Roadmaps for Renewable Energy Development: *accelerating global energy transformation*

Yong CHEN
International Renewable Energy Agency

Singapore, 20 June 2018

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Where we are

Global REe installed capacity 2007-2017

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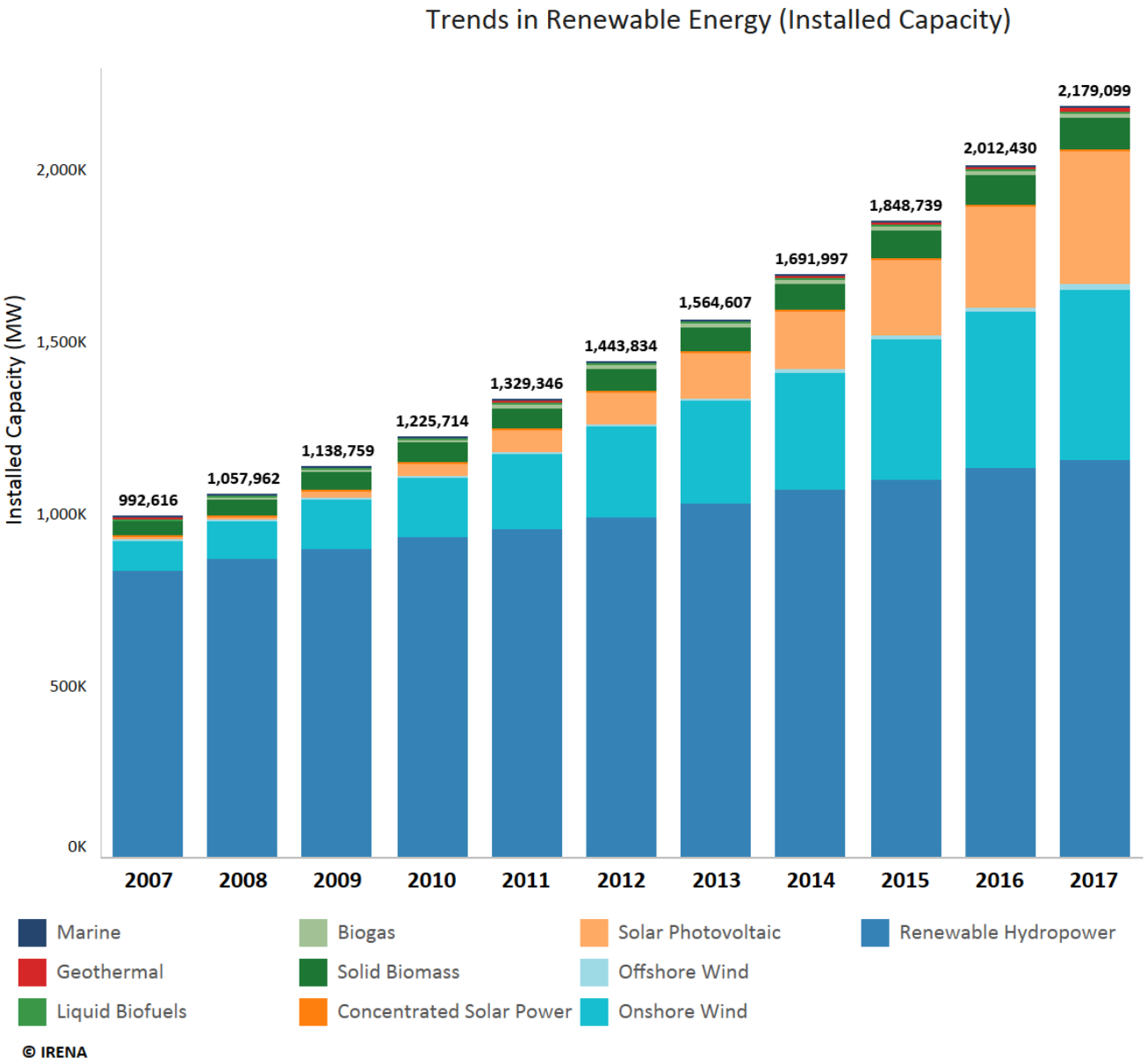
Key Messages:

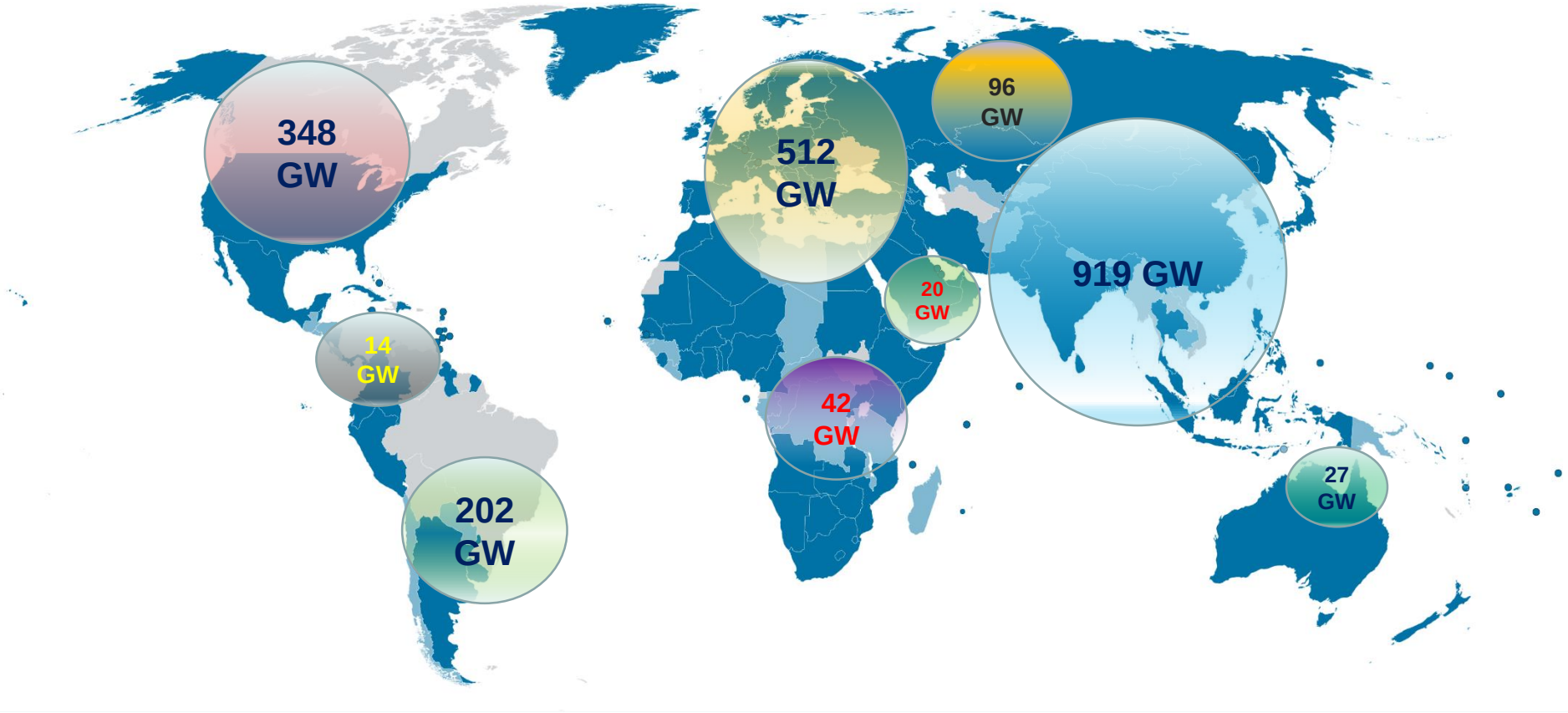
- ❑ capacity more than doubled in 10 years
- ❑ hydropower remains to be lion's share
- ❑ wind and solar growing fast

Other facts:

- ❑ since 2012, RE presenting >50% of total capacity additions
- ❑ around 31% and 25% of global total installed and production, respectively



Regional breakdown (2017)

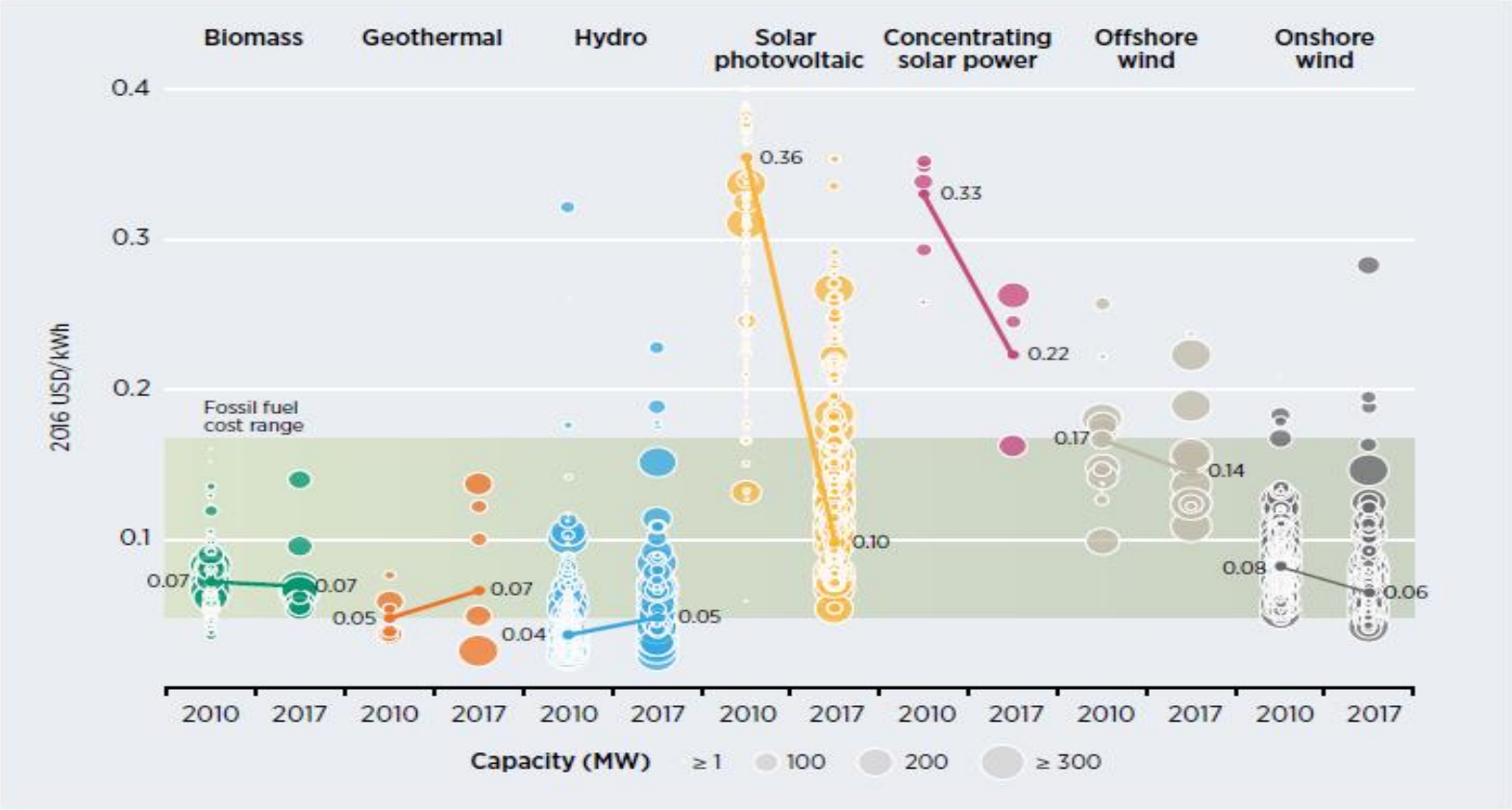


Key Messages:

- Asia is leading the growth with 13% increase
- Africa set a new record of growth with an increase of 3.5 GW or 9.2%
- solar and wind account for 85% of the 2017's addition

Key driver: declining cost

Global average LECO from utility-scale REe generation technologies 2010-2017

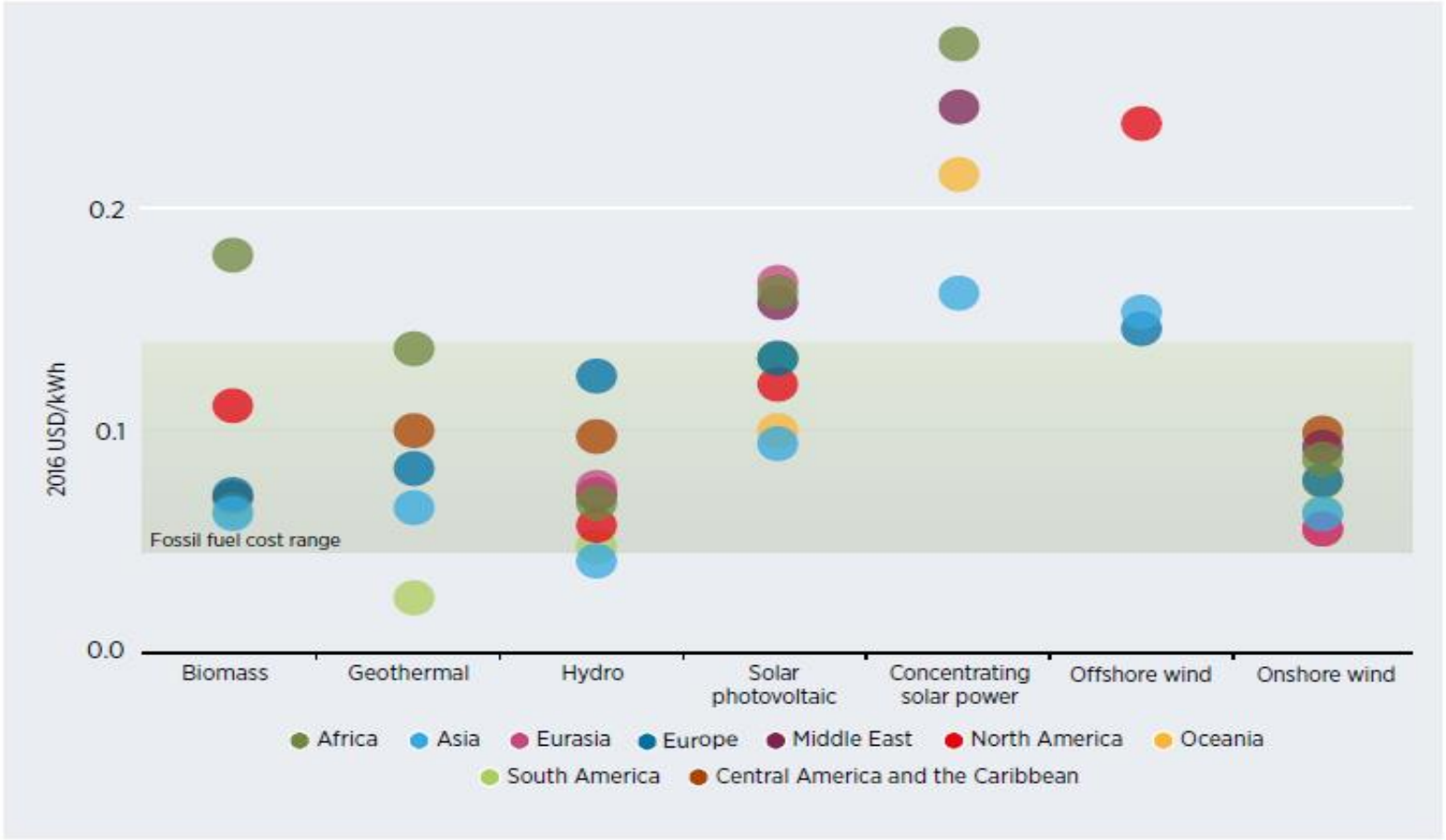


Forecasting cost reduction trend towards 2025:

- Investment costs (2015 USD/kW): solar PV could fall by 57% while on-shore wind by 12%
- LCOE: solar PV could fall by 59% while on-shore wind by 26%

Key driver: declining cost (cont.)

Regional average LECO by REe generation technologies 2017



Source: IRENA Renewable Cost Database.

- Competing head-to-head with fossil fuels in all regions

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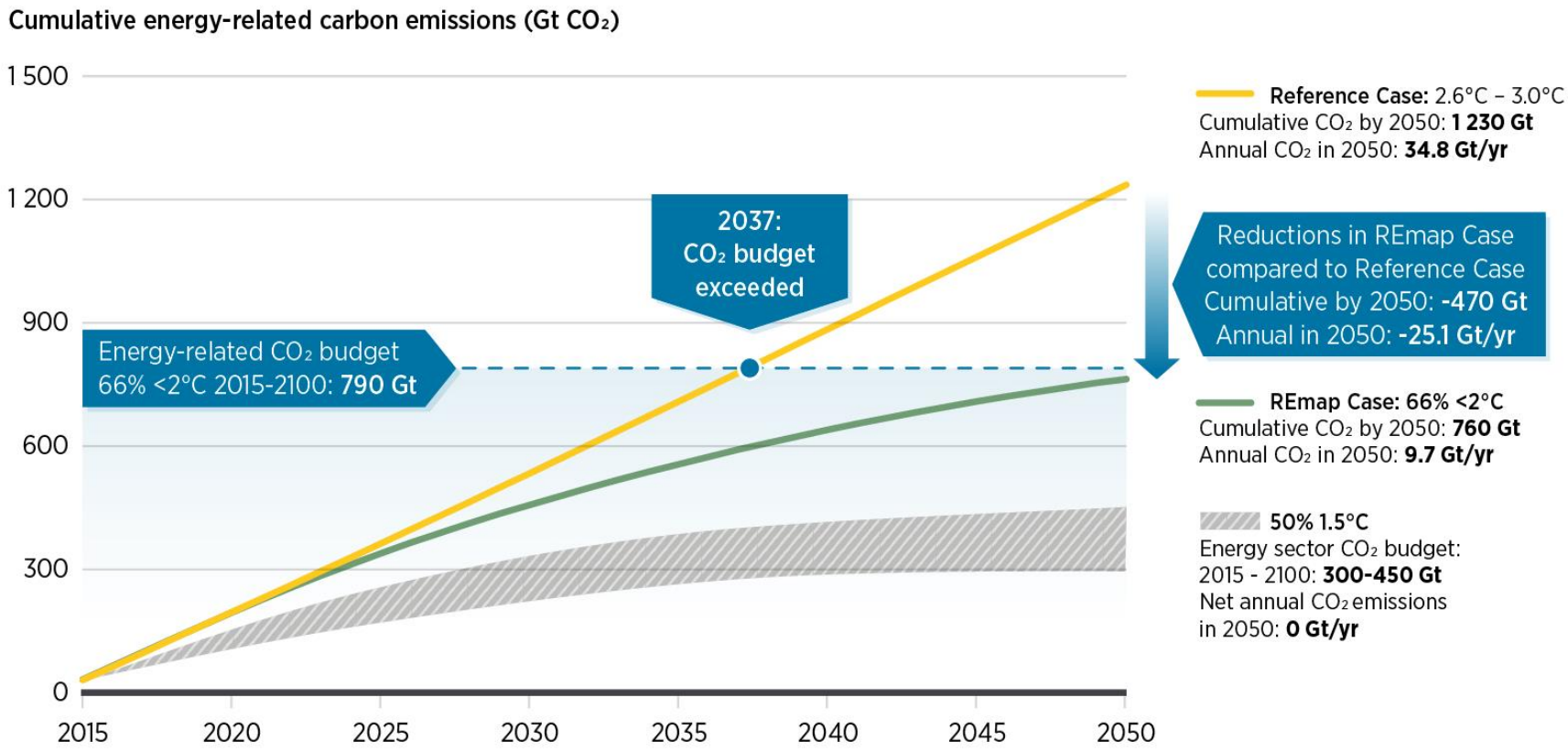
Global Roadmap

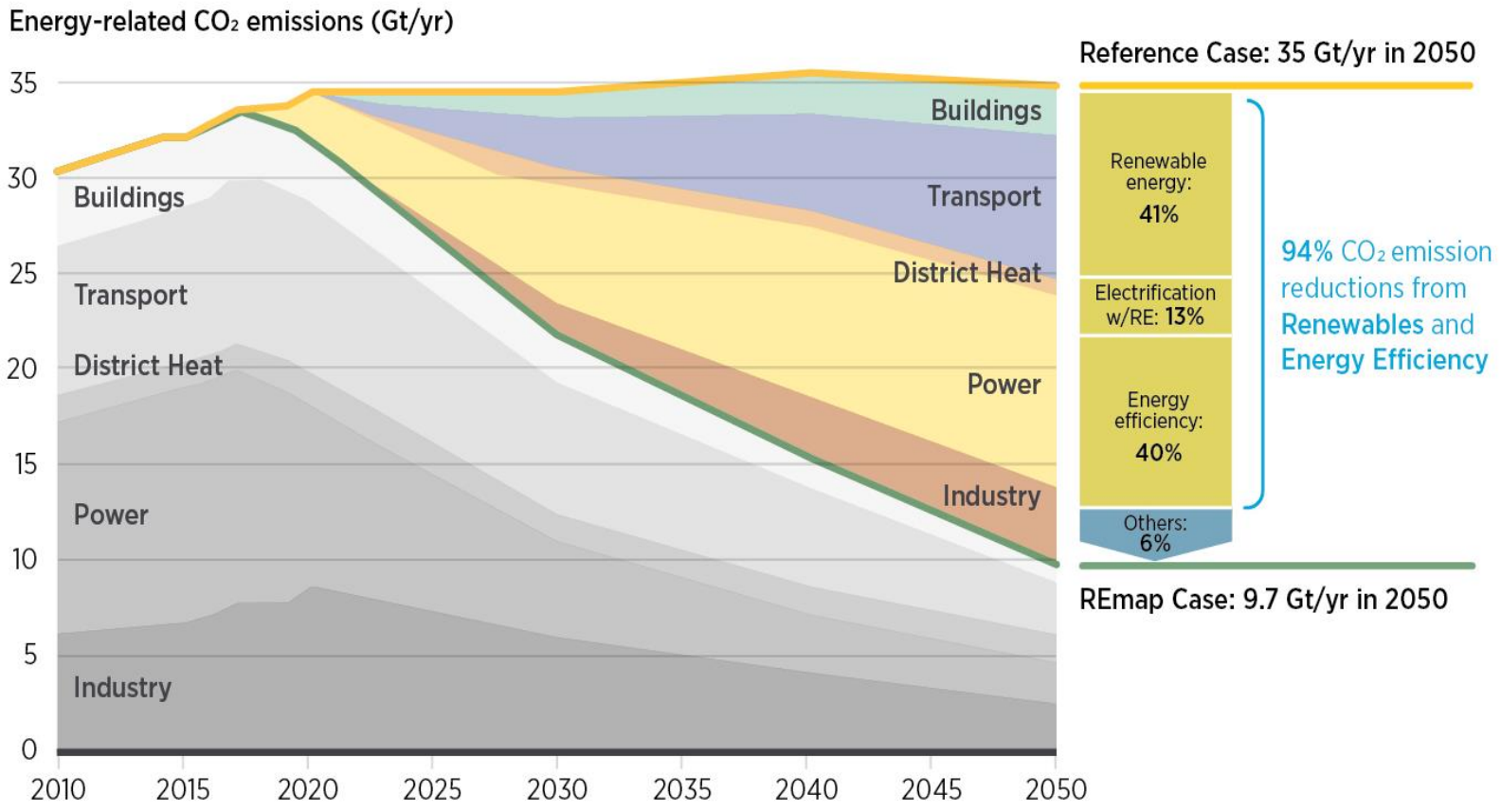
A global view to 2050 – Energy Transition



Key Messages:

- ❑ To meet <2 °C climate target set at COP 23 in Paris 2015:
  Carbon intensity of energy: needs to fall by about 85% in 2015-2050
  Energy-emission budget: 760 Gt CO2 from 2015 till 2100

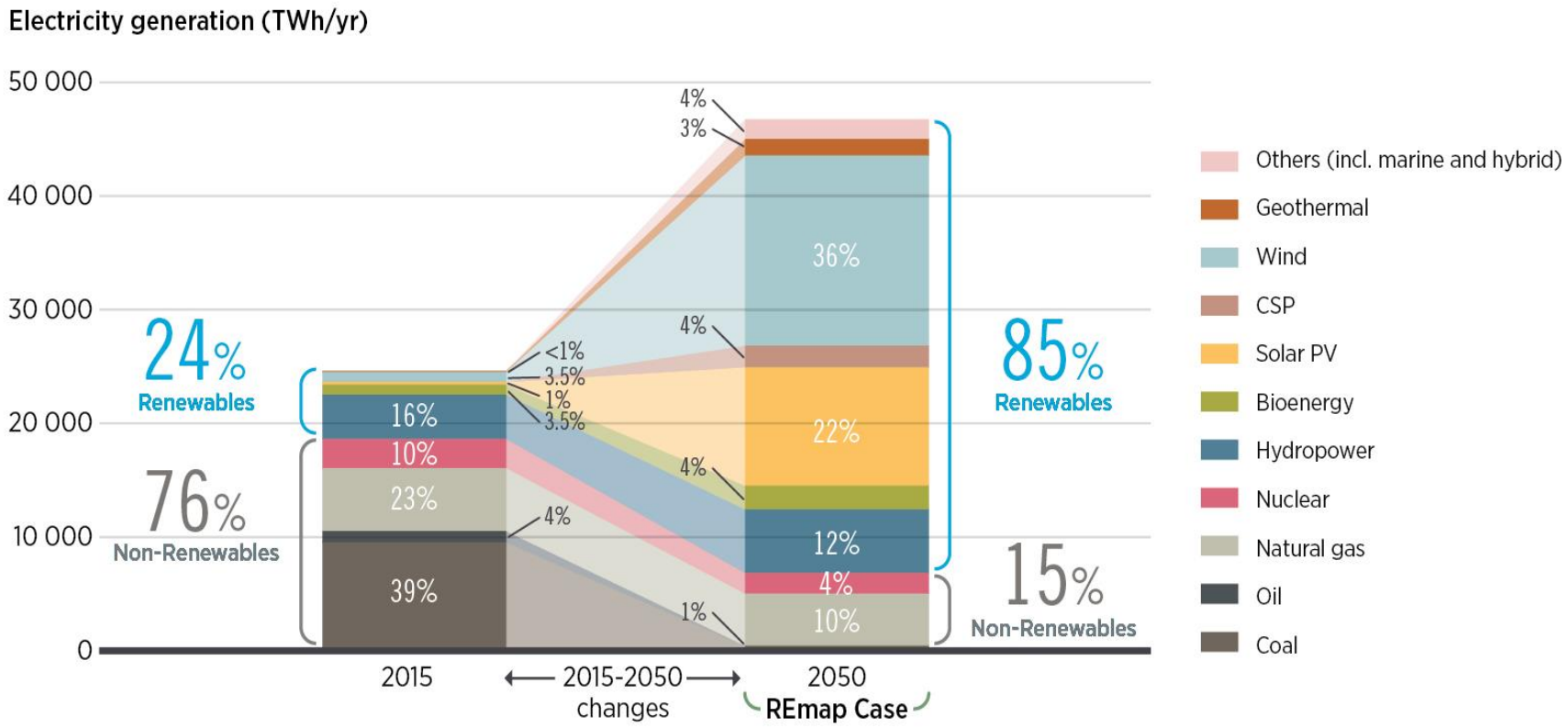
RE and EE can account for more than 90% of emission mitigation



Key Messages:

- ❑ Renewables acceleration needs an 6-7X increase compared to recent years
- ❑ Renewables in 2050 represent 2/3 of the energy supply
- ❑ Efficiency gains need to rise to 2.8% per year in 2015-2050 (from 1.8%/yr in 2015)

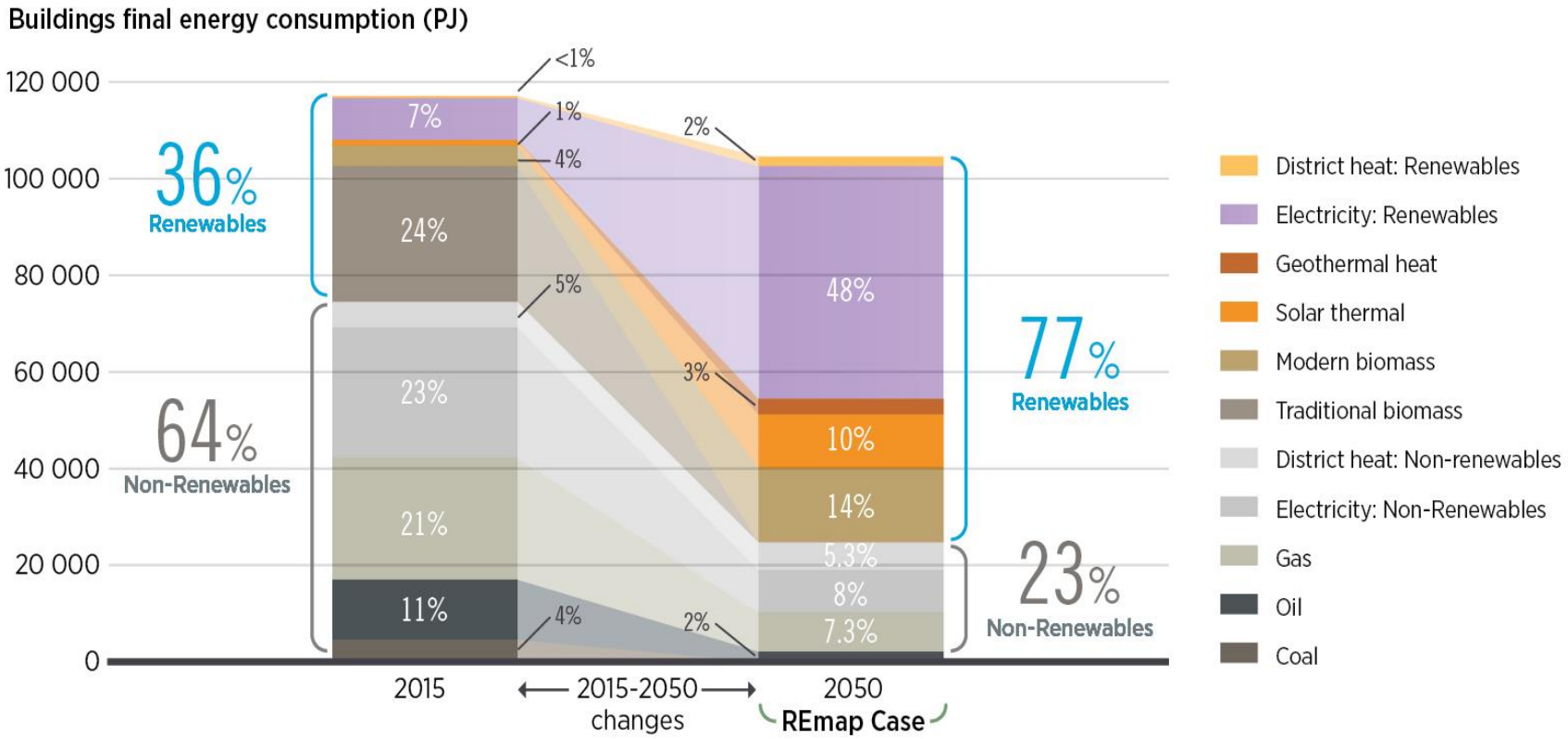
Decarbonized power sector is the key



Key Messages:

- ❑ Coal has to be phased out by 85% of the current capacity
- ❑ 85% of the total electricity is generated from renewables (1/5 from DEG)
- ❑ The power grid has to be very flexible and intelligent

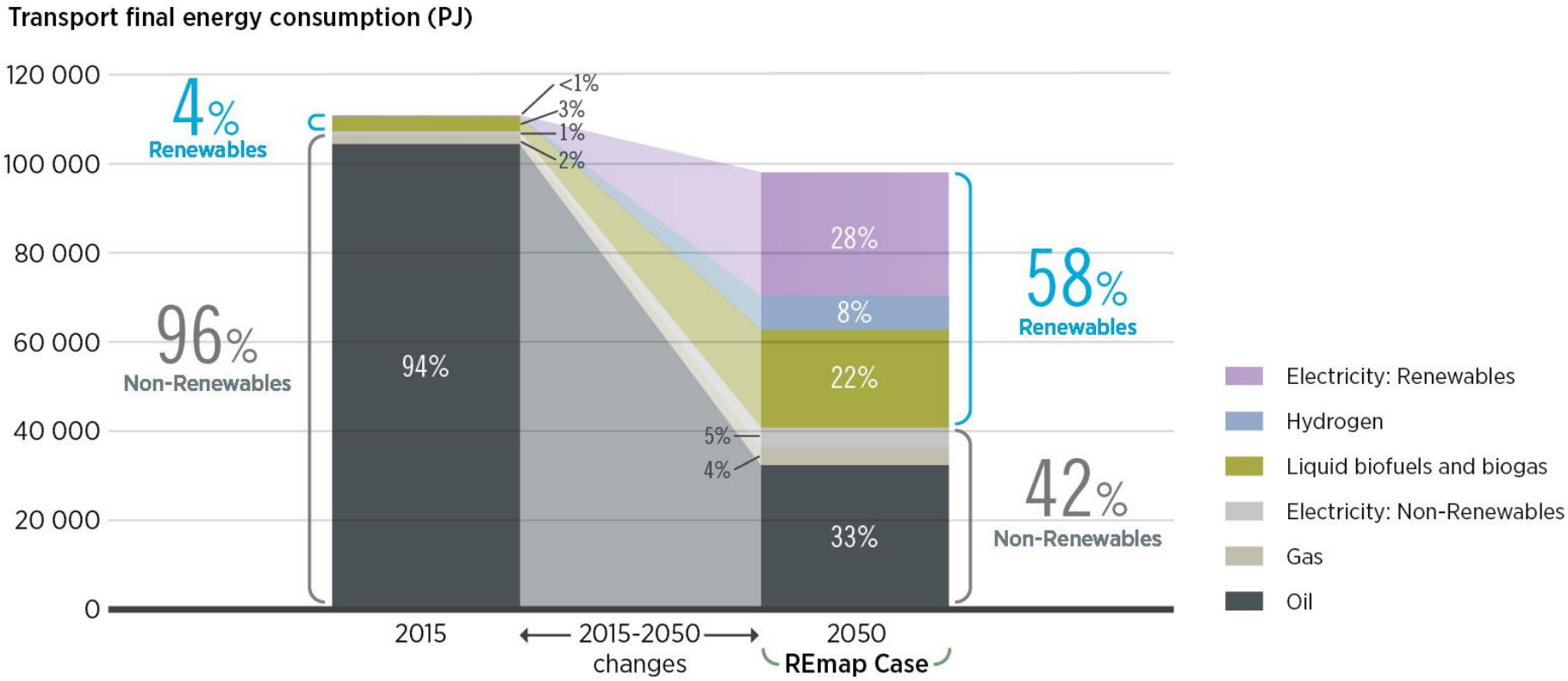
Buildings: RE+EE = Zero Energy?



Key Messages:

- ❑ The floor area of the residential and commercial buildings increases from 150 to 270 billion m² over 2015-2050
- ❑ Electricity demand in buildings is expected to increase significantly by 2050 as a result of increased use of sector coupling technologies
- ❑ Perfect cases to show synergies of RE and EE – moving but not there yet, especially existing building stock

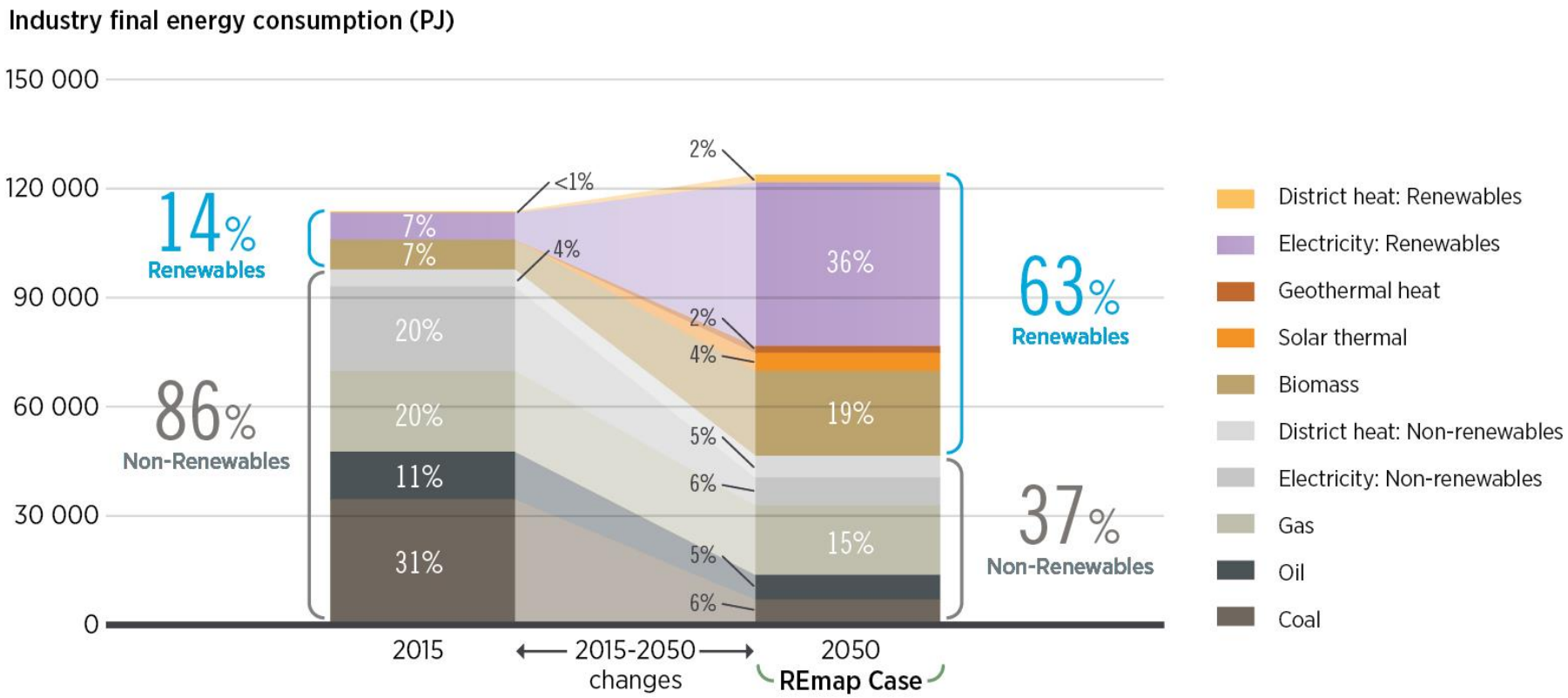
Transport sector: EV, hydrogen or biofuels?



Key Messages:

- ❑ The sector needs a deep decarbonization, with potentially 70% fossil replaced with alternatives
- ❑ A clear long-term sector development roadmap is needed to signal the future direction
- ❑ Rapid paradigm change is taking place but technology pathway might be a multiple choice

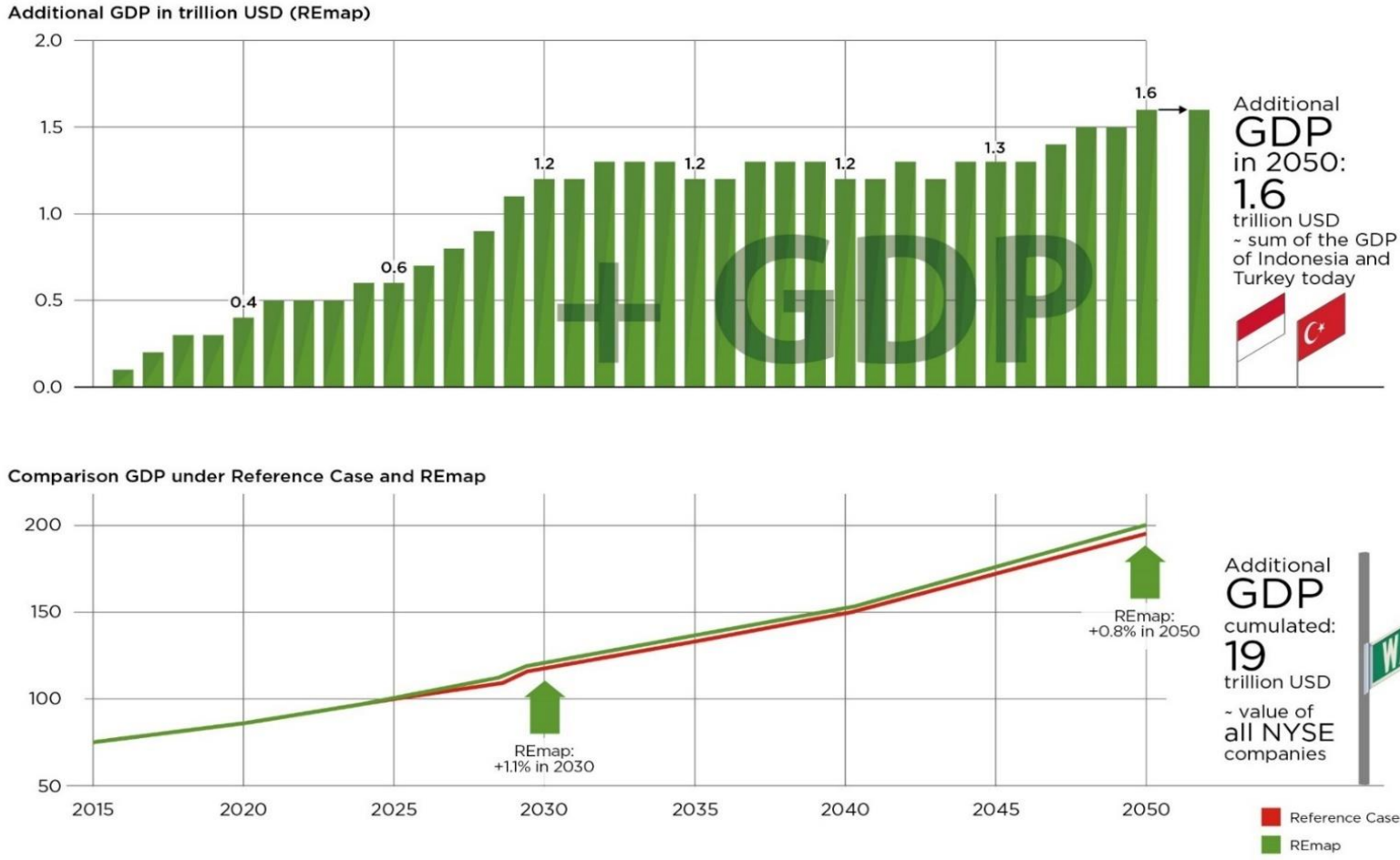
Industry



Key Messages:

- The second largest emitter of energy-related CO2
- Decarbonizing the energy-intensive sectors such as chemical, petrochemical, iron and steel is difficult

Macro-economic impact of the Transition



Key Messages:

- Decarbonizing the energy sector in line with REmap increases global GDP by around 1% by 2050 compared to the Reference Case
- That is the equivalent of almost 19 trillion USD in increased economic activity between today and 2050

Focus areas

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1. Tap into **synergies** between renewable energy and energy efficiency
2. Make a coordinated power sector **planning** for integrating high-share VREs
3. Increase the use of **electricity** in end use sectors: transport, building and industry
4. Forster system-wide **innovation**
5. **Align** socio-economic structures and investment with the energy transition
6. Ensure that transition costs and benefits are **fairly distributed**

Regional Roadmaps

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#REmap

RENEWABLE ENERGY OUTLOOK FOR ASEAN

A REMAP ANALYSIS

With financial support from
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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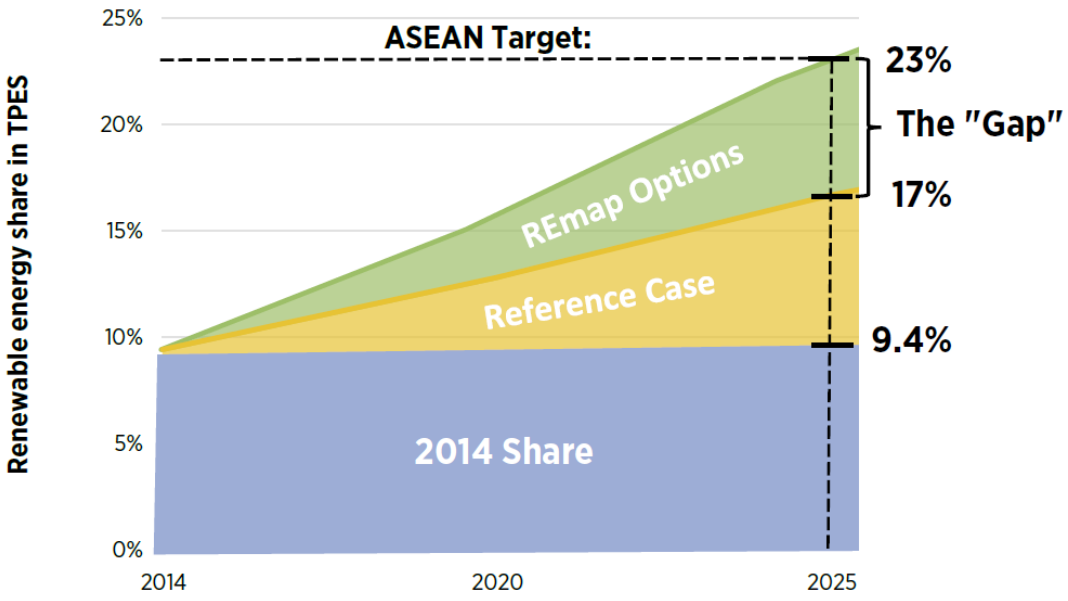
Renewable Energy Outlook for ASEAN

Aspirational target of 23% renewable energy share in total primary energy supply (TPES) by 2025



- 2014 – 9.4%
- 2025 Reference Case (APS + latest country updates) – 16.9%
- A 6% point gap to the 23% target
- REmap Options identified how to close this gap in consultation with the ten ASEAN Member States: notably solar PV, solar thermal, bioenergy
- Significant health, climate benefits
- Findings used for AEO5

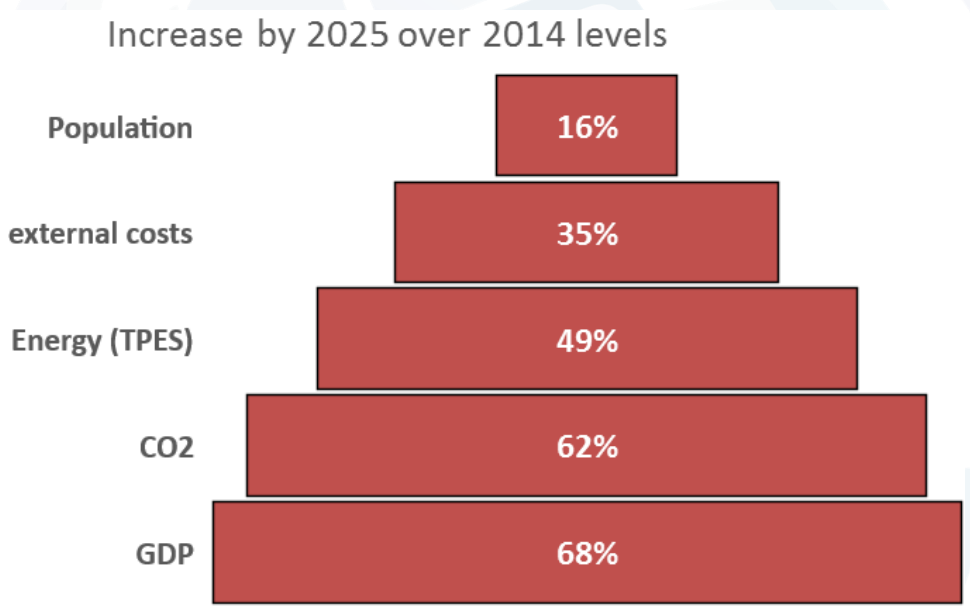
Rapid growth, pollution, CO2 and imports

The effects of rapid economic and industrialized growth result in the largest growth in GDP with almost a 70% increase

Energy demand soars 50%, with most demand covered by fossil fuels

With this growth comes the impacts of increasing use of fossil fuels:

- **USD 225 billion per year** air pollution associated health and environmental costs
- **Energy-related CO_2 emissions 2.2 Gt/yr** (~5% of all global emissions)
- **Rising imports** of oil and gas



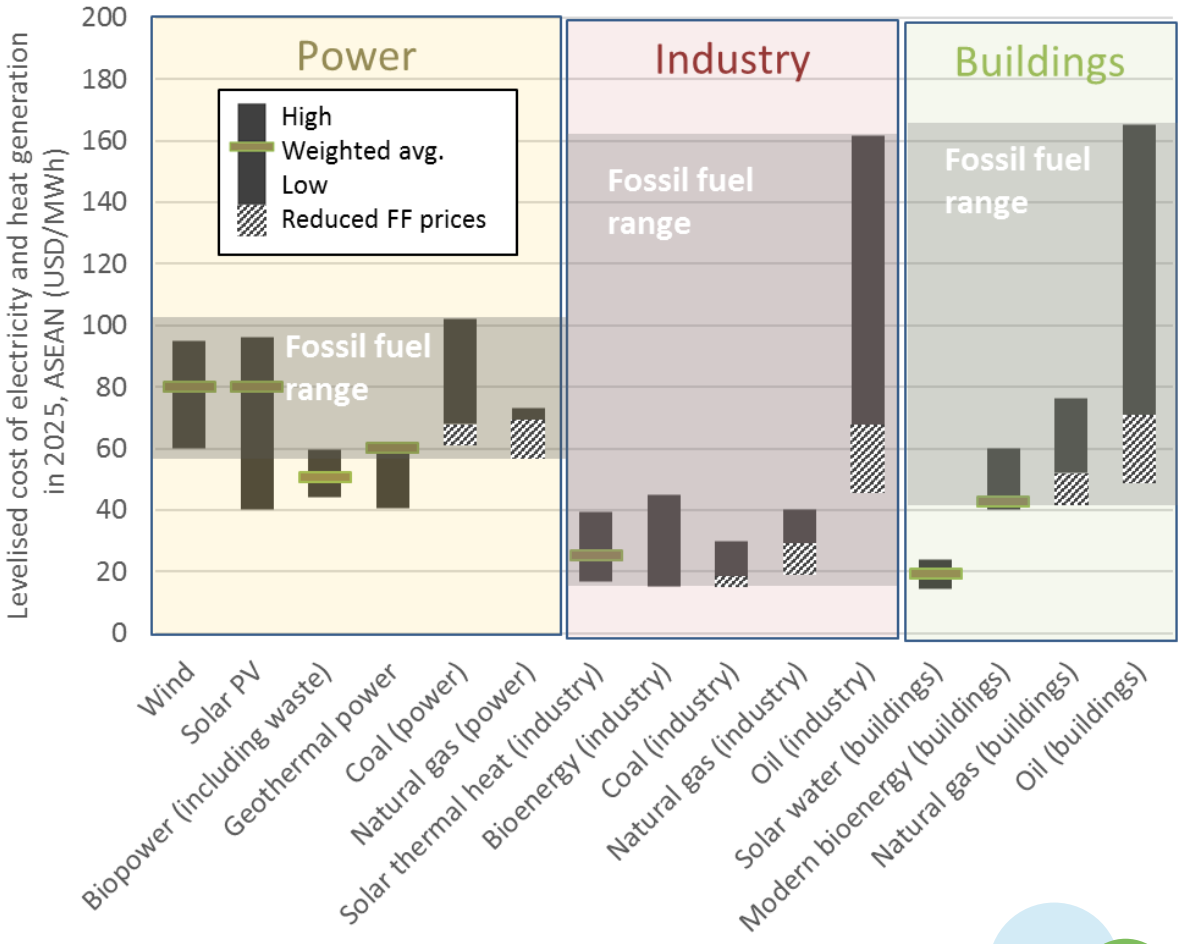
Note: For ASEAN region, based on the Reference Case in 2025

Note: Energy efficiency improvements are only assumed to take place in the Reference Case. REmap did not assess additional options to improve energy efficiency which would result in lower overall energy demand.

Please note that results are preliminary and may be revised ahead of the final report release

Drivers for a renewable revolution in the region

- The region has fairly good renewable energy resources
- Renewable energy is becoming increasingly cost-competitive:
  - Declines in the costs of renewable energy technologies
  - Increasing costs from import price volatility
- Health benefits, improved wealth distribution, especially in rural areas
- Renewable energy drives economic activity & creates employment



Note: reduced fossil fuel (FF) prices assumes lower average commodity prices for fossil fuels for coal (-10%), natural gas (-20%) and oil (-30%)

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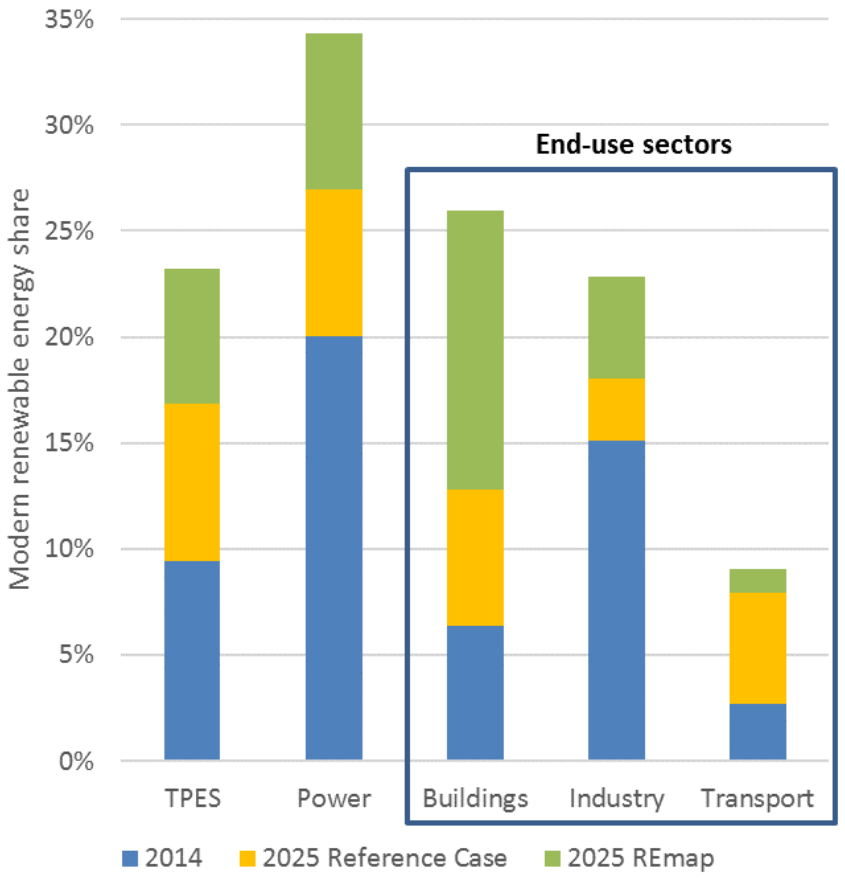
Renewable energy share by sector 2014-2025

Renewable shares increase in all sectors, but mostly in end-use sectors

- Power sector – highest share of renewable energy at 34%
- Buildings –largest increase in share due to the substitution of traditional uses of bioenergy
- Industry – large untapped potential compared to the Reference Case
- Transport – largest growth in renewable energy use according to the Reference Case



Note: End-use sectors include the consumption of electricity sourced from renewables. Shares presented in figure exclude traditional uses of bioenergy.

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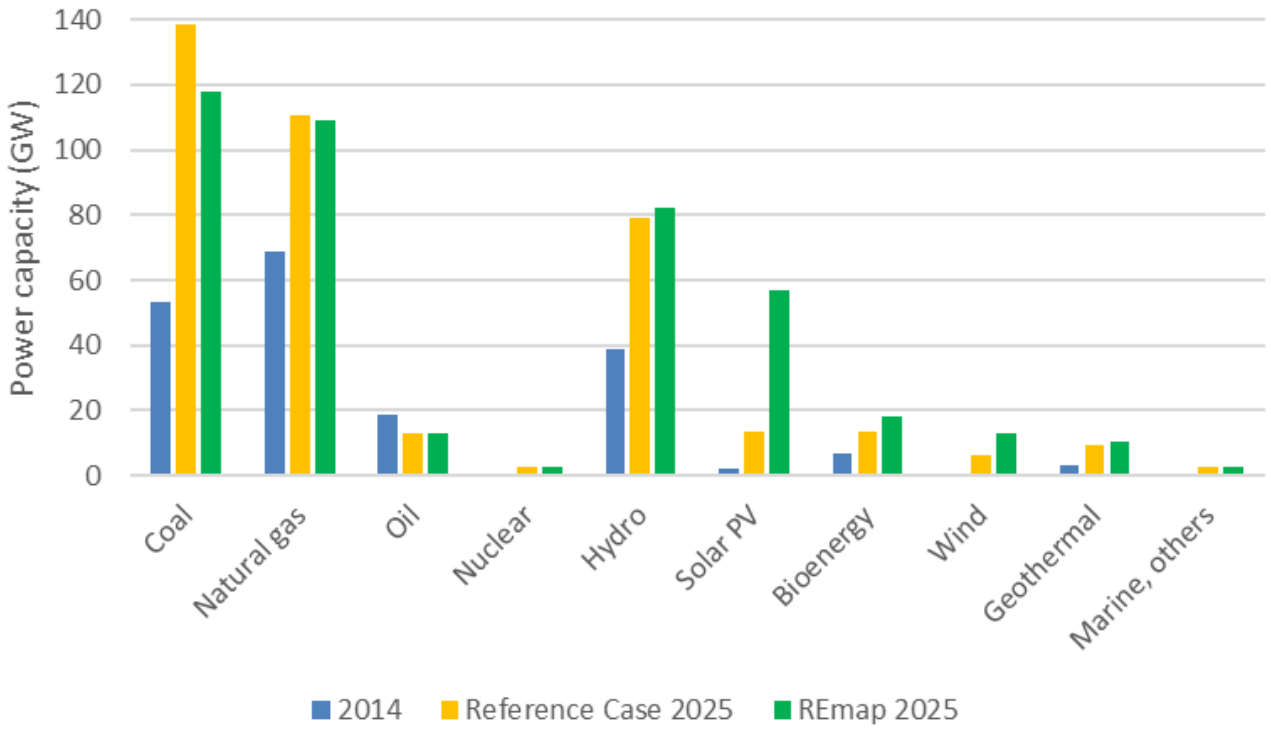
Closing the gap: power sector

In REmap, power generation capacity grows almost by 240 GW to more than 400 GW

- Coal and natural gas will have the largest installed capacity
- Hydropower increases significantly in the Reference Case
- Largest growth in REmap is for solar PV



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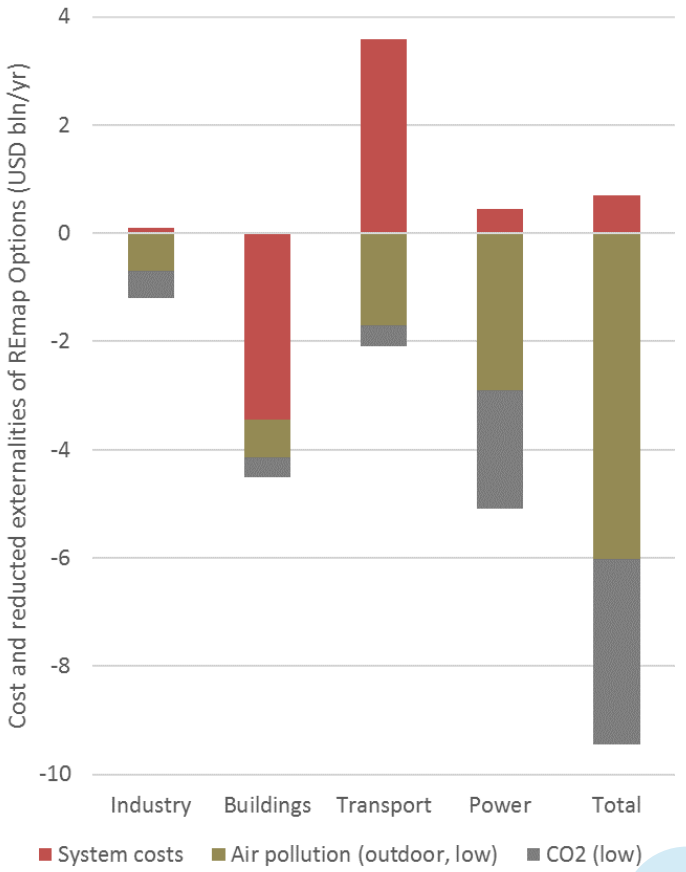
Costs and savings of closing the gap

The REmap Options for closing the gap to 23% are represented by an incremental cost of USD 1.9 per MWh by 2025

- The REmap Options would result in slight incremental costs of USD 1.9/MWh or USD 0.7 billion per year in absolute terms
- Reduced externalities would outweigh costs. Savings exceed the cost:
  - 10x for outdoor air pollution
  - 6x for climate change
  - 38x for indoor air pollution (not shown in figure)
- ASEAN's fossil fuel expenditures would be lowered by USD 40 billion per year by 2025



Note: Reduced externalities resulting from lower levels of indoor air pollution are excluded from the figure.

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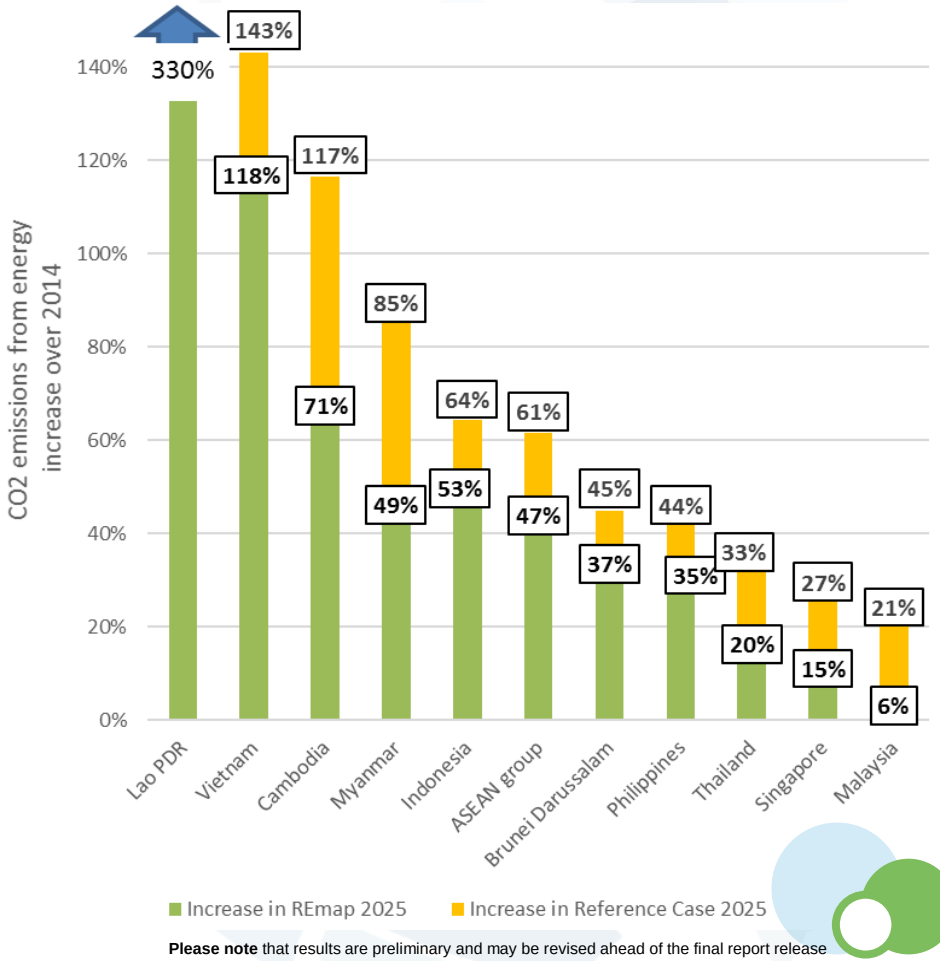
Carbon dioxide emissions from energy

Energy-related CO_2 emissions will rise by 60% in the Reference Case. With the renewable energy target reached, growth is restrained to 47%

- Due to soaring energy demand many countries see significant growth in energy-related CO_2
- Realising the ASEAN renewable energy target can reduce this growth by one-fifth
- Besides renewables, energy efficiency plays a key role
- Energy intensity improvements are consistent with the region's target of a reduction of 30% over 2005 levels by 2025



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Key Conclusions and areas for further work

- The regional target of 23% renewable energy is achievable **with concerted efforts by all ASEAN countries**
- Savings related to reduced externalities resulting from increased renewables far exceed additional costs of those renewables
- **Investment in renewable capacity will need to double**, and mobilizing finance will be key to achieving the target
- **Synergies** between strengthened energy efficiency and renewable energy efforts should be explored further
- Transmission and distribution grids across the region must be **expanded and strengthened**
- Efforts need to be expanded for **renewable energy uptake in the heating, cooking and transport sectors,** with special attention for the potential of bioenergy and solar thermal

REmap 2030
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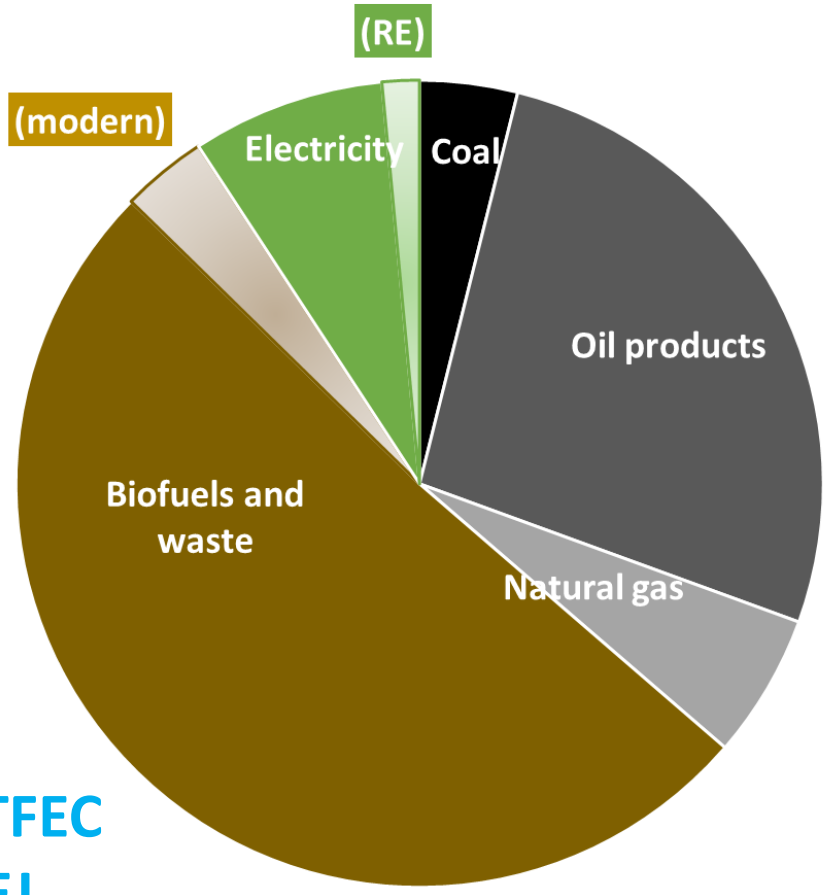
AFRICA 2030:
ROADMAP FOR A RENEWABLE ENERGY FUTURE

Renewable energy use in 2013



Total TFEC 23 EJ

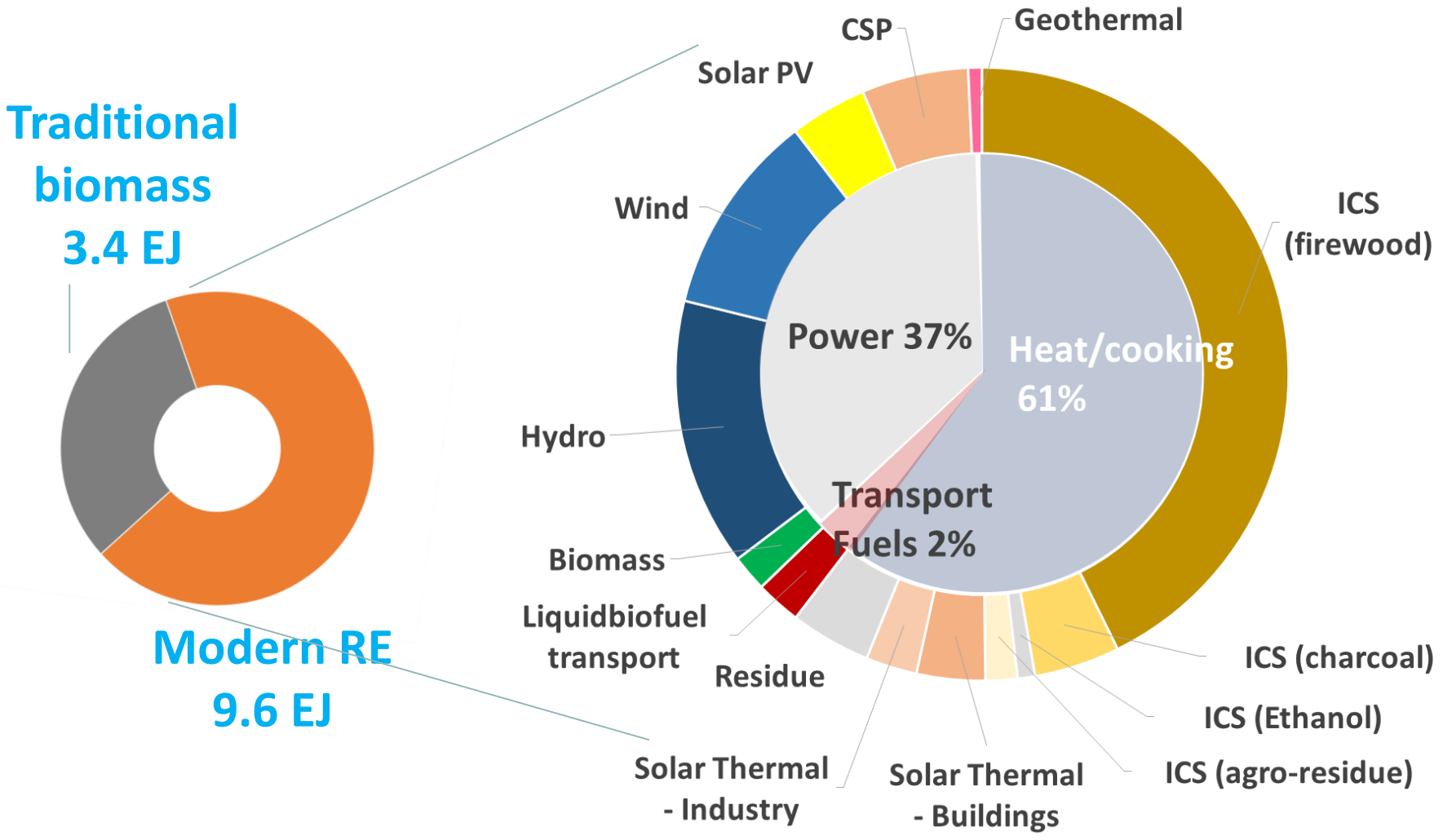
Modern RE: 5% of TFEC

Modern RE 1.1 EJ

Traditional biomass 11.8 EJ

Modern RE: 10% of total RE

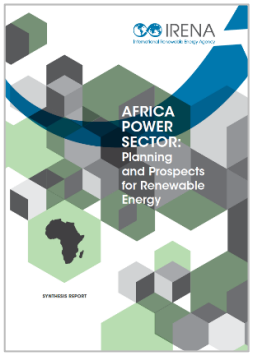
REmap options in 2030



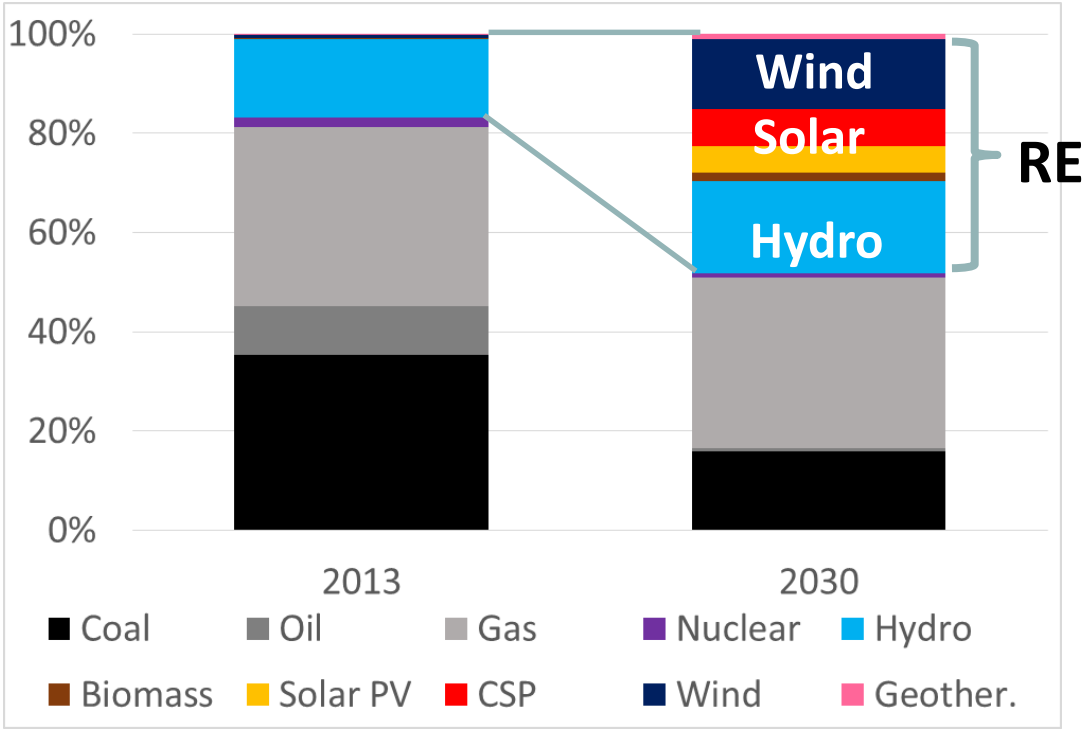
- A doubling of TFEC to 45 EJ in 2030
- Share of modern RE use in TFEC increases from 5% in 2013 to 22% in 2030

Diversified power generation mix

- Total installed capacity by 2030: 610 GW, up to 310 GW renewables – more than an 8-fold increase
- REmap options
  - Hydro: 100 GW
  - Wind: 100 GW
  - Solar PV: 55 GW
  - CSP: 38 GW
  - Biomass: 32 GW



Generation mix in 2013 and with REmap options



2030 energy mix to be characterized by diversified power sources

Renewables provide affordable power

Recent project deals

Solar PV in South Africa: USD 7.5 cent per kWh
CSP in South Africa: USD 12.4 cent per kWh
Wind in Egypt: USD 4.1 cent per kWh

→ Among most competitive in the world

Investment needs between 2015 and 2030:

70 billion per year for the power sector including

- 7 billion for hydro
- 25 billion for other renewable generation options
- 25 billion for T&D

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National and Sectoral Roadmaps

National Roadmaps

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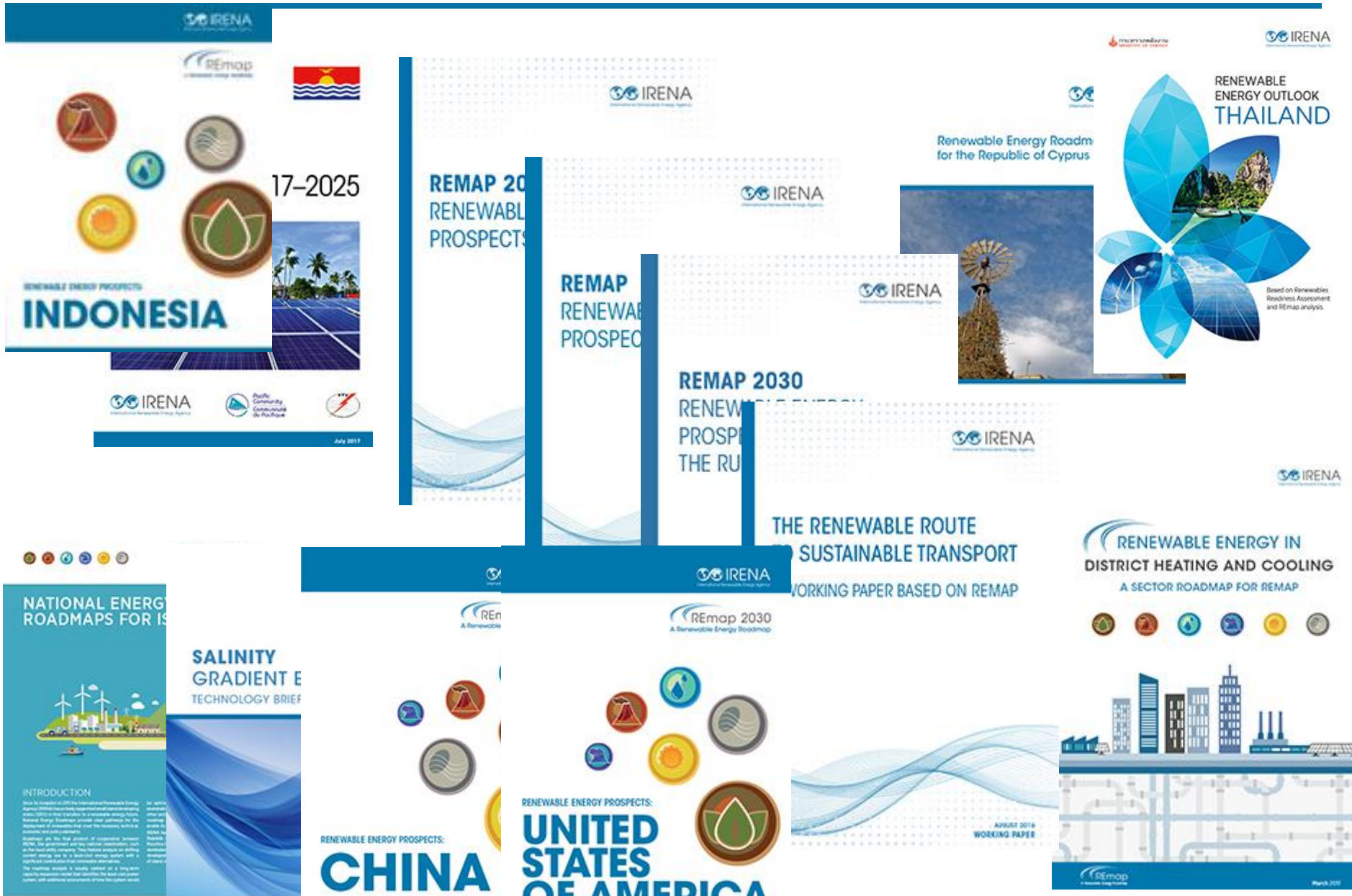

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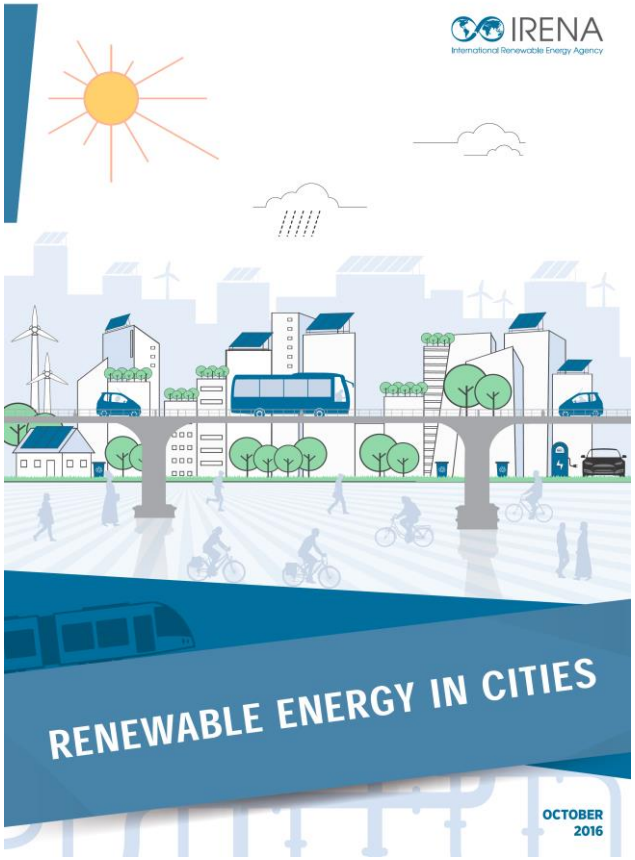
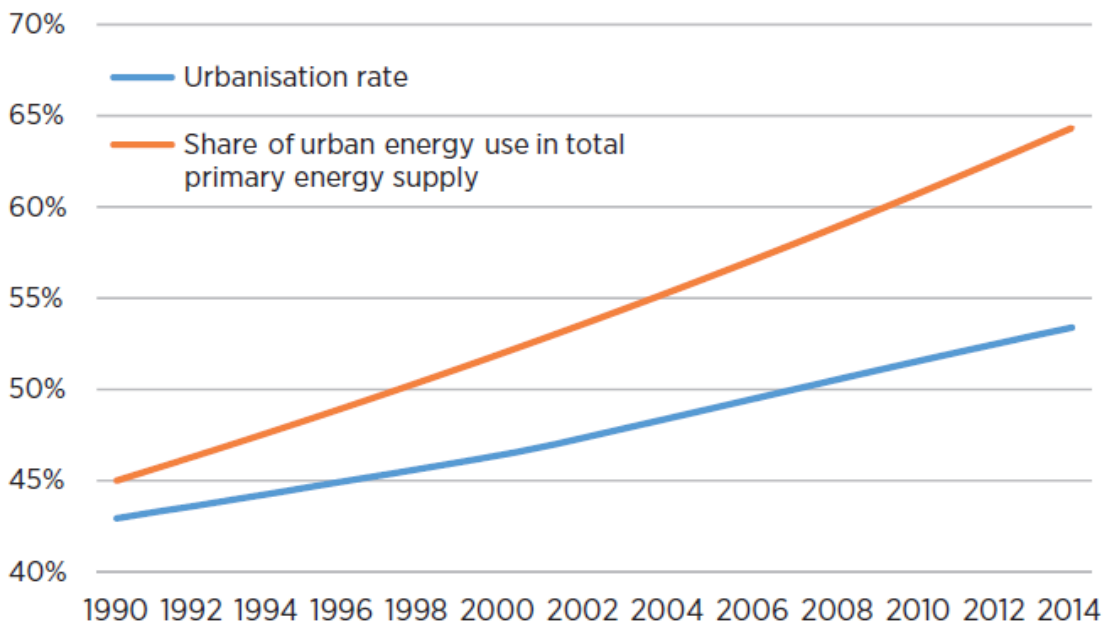
Renewables in Cities



Strong growth in urban energy use

- More than half of all people live in cities and this share is rising
- 65% of energy use is concentrated in urban areas today; this share is growing

Figure 1: Global urbanisation rate and share of urban energy use in total primary energy supply, 1990-2014



- More than 90% of urban citizens is exposed to significant air pollution from energy use

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Renewables account for 20% of urban energy use today

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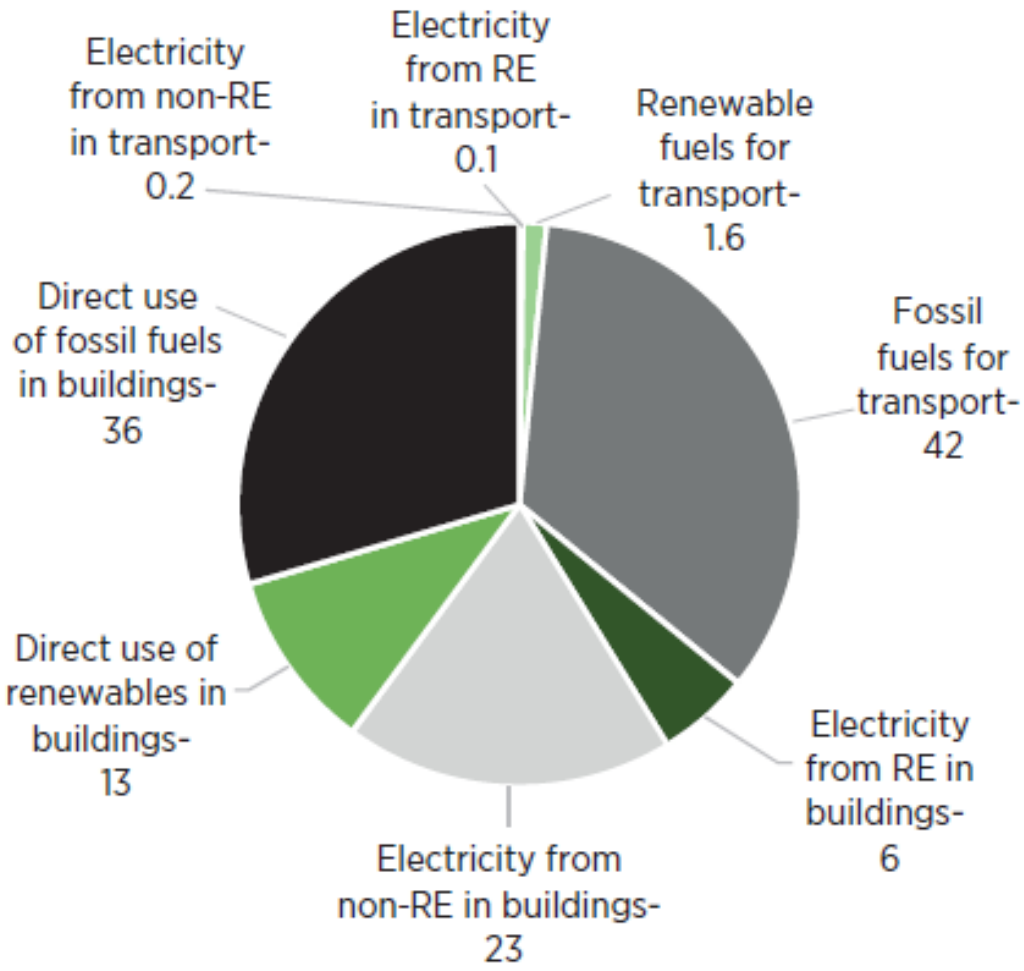
- 1/3 transport energy, 2/3 building energy
- Today most RE use in buildings, and much less in transport
- Total 123 EJ/yr (excluding industry)

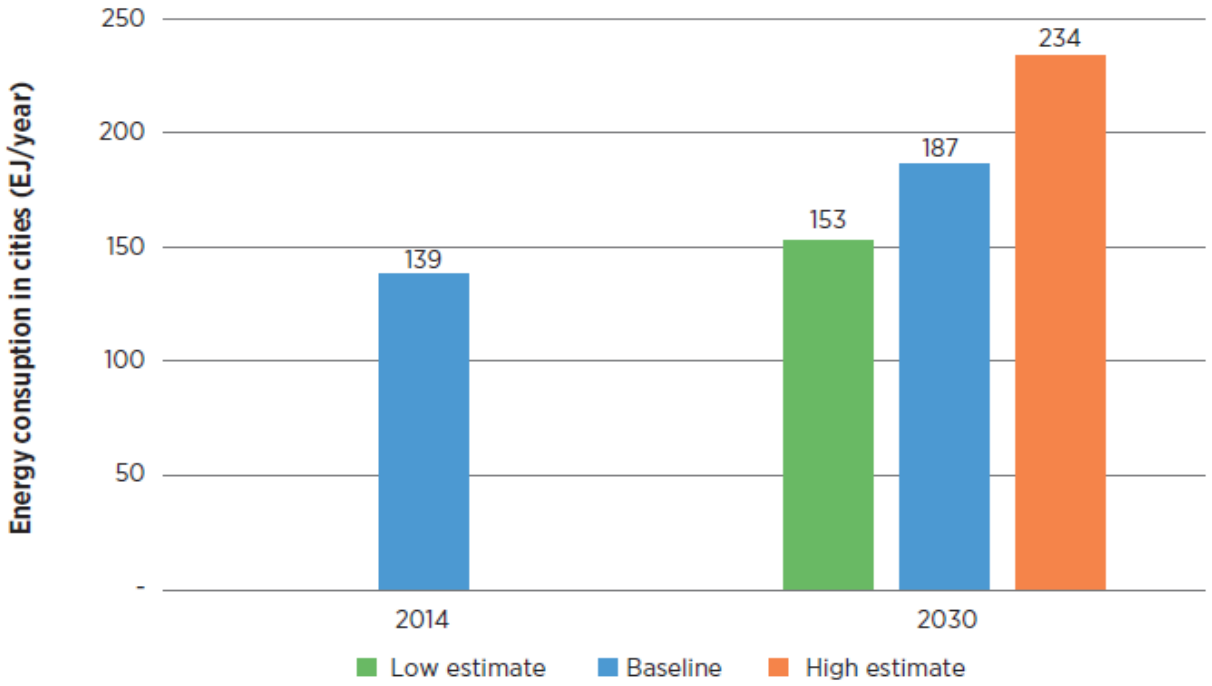
Figure 4: Breakdown of urban energy use in buildings and transport by



Continued growth in cities' energy use to 2030

- REmap analysis shows wide range in 2030 energy demand outlook
- Cities will account for 70% of the total primary energy supply by 2030

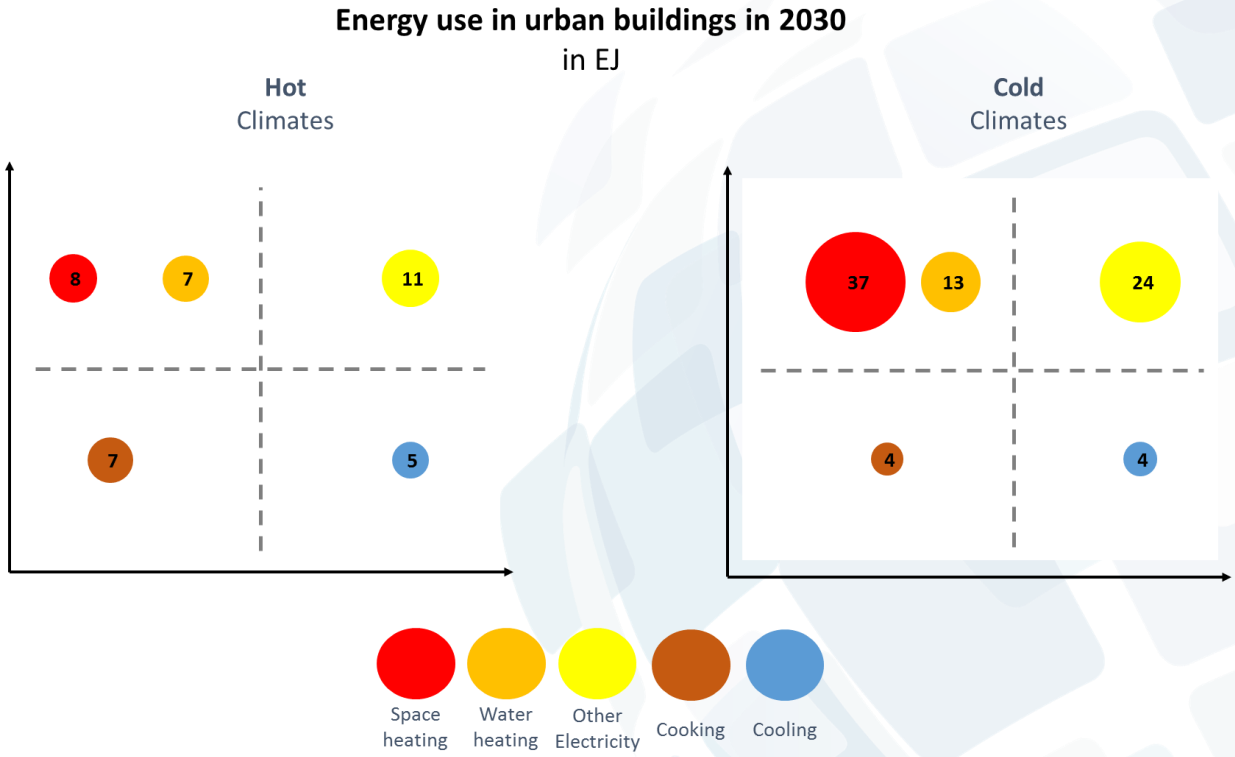
Figure 9: Energy use in buildings and for transport in cities, 2014 and 2030



- Database of energy use of 3 500 cities, distinguishing growth rates, population density, climate differences

Heating ~50% of urban building energy use in 2030

- Large part of global urban energy demand will continue to be for space heating in cold climates, much of which in existing buildings



- Database of energy use of 3 500 cities, distinguishing growth rates, population density, climate differences

Options to expand RE use in urban environment (examples)

- **Heating/cooling**
  - Electrify heating - Heat pumps
  - Solar water heating and solar cooling
  - Biomass boilers
  - Renewable district heat/cooling
- **Renewable electricity supply**
  - Rooftop and building integrated PV
  - Buy renewable electricity from the grid
- **Replace traditional biomass with modern renewables or electricity for cooking**
- **Renewables for transportation**
  - Electric vehicles
  - Biofuels
  - Modal shift

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Questions for discussion

- What would be best approach to integrate low-carbon options into the urban energy planning processes?
- Zero energy buildings for new/planned districts/cities v.s. retrofitting for energy efficiency improvements: how to prioritize?
- To increase the electricity use in end-use sectors, sector-coupling technologies would play an important role, how to assess the technical and economic potentials in order for the investors to capitalize the opportunities and make the informed decisions?