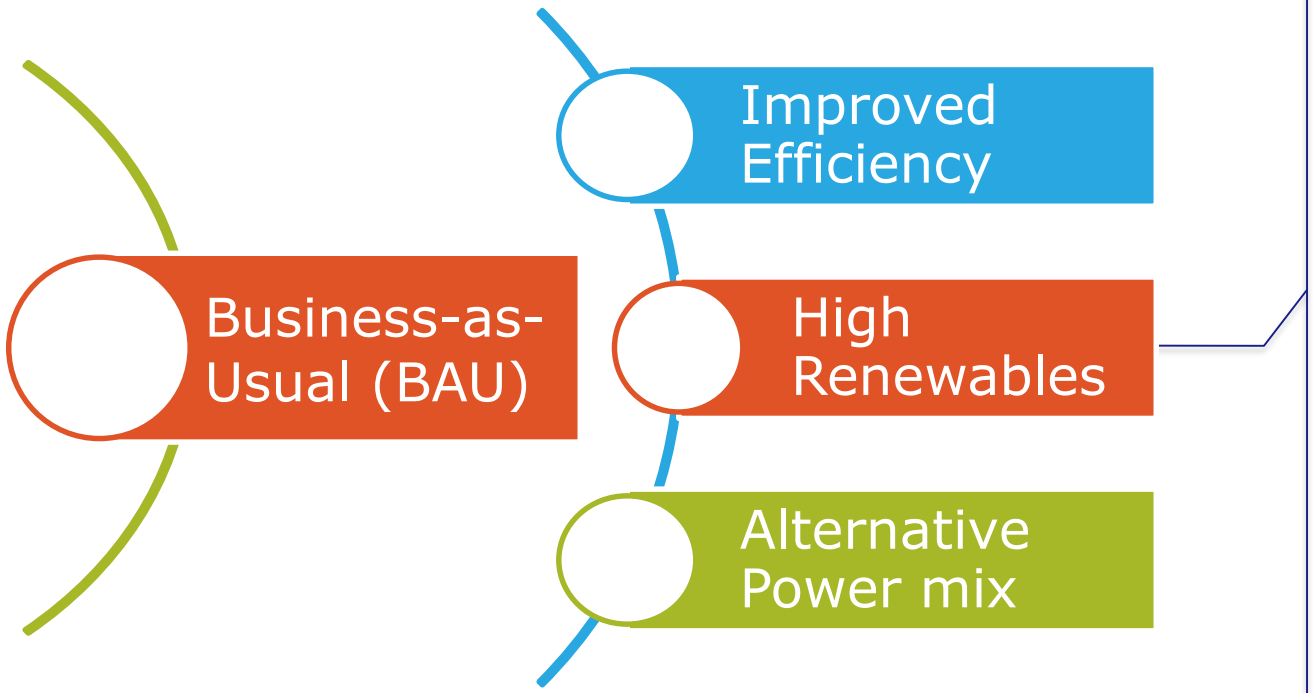
APEC EDSO 6th edition



- *Volume 1: APEC: sectoral view*
- *Volume 2: Economy Review*

APEC EDSO 6th edition Scenarios framework



The APEC Leaders have introduced an aspirational goal of

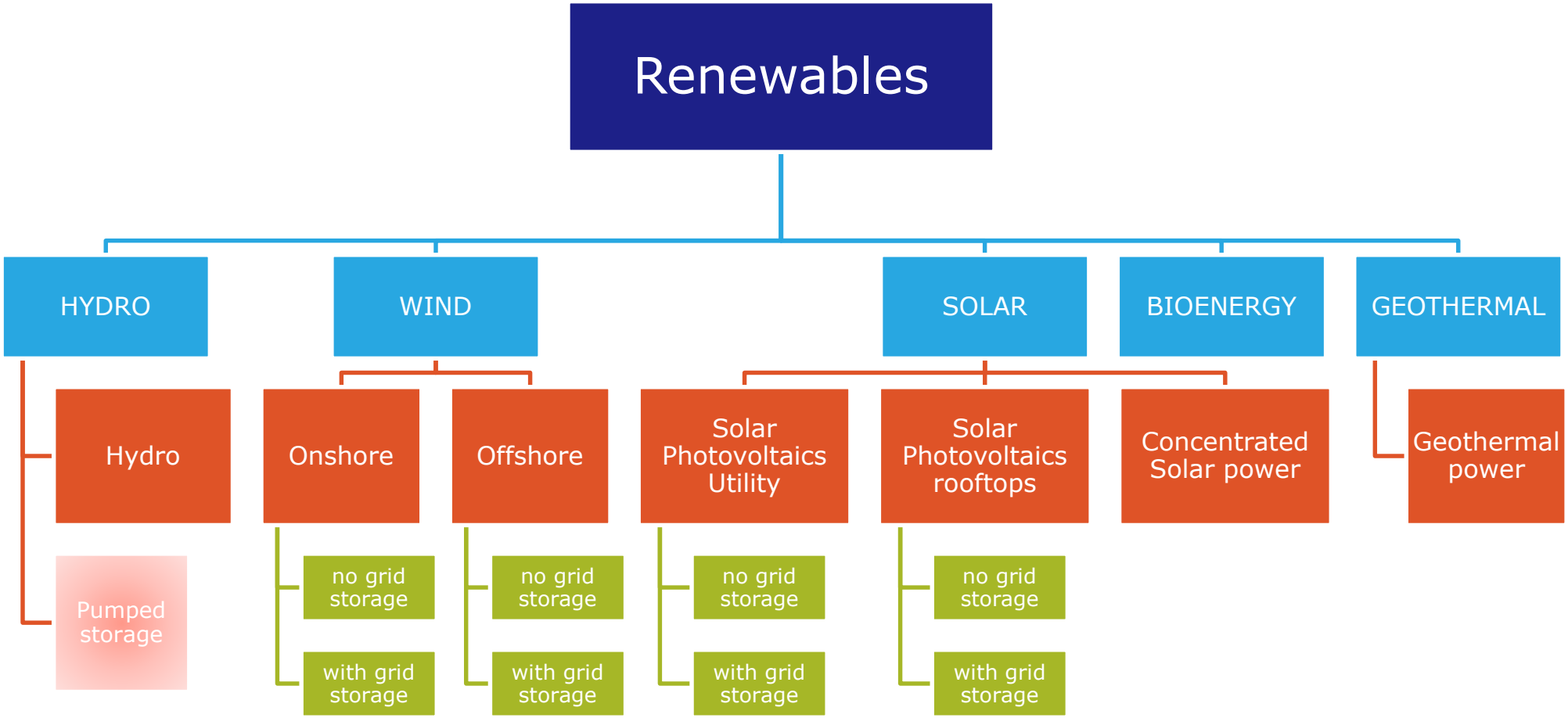
"doubling the share of renewables in the APEC energy mix, including in power generation, from 2010 levels by 2030"

(Beijing Declaration, 2014)

BAU and High Renewables scenario comparison

	BAU	High RE
Policies	Current policy	Support RE development
Energy demand	Historical trend	Historical trend
RE Capacity additions	Historical trend + Current policy	Historical trend + Current policy + All announced targets
RE CAPEX	Modest CAPEX reduction	Accelerated CAPEX reduction
RE Capacity factor	No/slow improvement	Accelerated improvement for Solar and Wind
Applicable	All sectors	Focused on Power and Transport, other sectors same as BAU

Renewable Energy technologies in the 6th Edition



Data collection

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Example of data sources

Publisher	Selected publications
APEC	• Establishment of the Guidelines for the Development of Biodiesel Standards in the APEC Region
IEA	• Projected Costs of Generating Electricity • World Energy Statistics 2015 • Integration of Variable Renewables
IRENA	• Rethinking Energy: Towards a New Power System • Renewable Capacity Statistics 2016
REN21	• Renewables 2014 Global Status Report
FAO	• Data on unutilized arable land, yields, trends
Economy's data sources	• Ministries, statistics bureau etc.

Energy policy context: Japan's example

RE specific legislation	Strategic Energy Plan 2014 (Section 3, Chap. 3); Long-term Energy Supply and Demand Outlook 2015
RE-related policy/plan	Energy mix increases RE to about 15% from 10% in FY2010
Target RE generation share	22%-24% in 2030 (hydro 9.2%, solar 7.9%, wind 1.7%)
Feed-in tariff (FiT)	23.10 ~ 57.75 JPY/kWh (tax included)[1]
Renewable Portfolio Standard (RPS)	Was available, but replaced by FiT
Tax incentive	Tax for Climate Change Mitigation (2012)

[1] Act on Purchase of Renewable Energy-Sourced Electricity by Electric Utilities (2011)

Renewable policies summary for power in APEC

Economy	RE-specific legislation	RE-related policy /plan	Development strategy	Target RE generation share	Feed-in Tariff (FiT)	RE portfolio standard (RPS)	Tax incentive
Australia	√	√	√	23.5% in 2020	-	-	√
Brunei Darussalam	-	√	√	10% by 2035		-	-
Canada	-	√	√	√*	√*	√*	√
Chile	√	√	√	20% in 2025, 70% in 2050	-	-	-
China	√	√	√	20% primary in 2030	√	√	-
Hong Kong	-	√	√	√	-	-	√
Indonesia	-	√	√	232 Mtoe (247.4 GW) in 2050	√	-	√
Japan	√	√	√	22-24% in 2030	√	-	√
Korea	√	√	√	(13.4%) in 2035	-	√	√
Malaysia	√	√	√	3% in 2020		√	√
Mexico	√	√	√	(29.1%) in 2028	-	-	√
New Zealand	-	√	√	90% in 2025		-	-
Papua New Guinea	-	-	-	100% in 2050		-	-
Peru	√	√	√	60% (5%^) in 2020		-	-
The Philippines	√	√	√	(+9.9 GW, +200%) in 2030	√	√	√
Russia	-	√	√	4.5%^ (25 GW^) in 2030	√	-	-
Singapore	-	√	√	-	-	-	-
Chinese Taipei	√	√	√	12.6% (27.1%) in 2030	√	-	√
Thailand	-	√	√	20% in 2036	√		√
United States	-	√	√	√*	√*	√*	√
Viet Nam	-	√	√	6% in 2030	√	-	-

*Note: √ = existing; - = not existing currently; * = applied in some local territories or states; ^ = target excludes large-scale hydro; (…) corresponds to installed renewables capacity targets*
Sources: APERC analysis and economy reports

Biofuel policies in APEC

Economy	Regulation	Blend rate mandate		Blend rate target		Incentives, subsidies and taxation
		Bioethanol	Biodiesel	Bioethanol	Biodiesel	
Australia	√	√*	√*	E4/E5*	B2*	√
Brunei Darussalam	-	-	-	-	-	-
Canada	√	up to E8.5^	up to B4^	E5	B2	√
Chile	-	-	-	-	-	-
China	-	E10^	-	10 Mt (2020)	2 Mt (2020)	√
Hong Kong	√	-	-	-	-	√
Indonesia	√	E3	B10	E20 (2025)	B30 (2025)	√
Japan	√	√	-	0.5 million Loe (2017)		√
Korea	√	-	B2	-	B5 (2020)	√
Malaysia	√	-	B7	-	B10	√
Mexico	√	E2	-	√	-	√
New Zealand	-	-	-	-	-	-
Papua New Guinea	-	-	-	-	-	-
Peru	√	-	-	E7.8	B5	√
The Philippines	√	E10	B2	E20 (2020)	B20 (2025)	√
Russia	√	-	-	-	-	-
Singapore	-	-	-	-	-	-
Chinese Taipei	√	-	-	-	-	√
Thailand	-	-	B7	4 billion L/yr	5 billion L/yr	√
United States	√	up to E15^	up to B10^	136 billion L/yr (2022)^		√
Viet Nam	√	E5	-#	E10 (2017)	-	√

*Note: √ = existing; - = not existing currently; * = applied in New South Wales and Queensland for bioethanol and in New South Wales for biodiesel; ^ = applied at federal level and in some local territories or states; # = biofuels traded with no mandated blend rate; Mt = million metric tonnes; Loe = litres of oil equivalent; L/yr = litres per year.*

Sources: APERC analysis and IEA statistics 2015.

Modelling methodology

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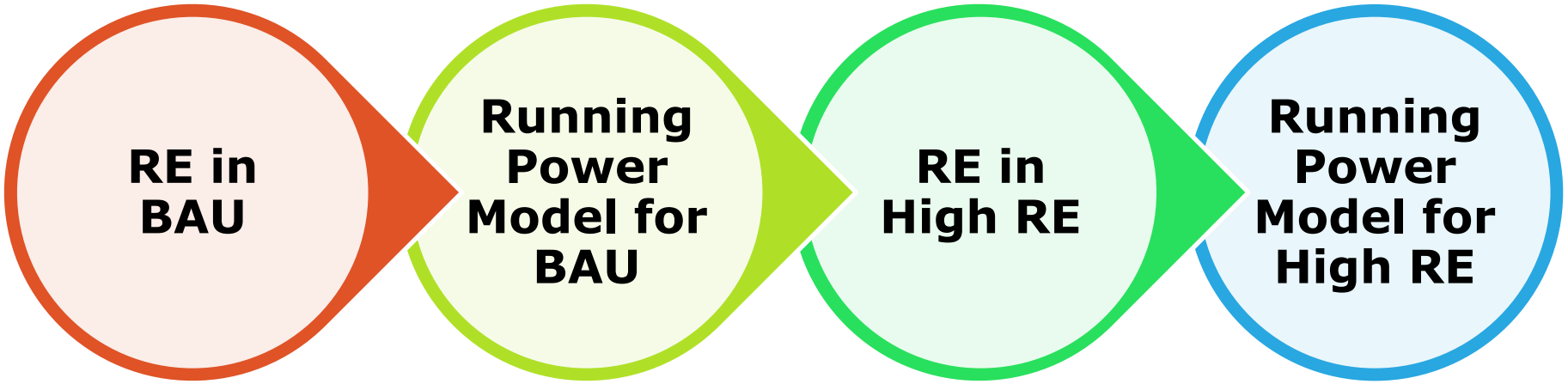
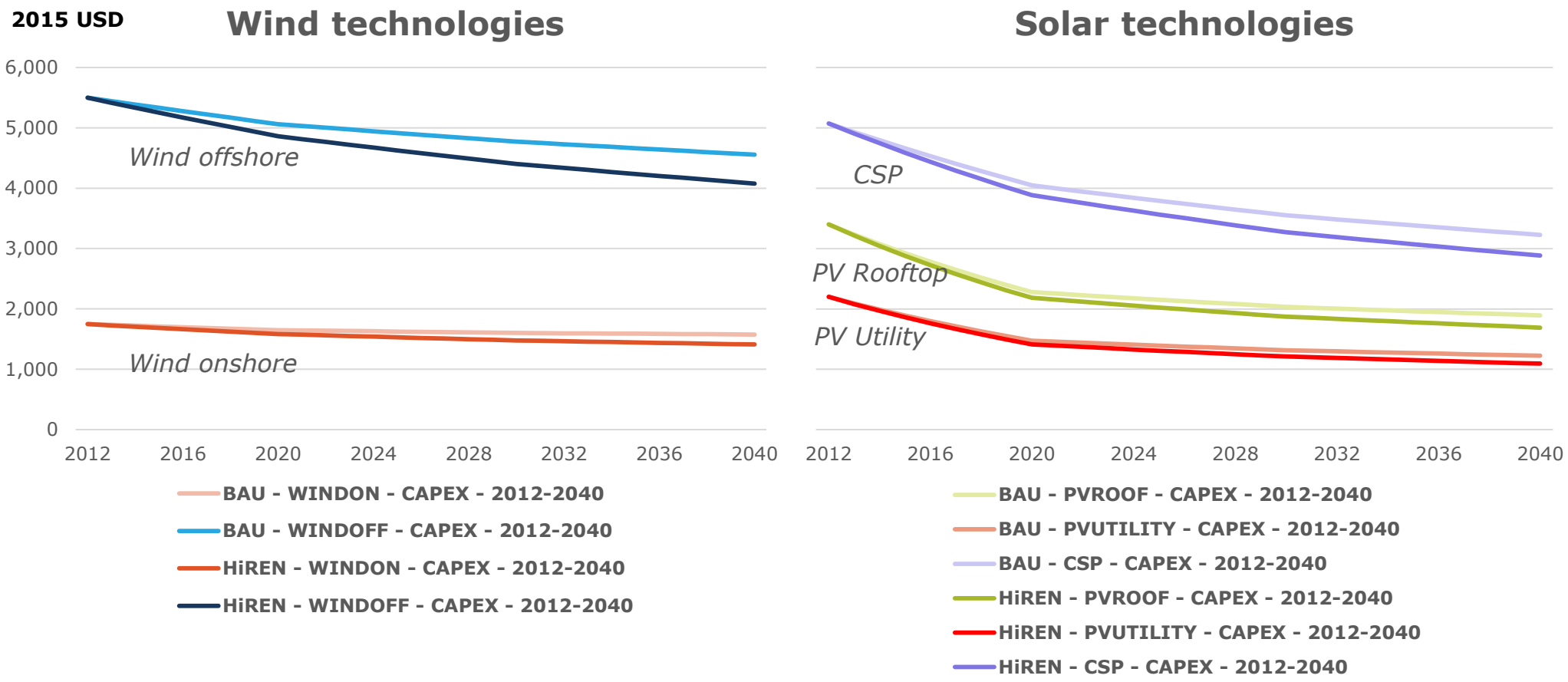
Modelling Renewables in Power for BAU and High Renewables



- BAU assumptions:
  - RE capacity,
  - RE shares,
  - RE CFs
- Power results:
  - refined capacity,
  - generation (incl. daily load curves)
- High RE assumptions:
  - maximum potential, targets,
  - additional RE capacity as per supply curve
- Final results:
  - for capacity and generation,
  - refined CF (Variable RE),
  - grid storage

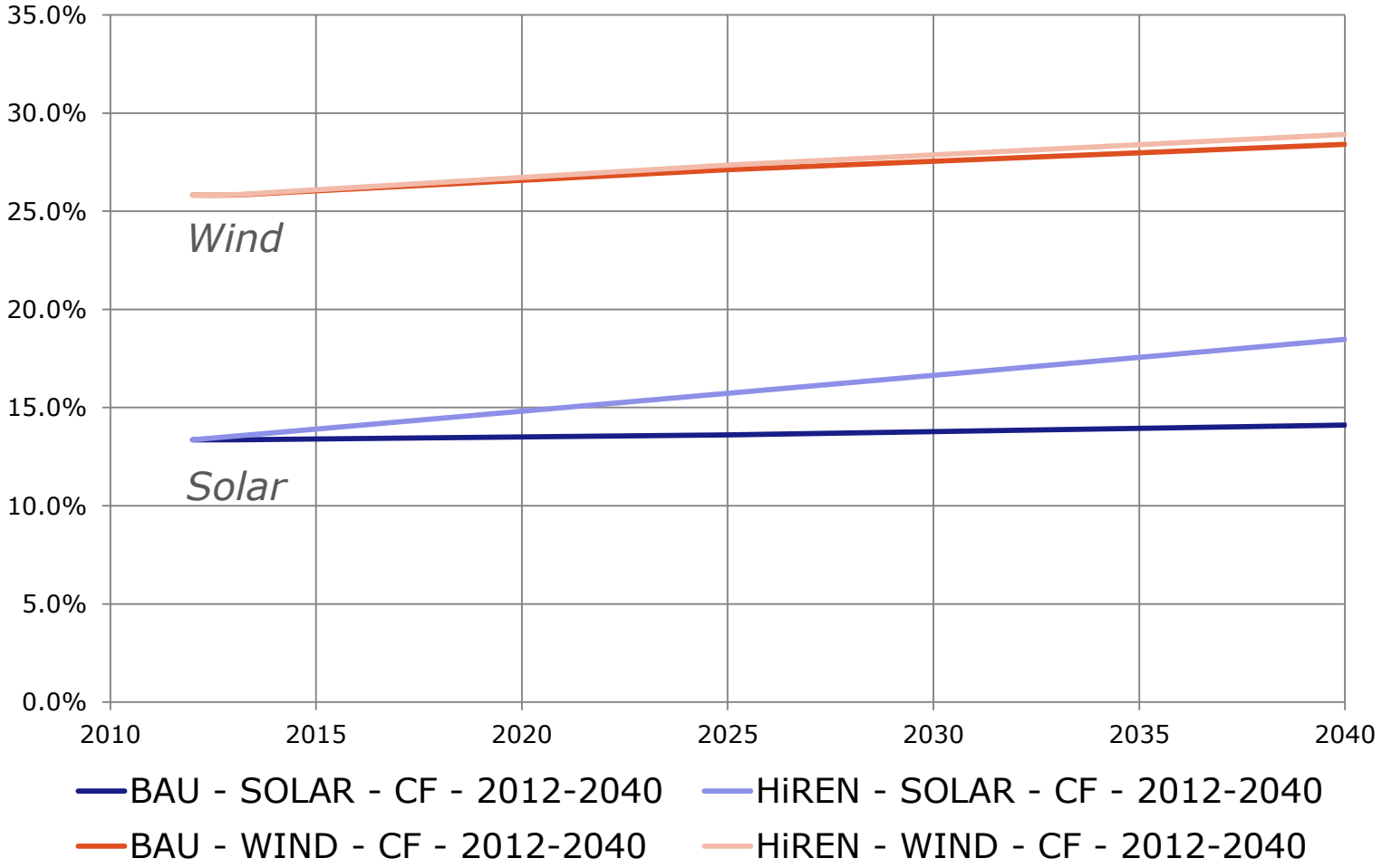
- BAU demand is used in both cases
- Doubling the share of RE in power from 16.1% (2010) to 32.2% (2030)
- RE Supply curve based on LCOE

RE assumptions: Wind and Solar CAPEX in Australia



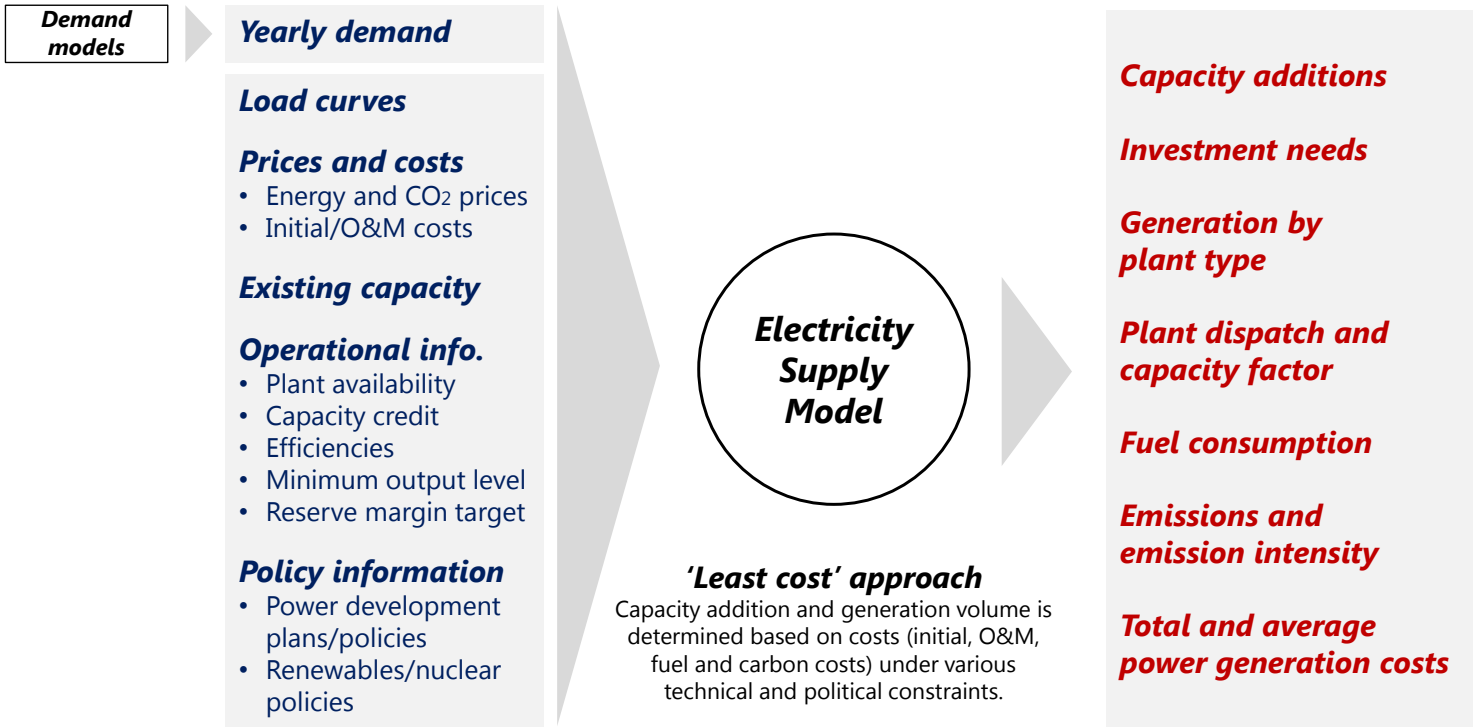
Shared vertical axis; Unit: USD
Source: APERC analysis

RE assumptions: CF for Wind and Solar in Australia



Power model structure

Power supply model structure



Modelled technologies

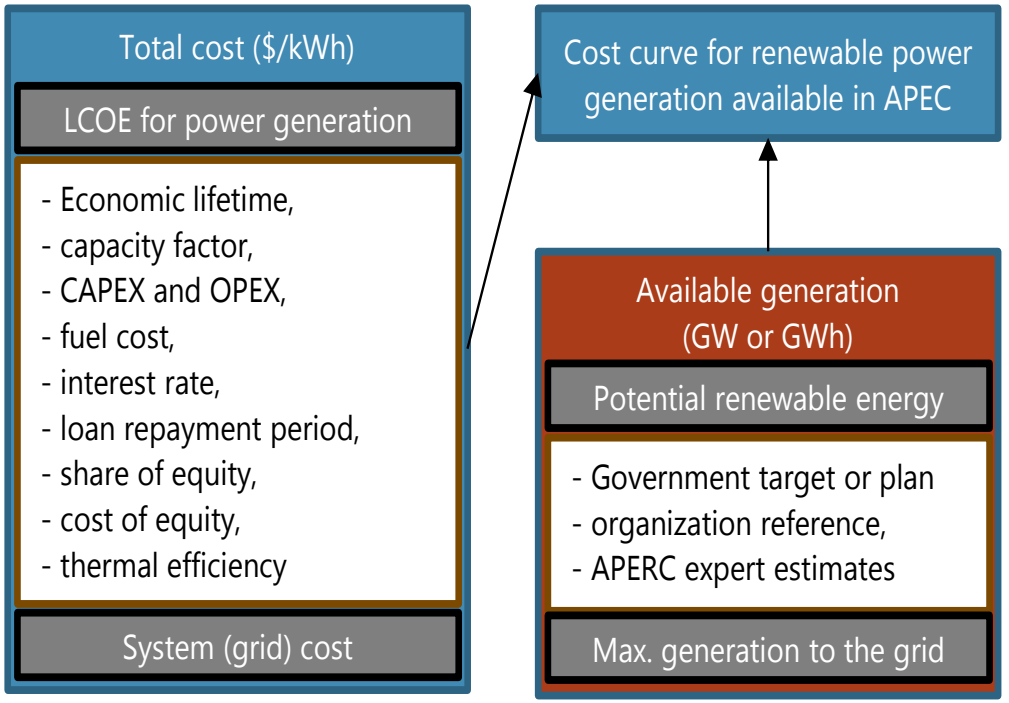
Generation
- Nuclear
- Coal-fired (sub-critical)
- Coal-fired (super / ultra-super critical)
- Gas turbine
- Gas combined cycle
- Oil-fired
- Solar PV & solar thermal
- Wind (onshore, offshore)
- Geothermal
- Biomass and others

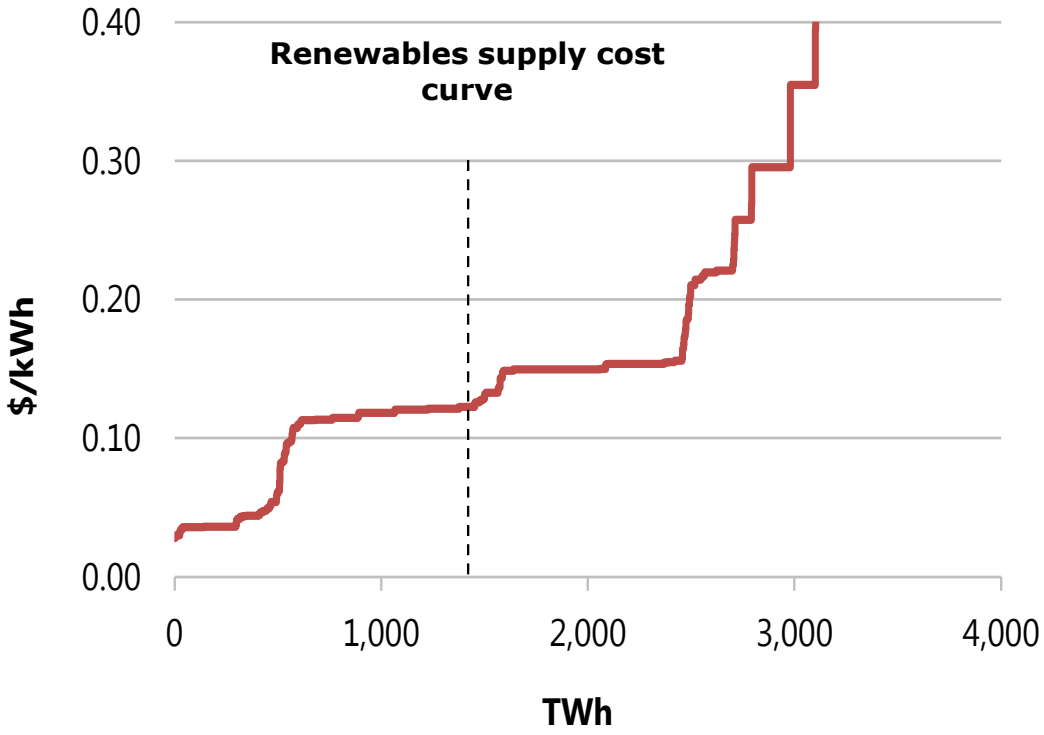
Storage
- Pumped hydro
- Battery

- Least cost optimisation model (written in GAMS)

Source: APERC

RE supply cost curve details





- A mix of additional RE generation is defined by using the supply curve, while knowing the required RE generation for a certain year
- Total cost of RE electricity = LCOE of RE generation + system (grid) costs

Variable RE assumptions and LCOE calculation

- Variable RE technologies, despite the grid storage are limited to:
  - 20% in developing economies, and
  - 30% in developed economies
- With technology improvement, and increasing CF, LCOE will lower each year,

$$LCOE = \sum_t \frac{(Investment_t + O\&M_t + Fuel_t) * (1+r)^{-t}}{\sum_t (Electricity_t * (1+r)^{-t})}$$

Where:

$Investment_t$	: Investment in year "t" (i.e. CAPEX)
$O\&M_t$	: Operation and maintenance costs in year "t" (i.e. OPEX)
$Fuel_t$	: Fuel costs in year "t"
$(1 + r)^{-t}$	: The discount factor for year "t"
$Electricity_t$	: The amount of electricity produced in year "t"

- LCOE varies from $0.03/kWh (hydro) to $0.31/kWh solar PV rooftop

Selected results

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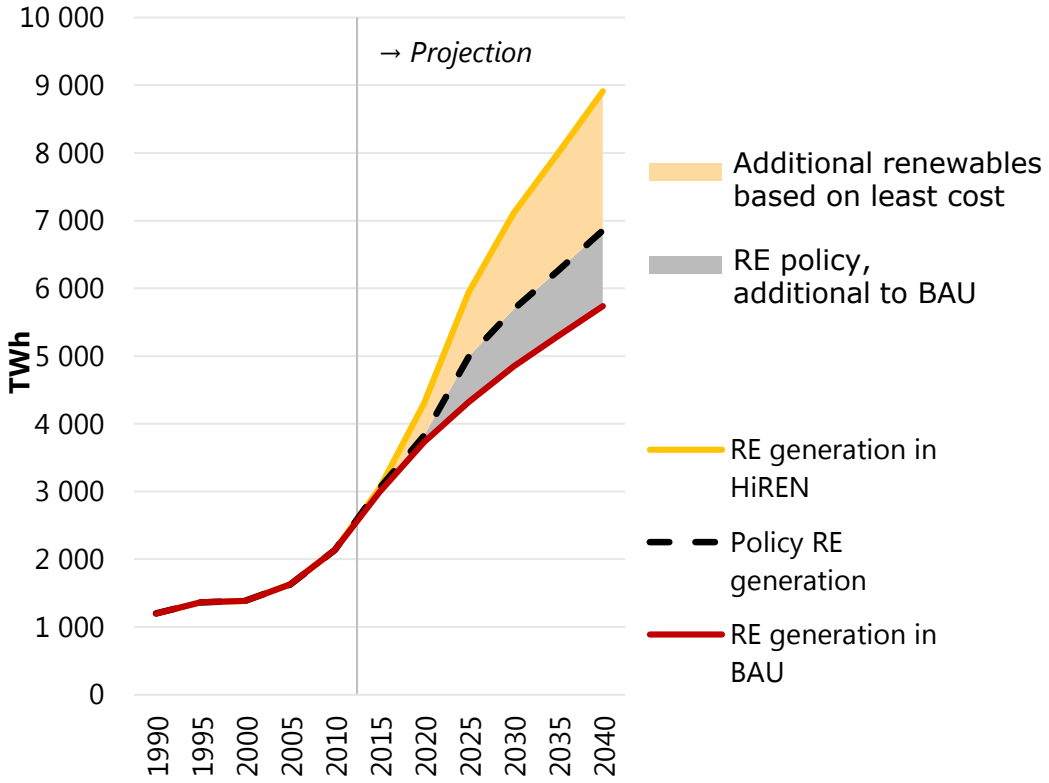
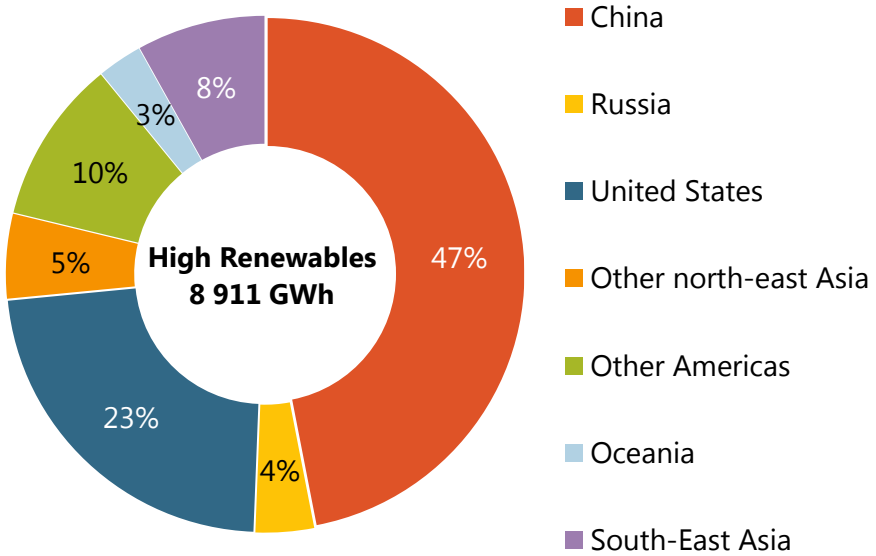
Current renewable policy falls short of the doubling

Renewable generation by scenario



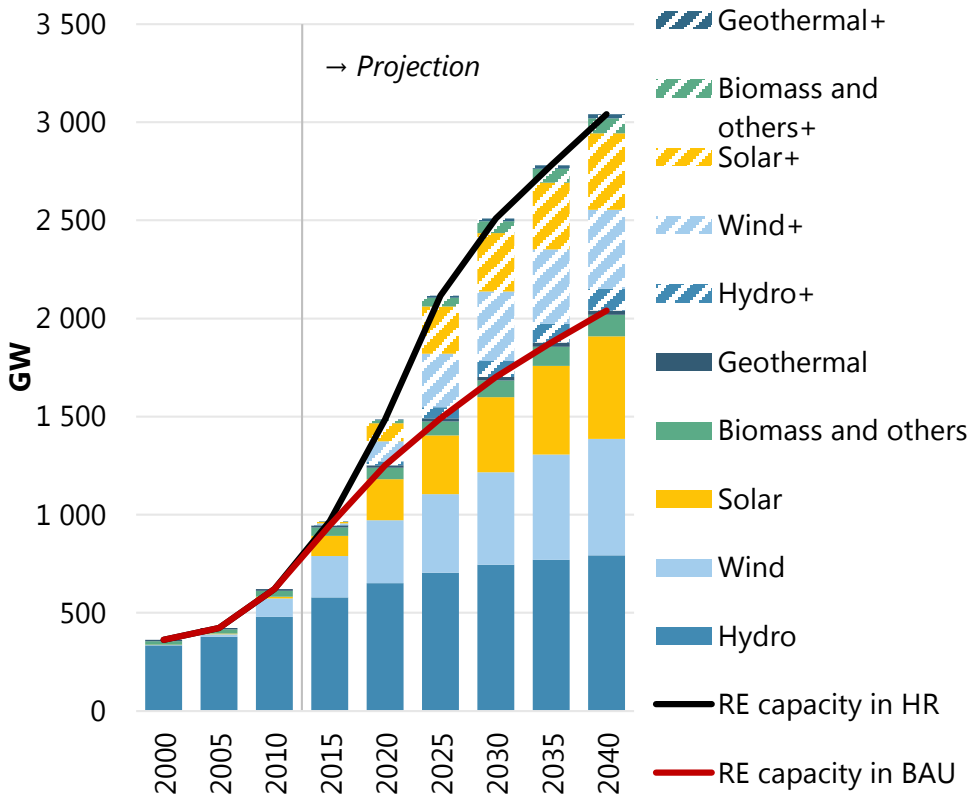
Renewable generation in 2040

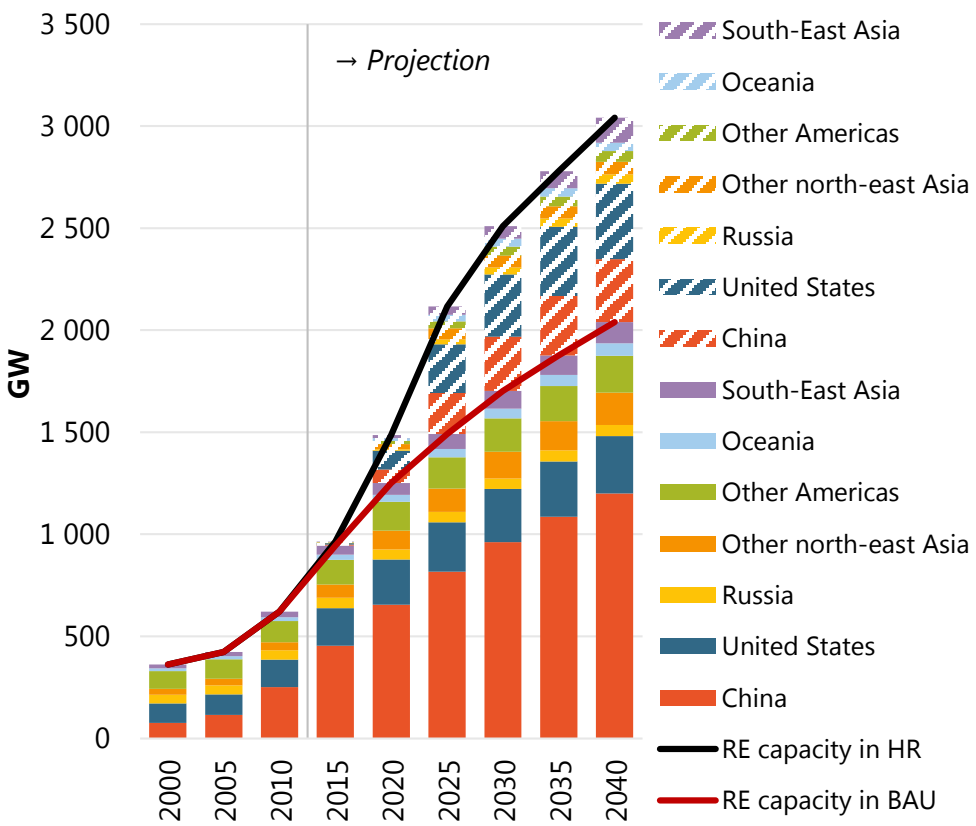


Renewables expand greatly in China, the United States and South-East Asia. China is leading in both installed capacity and generation.

Note: this map is for illustrative purposes and is without prejudice to the status of or sovereignty over any territory

Renewable capacity in the High Renewables





RE capacity increases fourfold from 620 GW to 2 510 GW (2030), translating to about 100 GW/yr

A lower CAPEX for solar leads to enormous increase in its installed capacity - 73 times increase from 2010 to 2030 compared with BAU

Source: IEA (2015), APERC analysis
NOTE: BAU = Business-as-usual, HR = High Renewables

Transport

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Transport: projecting biofuel

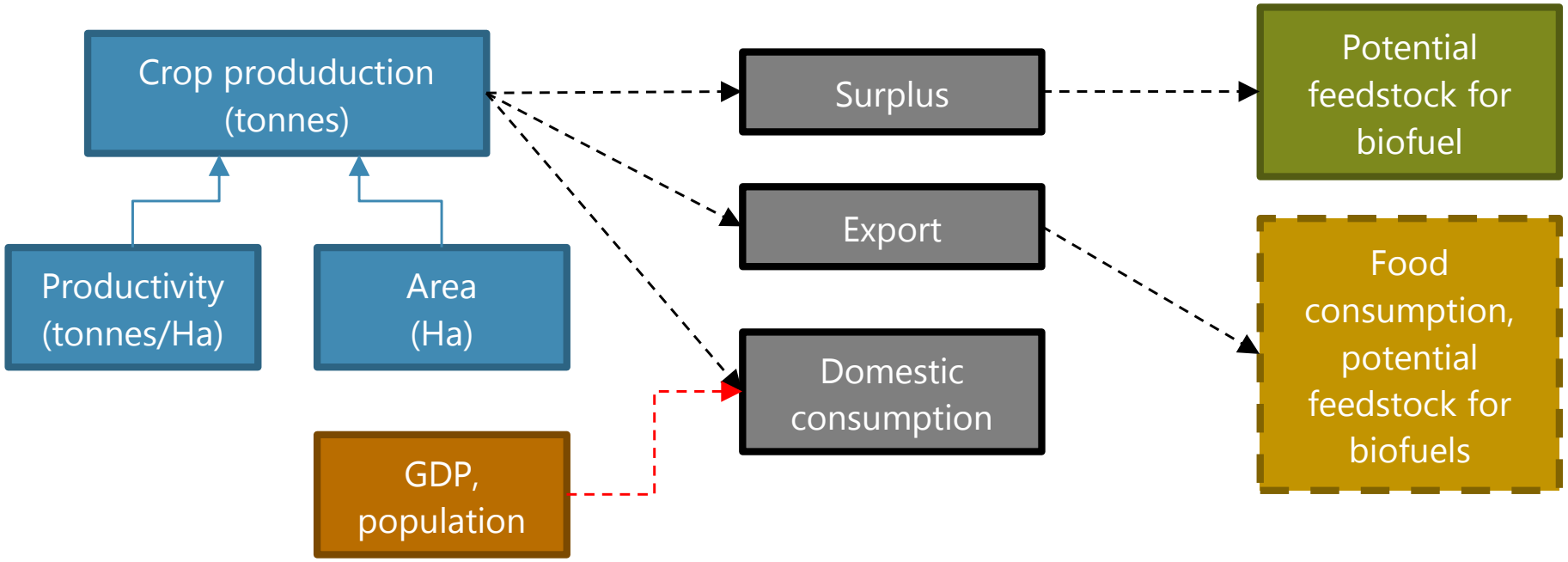
- Historical production and productivity are used for the base year 2010, then productivity increases due to improved technology
- In each case regional feedstock potential is calculated
- Demand and Supply for two fuels: Bioethanol and Biodiesel are considered
- Doubling the share of RE from 2010 to 2030: 4.6% (= 2 x 2.3%)

APEC Biofuels Demand and Supply in BAU scenario

Unit: Mtoe	2010	2015	2020	2025	2030	2035	2040
Total Biofuels Demand	28.6	38.3	46.2	51.3	55.6	60.7	64.6
Bioethanol	25.9	30.5	35.0	36.6	37.3	39.9	41.9
Biodiesel	2.8	7.8	11.2	14.7	18.3	20.7	22.8
Total BAU Supply Biofuels	62.0	71.8	77.6	83.6	89.6	95.6	100.9
Bioethanol	32.5	37.2	39.2	41.0	42.8	44.5	46.1
Biodiesel	29.5	34.7	38.4	42.6	46.8	51.1	54.9

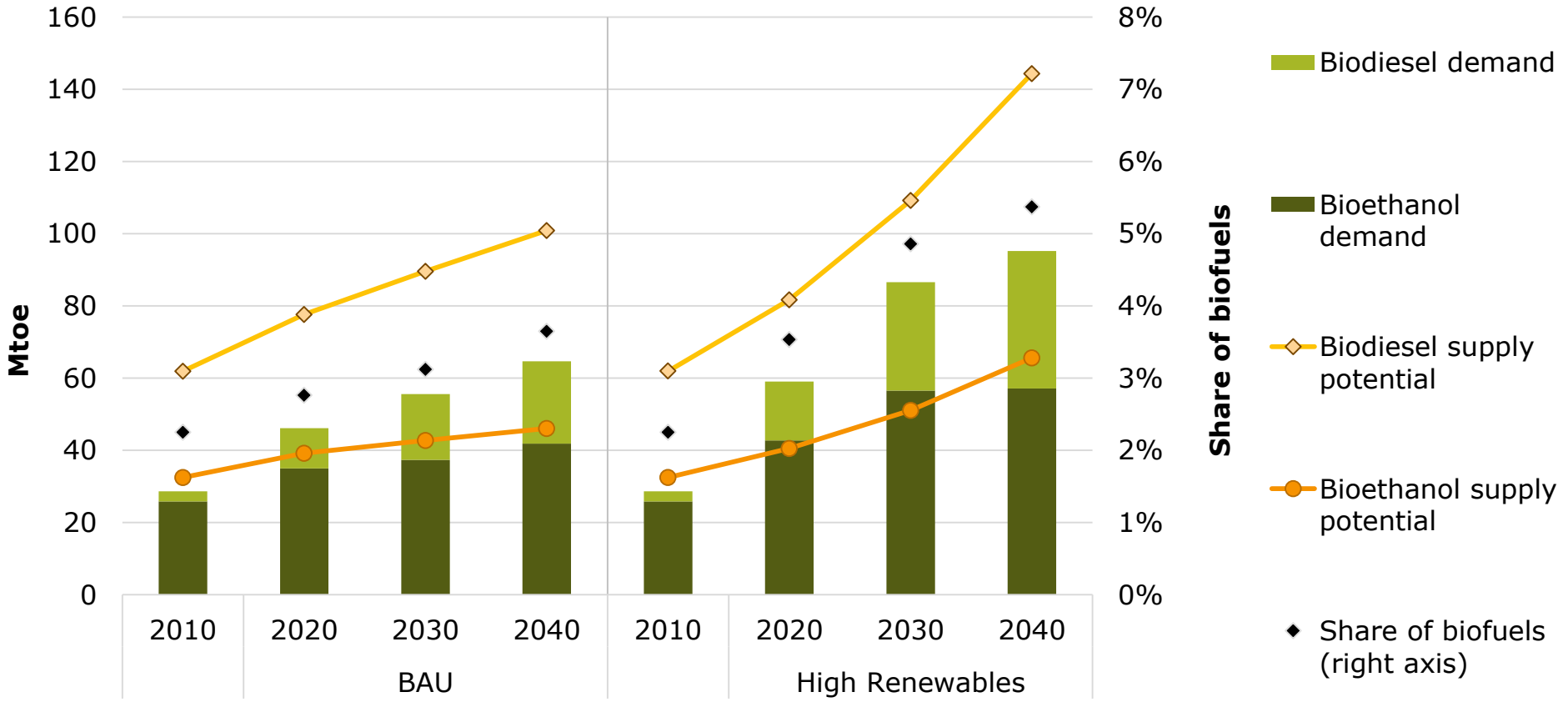
Source: APERC analysis

Transport: biofuel supply potential estimation



- 1st generation biofuels from 12 energy crops,
- maximising the arable land and enhancing productivity,
- surplus energy crops could be used as potential feedstock for biofuel supply,
- Biofuels demand is estimated through the current gov't biofuels policy and plan, in the absence of which, the supply potential is considered to introduce biofuels minimum blend rates.

APEC biofuels in BAU and the High Renewables scenario



Biofuel supply growing 2.7%/yr could meet over 5% of transport demand. Enough bioethanol to meet the growing demand, and surplus of biodiesel.

Sources: APERC analysis and IEA statistics 2015.

Future work

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Future Work

Detailed RE potential estimation by economy and by sector

Currently performed for Buildings and Industry (demand) and Bioenergy (supply)

APEC RE for Heating & Cooling applications assessment

Research project is underway

Improve load curves and power grid topology to quantify RE impacts

Detailed load curves being added for EDSO 7

Water-energy nexus (aspirational target)

Socio-economic-energy outlook

Thank you!

http://aperc.ieej.or.jp/

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