APERC Update

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Structure

- ✓ Modelling improvements

- ✓ Renewables analysis improvements

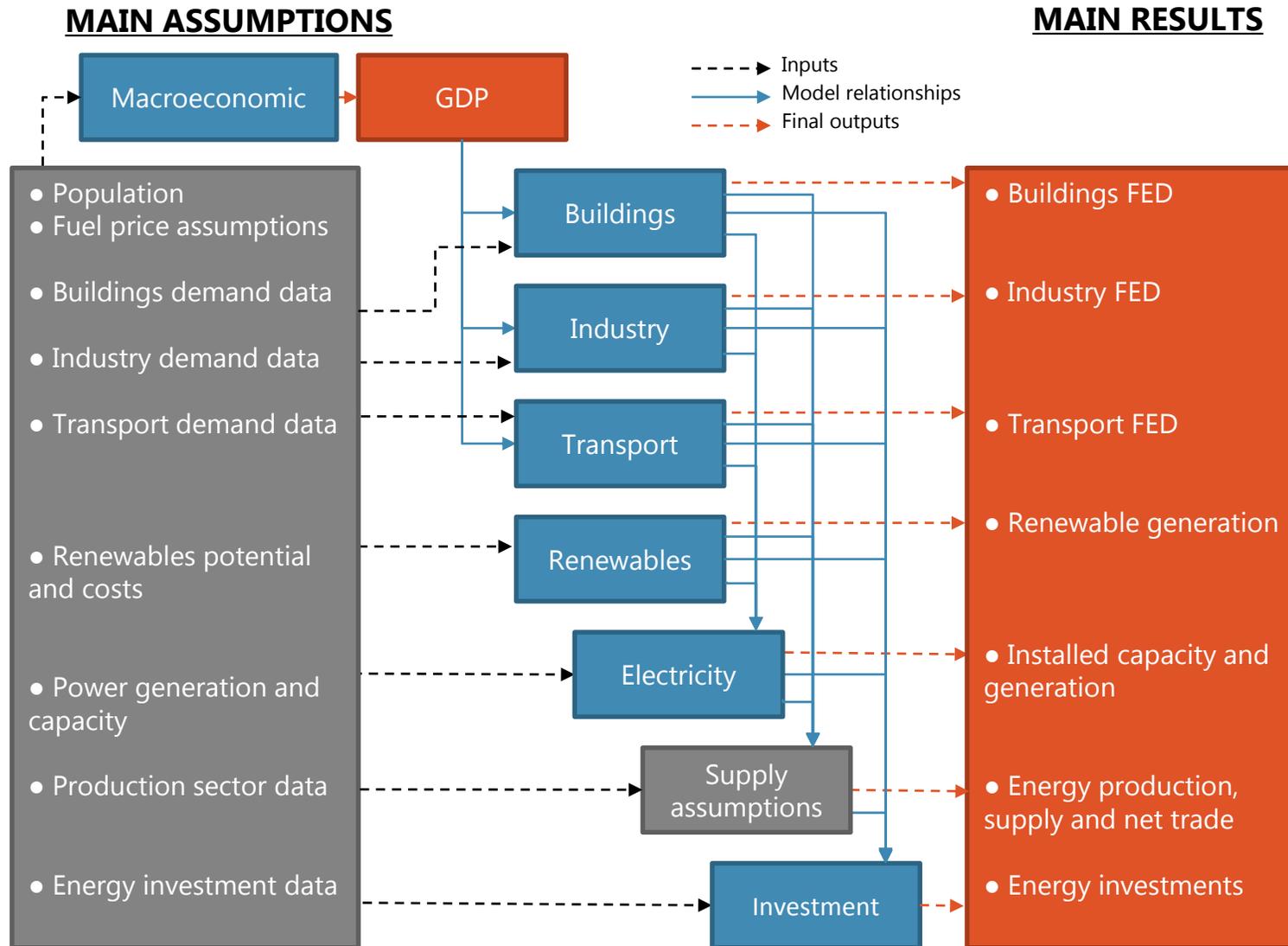- ✓ Renewables potential assessment

- ✓ Other updates

Modelling improvements

6th and 7th Edition of the Outlook: comparison

	6th edition	7th edition
Economies	21	21
Sub-regions	7	7
Scenarios	BAU + 3	BAU + 2
No. of models	7	10
No. of fuels	12	29
Outlook period	From 2013 to 2040	From 2015 to 2050

Further updates expected, as at 2017.03.24

6th Edition of the Outlook: model structure

MAIN ASSUMPTIONS

MAIN RESULTS

Macroeconomic → GDP

- - - → Inputs
——→ Model relationships
- - - → Final outputs

- Population
- Fuel price assumptions

- Buildings demand data

- Industry demand data

- Transport demand data

- Renewables potential and costs

- Power generation and capacity

- Production sector data

- Energy investment data

Buildings

Industry

Transport

Renewables

Electricity

Supply assumptions

Investment

- Buildings FED
- Industry FED
- Transport FED
- Renewable generation
- Installed capacity and generation
- Energy production, supply and net trade
- Energy investments

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Working document, no referencing or citing

7th Edition of the Outlook: sectoral model updates (1)

➢ **Macroeconomic:**

    ➢ Use OECD GDP forecasts (where available),

➢ **Buildings:**

    ➢ Activity driven model (space/water heating, space cooling, lighting, appliances),

    ➢ Extensive work underway to address Commercial buildings end-use data unavailability,

➢ **Transport:**

    ➢ Light Trucks and Buses added, taxis are considered

    ➢ Activity driven model,

    ➢ Modal shift,

    ➢ More detailed fuels analysis,

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7th Edition of the Outlook: sectoral model updates (2)

➢ **Industry:**

    ➢ Bottom-up approach

    ➢ Moving away from ISIC,

    ➢ Energy-intensive sub-sectors are physical output driven, other sub-sectors - value added,

➢ **Renewables:**

    ➢ Dedicated model no more,

    ➢ Integration with Electricity and Demand sectors,

- **Supply:**
  - Production and trade forecast

- **Electricity:**
  - Extensive list of technologies, including Renewables,
  - Improved time-resolution

- **Heat:**
  - New model will accommodate commercial heating and cooling,

- **Investment:**
  - Demand sector investments, e.g. difference between reference and high efficiency appliances,

7th Edition of the Outlook: draft assumptions (1)

✓ Engaging the economy experts to review and comment our modelling assumptions

Renewables assumptions for RESIDENTIAL & COMMERCIAL BUILDINGS & POWER in 20_USA		Indicator	Unit	2015	BAU					Comments
					2020	2030	2040	2050	2015-2050,%	
RESIDENTIAL BUILDINGS										
Solar Thermal	Water heating	CAPEX	$	3,300	3,000	2,600	2,600	2,600	-0.7%	Avg. size: 2m², 200L
		Solar factor	SF	2.5	3.0	3.5	3.5	3.5	n/a	
Bioenergy	2015 Tech-Econ. potential and future market uptake		TWh, %						n/a	
	Solid biomass boiler: Space & Water heating	CAPEX	$	4,700	4,900	5,100	5,300	5,500	0.5%	Avg. size:
		Fuel cost	$/t	245	250	260	270	280	0.4%	36kBTU/h = 10.5kW
		Efficiency	%	78%	80%	81%	83%	84%	n/a	
	Biogas boiler: Space & Water heating	CAPEX	$	4,050	5,900	5,900	5,900	5,900	1.1%	Avg. size:
		Fuel cost	$/1,000m³	150	160	170	180	190	0.7%	36kBTU/h = 10.5kW
		Efficiency	%	82%	90%	90%	90%	90%	n/a	
Geothermal	Ground source heat pump: Space heating & cooling & Water heating	CAPEX	$	12,500	17,500	17,500	17,500	17,500	1.0%	Avg. size:
		Efficiency heating	COP	3.2	3.6	3.8	4.0	4.2	n/a	36kBTU/h = 10.5kW, EER is
		Efficiency cooling	EER	14.2	17.1	21.0	24.0	26.0	n/a	[kBTU/h / kWh]

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Renewables assumptions for **RESIDENTIAL** & **COMMERCIAL** **BUILDINGS** & **POWER** in 20_USA		Indicator	Unit	2015	BAU				
					2020	2030	2040	2050	2015-2050,%
		Efficiency cooling	EER	6.6	20%	22%	13%	14%	n/a
POWER GENERATION									
Hydro	Large hydro	CAPEX	$/kW	2,411	2,411	2,411	2,411	2,411	0.0%
		OPEX	$/kW/yr.	24	24	24	24	24	0.0%
		Capacity factor	%	42.6%	42.7%	42.7%	42.8%	42.8%	na
	Medium hydro	CAPEX	$/kW	3,020	3,020	3,020	3,020	3,020	0.0%
		OPEX	$/kW/yr.	44	44	44	44	44	0.0%
		Capacity factor	%	50.0%	50.0%	50.0%	50.0%	50.0%	n/a
	Small hydro	CAPEX	$/kW	3,620	3,620	3,620	3,620	3,620	0.0%
		OPEX	$/kW/yr.	73	73	73	73	73	0.0%
		Capacity factor	%	88.0%	88.0%	88.0%	88.0%	88.0%	n/a
Wind	Wind onshore	CAPEX	$/kW	1,644	1,630	1,600	1,560	1,530	-0.2%
		OPEX	$/kW/yr.	46	46	46	46	46	0.0%
		Capacity factor	%	32.7%	33.2%	34.2%	35.0%	35.0%	n/a
	Wind offshore	CAPEX	$/kW	6,331	6,170	5,870	5,590	5,310	-0.5%
		OPEX	$/kW/yr.	76	76	76	76	76	0.0%
		Capacity factor	%	37.7%	38.2%	39.2%	40.0%	40.0%	n/a
Solar	Solar PV: Residential	CAPEX	$/kW	3,690	3,460	3,030	2,660	2,330	-1.3%
		OPEX	$/kW/yr.	32	32	32	32	32	0.0%
		Capacity factor	%	11.2%	11.4%	12.0%	12.5%	12.5%	n/a
	Solar PV: Commercial	CAPEX	$/kW	3,090	2,890	2,540	2,230	1,950	-1.3%
		OPEX	$/kW/yr.	27	27	27	27	27	0.0%
		Capacity factor	%	12.2%	12.4%	13.0%	13.5%	13.5%	n/a
	Solar PV: Utility	CAPEX	$/kW	2,480	2,320	2,040	1,790	1,570	-1.3%
		OPEX	$/kW/yr.	21	21	21	21	21	0.0%
		Capacity factor	%	13.2%	13.4%	14.0%	14.5%	14.5%	n/a
	Concentrated Solar Power	CAPEX	$/kW	4,168	3,940	3,530	3,160	2,830	-1.1%
		OPEX	$/kW/yr.	69	69	69	69	69	0.0%
		Capacity factor	%	28.2%	28.4%	29.0%	29.5%	29.5%	n/a
Bioenergy	Solid biomass	CAPEX	$/kW	3,765	3,765	3,765	3,765	3,765	0.0%
		OPEX	$/kW/yr.	141	141	141	141	141	0.0%
		Capacity factor	%	68.2%	68.2%	68.2%	68.2%	68.2%	n/a

7th Edition of the Outlook: timeline (draft)

Expert Economy Review of model results	Oct 2017
EWG review of Vol II	Sept 2018
EWG review of Vol I	Oct 2018
Outlook 7th edition released	April 2019
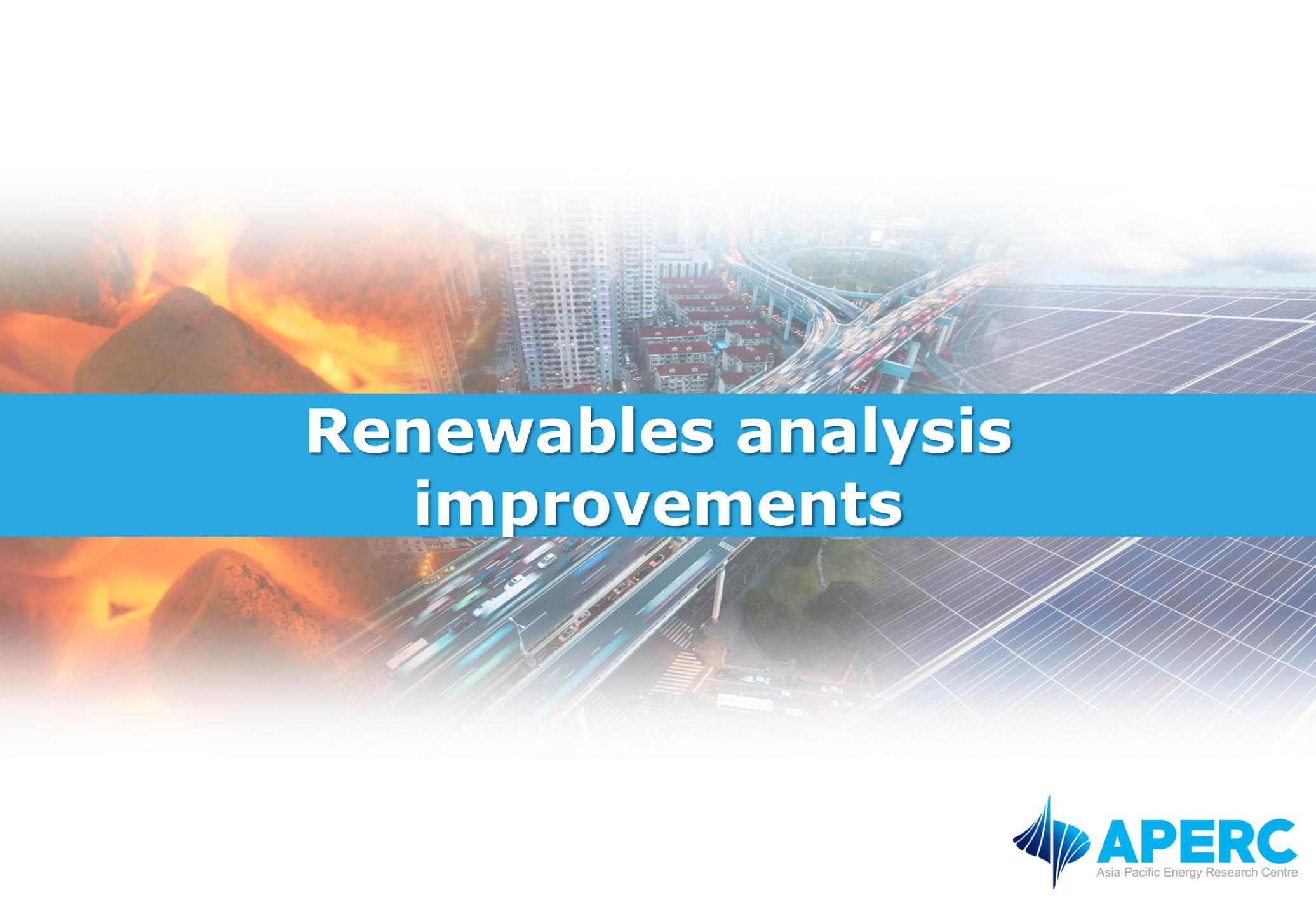
Renewables analysis improvements

Renewables

Hydropower	Wind	Solar Power	Solar thermal	Bioenergy	Geothermal power	Geothermal heat	Marine
Mini Hydro / Small Hydro / Large Hydro	Wind Onshore / Wind Offshore	Solar PV – Residential / Solar PV – Commercial / Solar PV – Utility / Concentrated Solar Power		Solid biomass / Liquid fuels / Gaseous fuels		Direct heat / Ground source heat	

Pumped storage
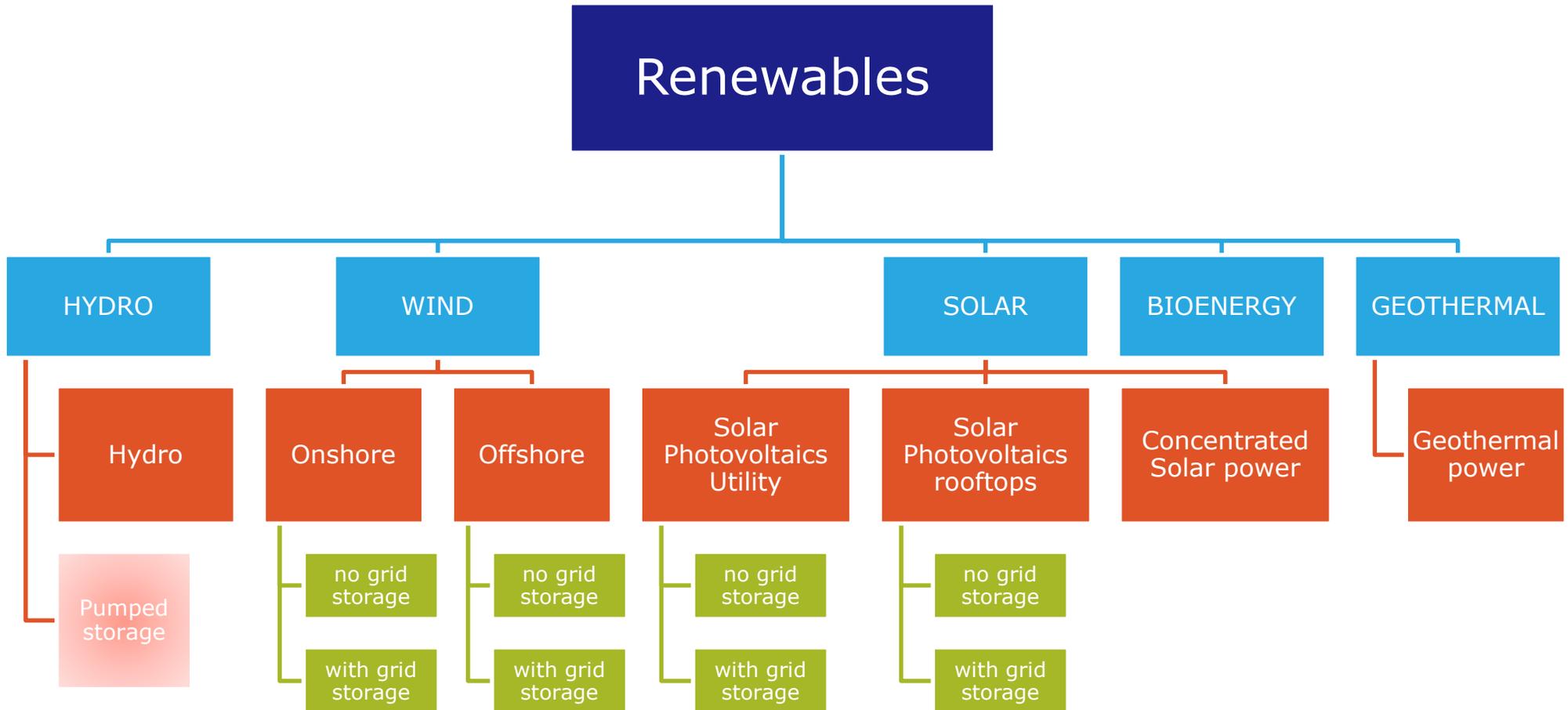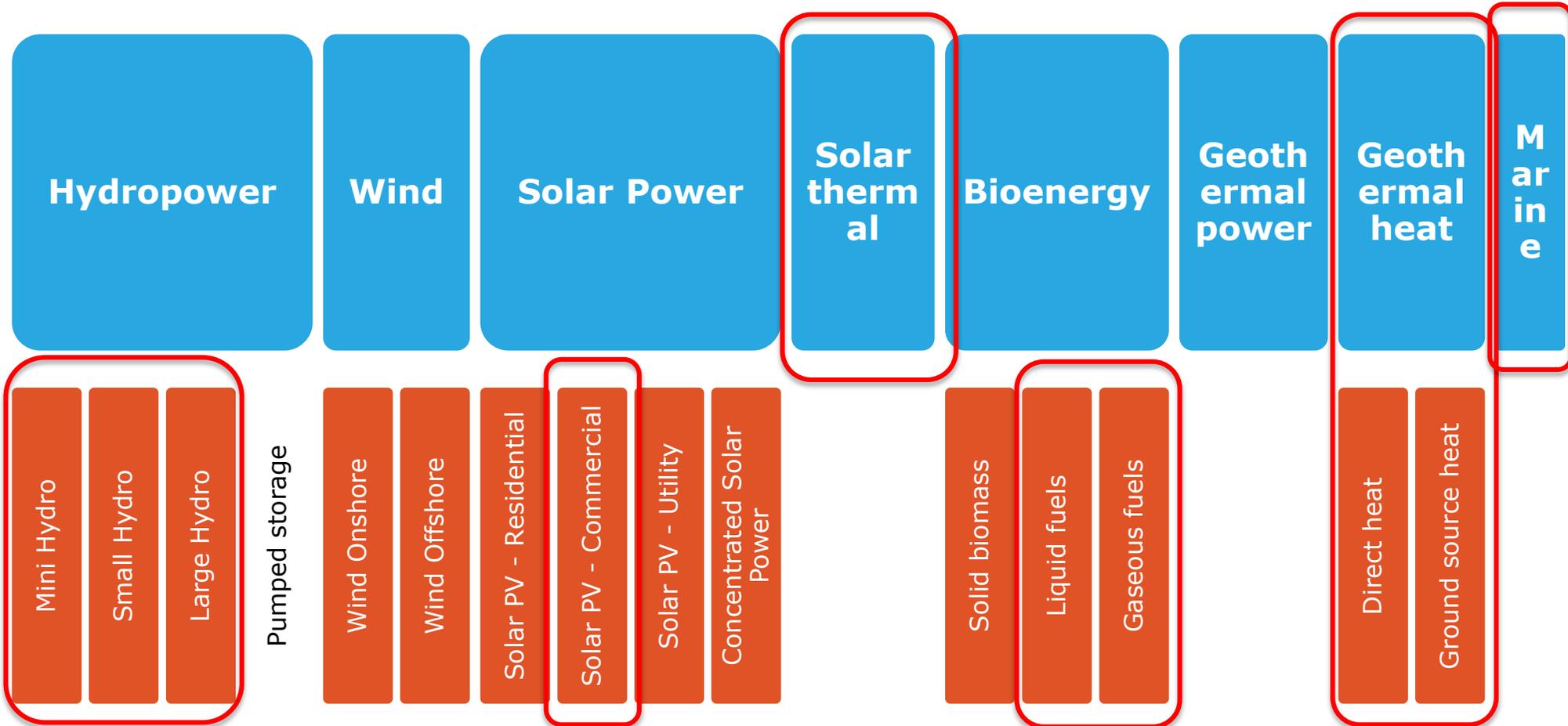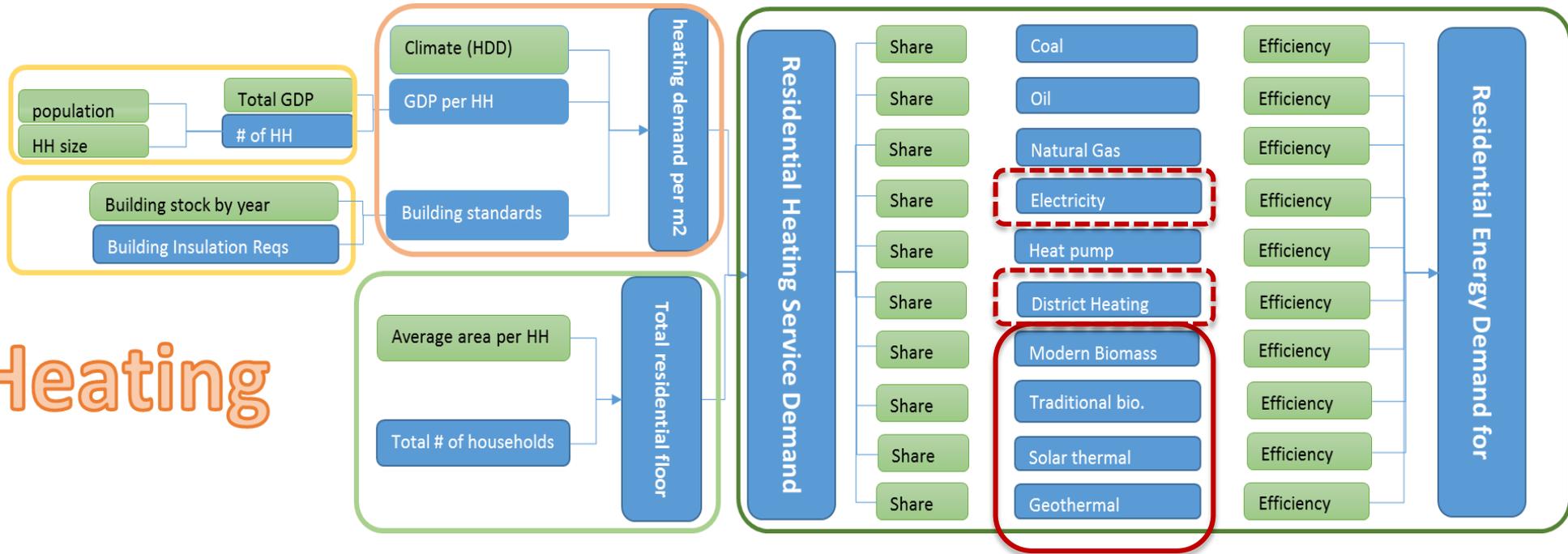
Renewables potential assessment

Estimates for Residential Rooftop solar PV and heat potential,

- ✓ An economy is split in urban and rural (urbanisation rate),

- ✓ Per capita floor size for urban and rural to calculate floor areas,

- ✓ Building footprints based on <u>average floor count</u>,

- ✓ Assume 1:1 ratio for footprint and roof area,

- ✓ Assume <u>10-25%</u> of roof area is suitable for installations,

- ✓ Account for efficiency change from 2015 to 2050,

- ✓ Use average or regional insolation data,

- ✓ For max solar heat case:

  - ✓ Assume 3m2 solar water heater collector size, however requires 8m2 of roof,

  - ✓ Remaining area is covered with Solar PV with 80-90% density factor.

Note:

A trial calculation for Residential sector in Viet Nam:

- ✓ All urban areas roofs are covered by Solar Water Heaters (SWH),

- ✓ In rural areas Solar PV is 20-35%, gradually declines

Note:

Estimates for Industrial Rooftop solar PV and heat potential,

- ✓ Industry is split into sub-sectors,

- ✓ Individual plants with known production are assessed in sub-sectors,

  - ✓ Assessment includes Value Added/Physical Output and Buildings footprint,

- ✓ Assume 10-30% of roof area is suitable for installations,

- ✓ Calculate the Value Added/Physical Output per 1m^2 of roof by sector,

- ✓ Account for efficiency change from 2015 to 2050,

- ✓ Use average or regional insolation data,

- ✓ For max solar heat case:

  - ✓ Assume solar heating installations with 80% density,

  - ✓ Assume Solar PV installation with 80-90% density.

Note:

For 7th Outlook, estimates for biomass supply potential will be included covering agricultural and forestry residues and animal wastes. Initial estimates for municipal solid waste might also be considered.

- Used the FAO database for agriculture production, area harvested, livestock and forestry production

Source: Pinterest

Estimating biomass potential from agricultural residues

Projection for the total harvested area until 2050
Total Harvested Area = f (GDP, POP, Capital Stock)

⬇

Assume the productivity using its historical trend
(logarithmic trend)

⬇

Production by crops = Harvested area * Productivity

⬇

Agriculture Residual = Production * Emission Rate (Waste)

⬇

Residual Available = Agriculture Residual * Available Rate

Source: https://greenheatug.wordpress.com/page/2/

Source: biomassmagazine

Estimating biomass potential from forestry residues

Projection for forest area = f(POP, Capital Stock)

Industrial wood = f(forest area, GDP Industry)
Wood fuel = f(forest area, industrial wood)
Wood chips = f(forest area, industrial wood)

Forest Residual = Wood Production * Emission Rate (Waste)

Residual Available = Production Residual * Available Rate

Source: woodpelltesolutions.co.uk

Source: energybook.info

Estimating biomass potential from animal waste

Projection for Livestock Per Capita = f(historical trend logarithmic)

⬇

Number of Livestock = livestock per capita * Population

⬇

Animal Waste = Number of Livestock * Emission Rate (Waste)

⬇

Animal Waste Available = Animal Waste * Available Rate

Source: woodpelltesolutions.co.uk

Source: energybook.info

Estimating biomass potential from municipal solid waste

Projection for municipal solid waste =
f(Waste per capita, POP, GDP per capita)

Available Municipal Waste = Volume of Municipal Waste *
Recovery Rate

Note:

Higher recovery rate is assumed for developed economies with waste segregation policy/program.
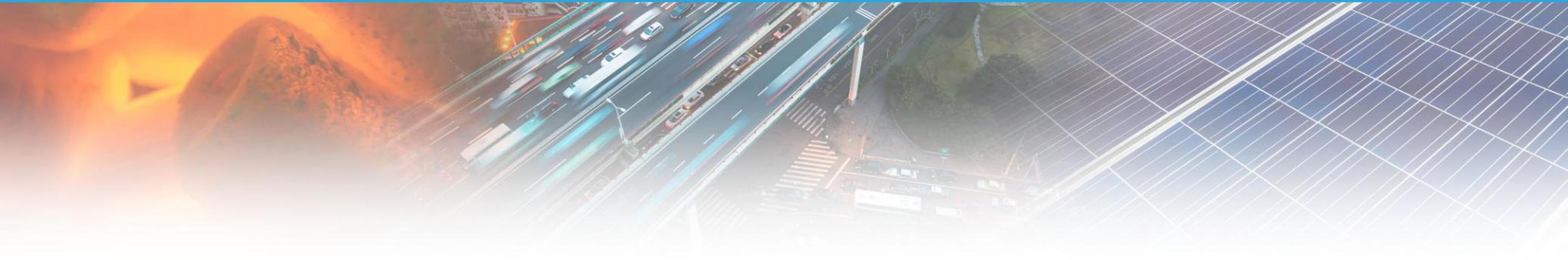
In the case of Japan, the recovery rate is 50%.

Source: http://www.esru.strath.ac.uk/EandE/Web_sites/03-04/biomass/background%20info4.html

Source: care2.com

Other updates

Other updates

➢ **APERC – IEEJ: Renewable Heating and Cooling Study**

   ➢ Calibrating fuel-based coefficients for temperature analysis,

   ➢ IEEJ is preparing technical potential for Solar Thermal and Ground Source Heat Pumps in Industry,

   ➢ Not-choice model, but potential-based uptake of RE for buildings,

   ➢ Preliminary results are expected before the Annual Conference,

➢ **APERC has joined REN21**

   ➢ First data submissions and chapter review for GSR2017,

➢ **APERC to support Chinese Taipei with "Filling the gap" project**

   ➢ Quantitative analysis,

   ➢ Data on costs, potentials, best practices, financing mechanisms etc.?

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Thank you!

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

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