

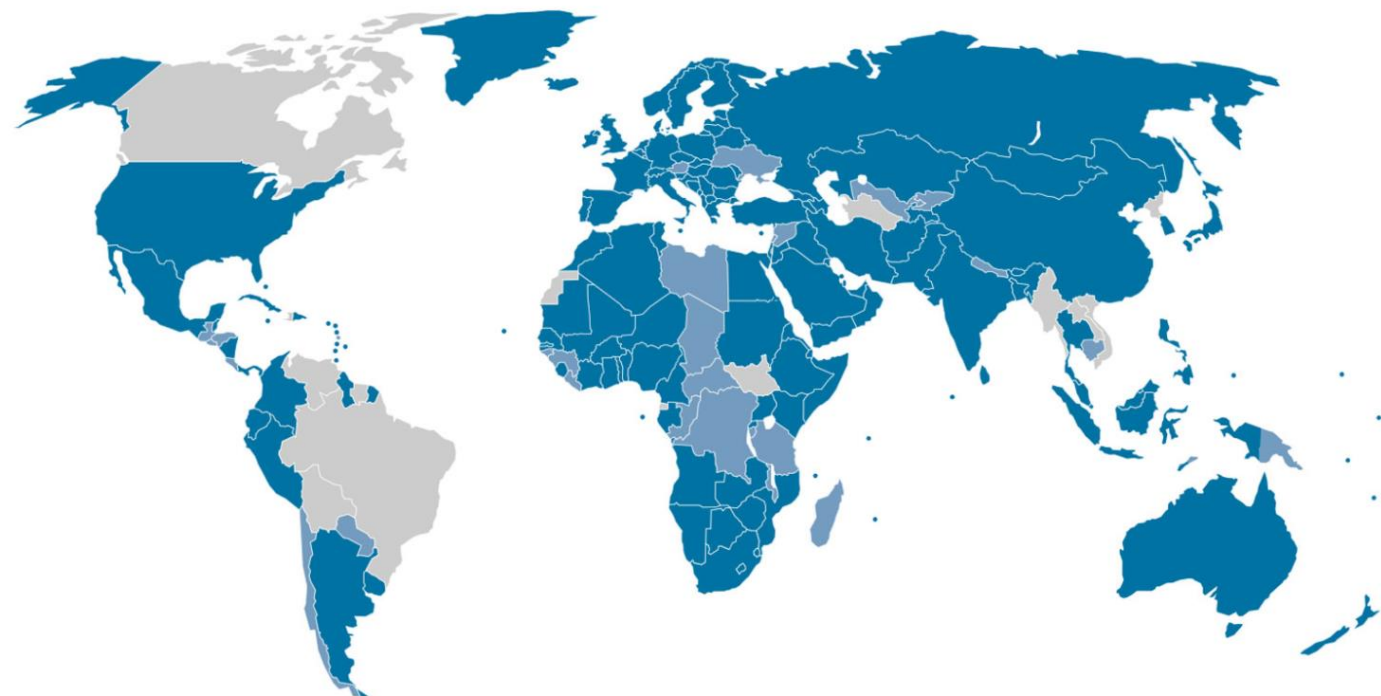
Deep-decarbonisation of the end-use sectors: the role of renewable energy

Findings from the reports *Perspectives for the Energy Transition* and
Innovation for Energy Transition

Key facts about IRENA



- Established in 2011
- Headquarters in Abu Dhabi, UAE
- IRENA Innovation and Technology Centre – Bonn, Germany
- Permanent Observer to the United Nations – New York

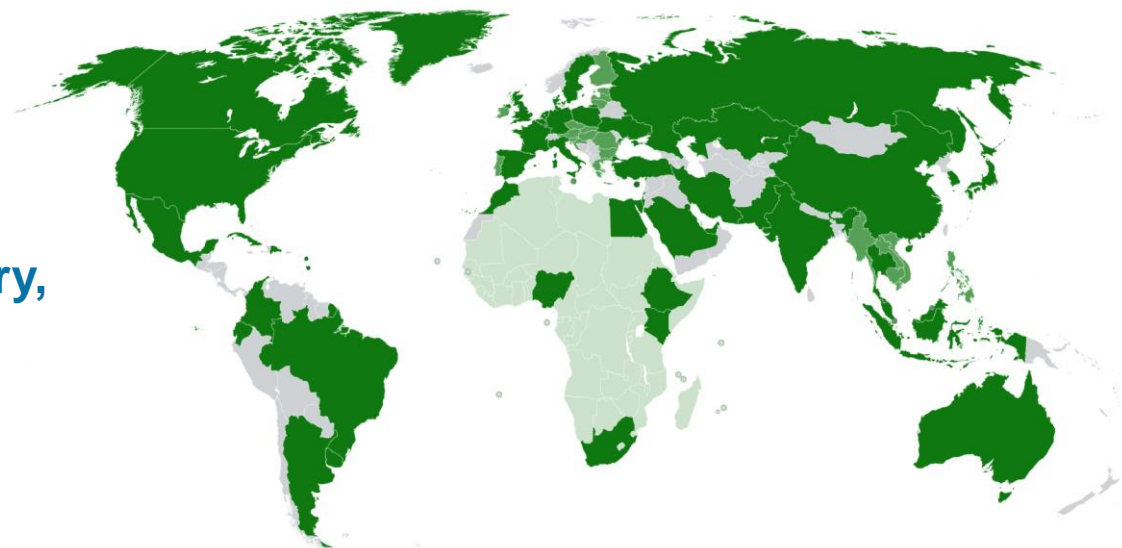


- 150 Members
- 30 States in Accession

Mandate: Assist countries to accelerate renewable energy deployment

IRENA's REmap programme

- IRENA's REmap programme explores potential, cost and benefits of accelerating the growth of renewables in global energy mix
- Technology Options in power, district heat, **end-uses (industry, transport, buildings)**
- Unique - developed together with and validated by country experts from 70 countries, representing over 90% of global energy demand



Efforts in heating, cooling and cooking

- Global: **G20 Energy Transition and Innovation reports (decarbonisation reports)**
- Country and regional: ASEAN RE outlook, country reports Indonesia and India
- 2014 RE in Manufacturing Roadmap and technical paper
- Bioenergy assessments, and technical briefs (biomass heat, solar thermal heat)

Industry and buildings sector final energy demand

	Energy (EJ), final			Shares (%)		CAAGR (%)	Energy (PJ), final		Shares (%)	CAAGR (%)
	2015	2030	2050	2015	2050	2015-2050	2030	2050	2050	2015-2050
Reference Scenario							REmap Scenario			
Industry	129	156	193	100	100	1.1	129	147	100	0.4
Coal	50	52	53	39	28	0.2	29	21	14	-2.5
Gas	23	31	42	18	22	1.7	27	26	18	0.4
Oil	13	17	23	10	12	1.7	10	10	7	-0.6
Bioenergy	8	13	20	6	10	2.5	17	31	21	3.9
Solar	0	0	1	0	0	11.0	6	9	6	20.2
Geothermal	0	0	1	0	0	10.2	3	4	3	17.0
Other, hydrogen,	0	0	0	0	0	-	0	1	1	0
Electricity	30	37	46	24	24	1.2	32	37	26	0.6
District heat	5	6	8	4	4	1.1	5	6	4	0.6
Buildings	122	145	160	100	100	0.8	133	128	100	0.2
Coal	5	3	1	4	1	-3.9	2	0	0	-100.0
Gas	26	32	32	22	20	0.6	20	9	7	-3.0
Oil	12	15	15	10	10	0.7	10	5	4	-2.7
Bioenergy	34	32	28	28	17	-0.6	31	23	18	-1.2
Solar	2	3	4	1	3	2.5	12	26	20	7.9
Geothermal	0.8	0.9	1.4	0.6	0.9	1.7	3	4	3	4.6
Other, hydrogen	0	0	0	0	0	0.0	0	0	0	0
Electricity	35	51	69	29	43	2.0	47	57	44	1.4
District heat	7	8	8	6	5	0.5	8	5	4	-0.7

Industry

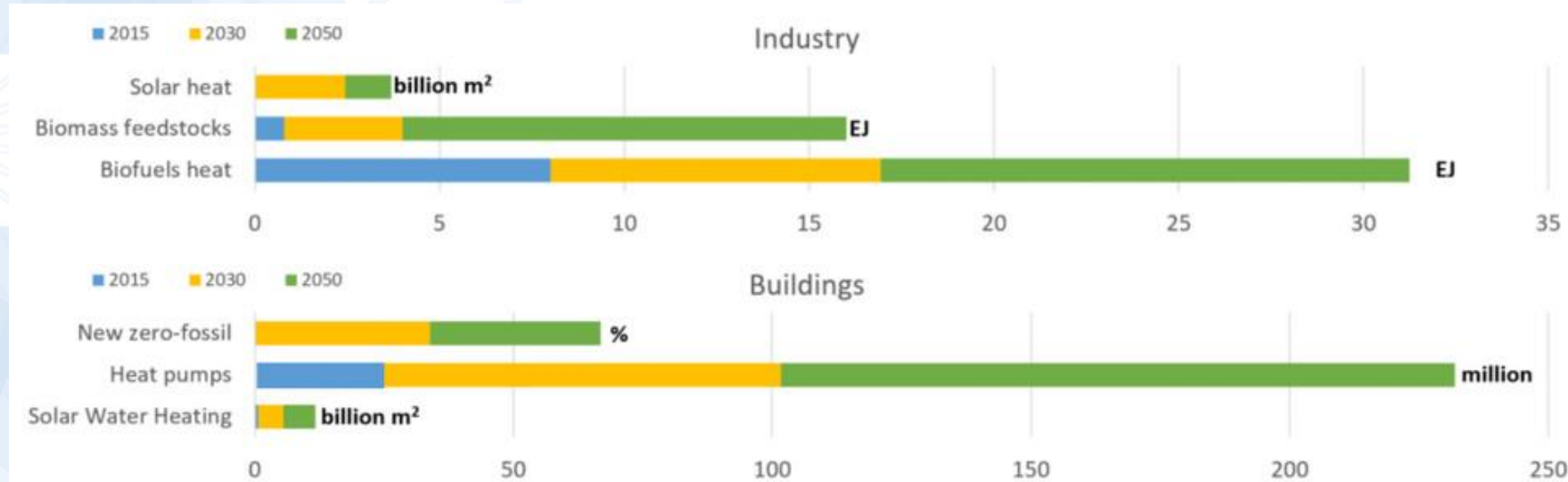
- ~75% fuels and direct-uses
- 6-10% RE share in fuels increases to over 30% in REmap

Buildings

- ~60-70% fuels and direct uses
- 30% RE share decreases to 20% in Ref, increases to over 40% in REmap
- Electricity share increases to almost half

Note: preliminary results

End-use sector transition: untapped areas



PRELIMINARY FINDINGS

Industry

- Industry is the most challenging sector
- Solutions include solar thermal process heat (LT and CST for MT) in food, chemicals
- Significant biomass utilization
- Electrification has large potential, and some small hydrogen, geothermal direct-use

Buildings

- Significant acceleration of buildings renovation needed, and greener building codes
- Cooling with decarbonised electricity, heat-pumps
- Solar thermal largest supply source (excluding electricity)
- Decrease in bioenergy use from ~35 EJ/yr to around 18 EJ/yr, but still 2nd largest fuel source (after ST)

Some SE Asia Biomass Potentials

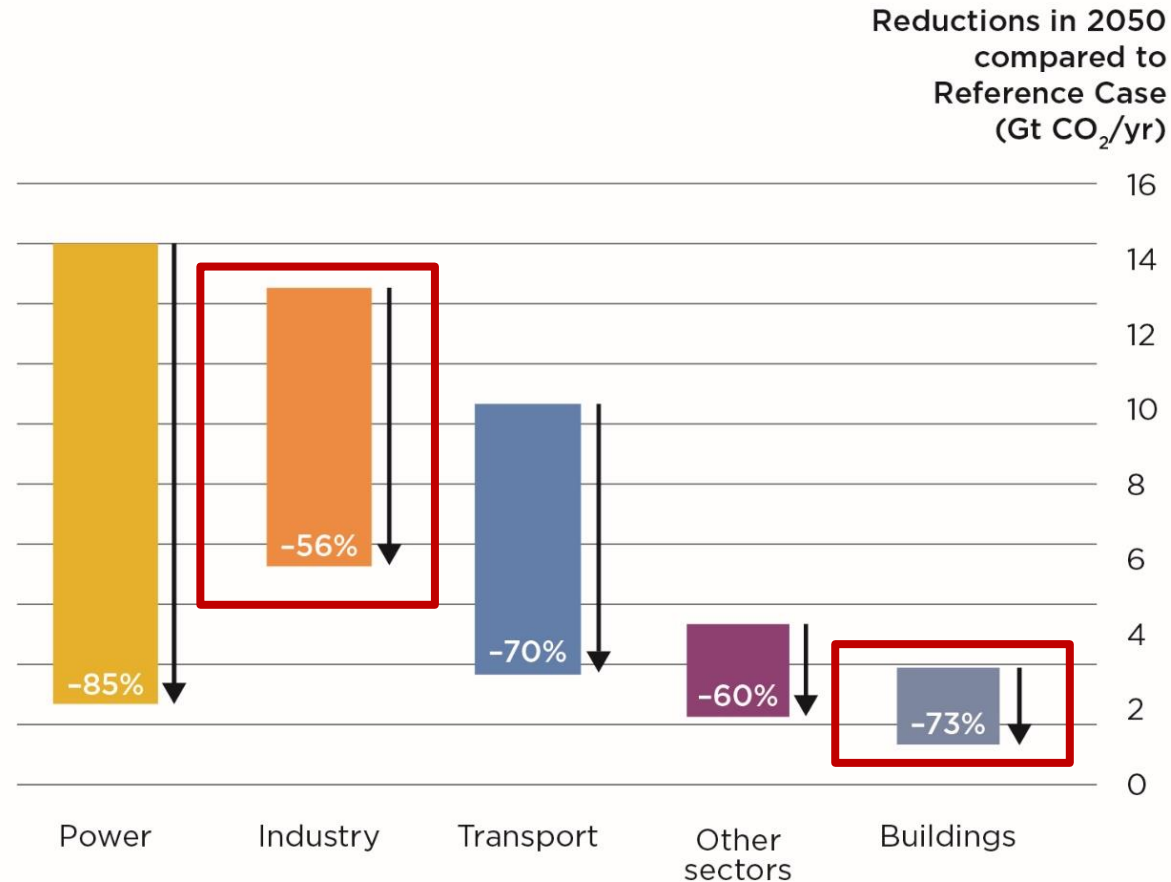
Country	Residues Potential with 50% Collection (PJ/year)	Potential from Closing Yield Gap (PJ/year)	Potential from Reduced Waste If Yield Gap Is Closed (PJ/year)	Forest Energy Wood Potential (PJ/year)	Total Primary Energy Potential (PJ/year)	Converted 40% to Advanced Biofuel (PJ/year)
Indonesia	2 505	638	1 645	395	5 183	2 073
Malaysia	179	190	420	187	976	390
Philippines	770	1 031	1 021	55	2 877	1 151
Thailand	1 635	518	849	191	3 193	1 277
Viet Nam	942	436	962	74	2 414	966
REGION	6 031	2 813	4 897	903	14 644	5 858

Biofuel Potential in Southeast Asia:
Raising food yields, reducing food waste and utilising residues



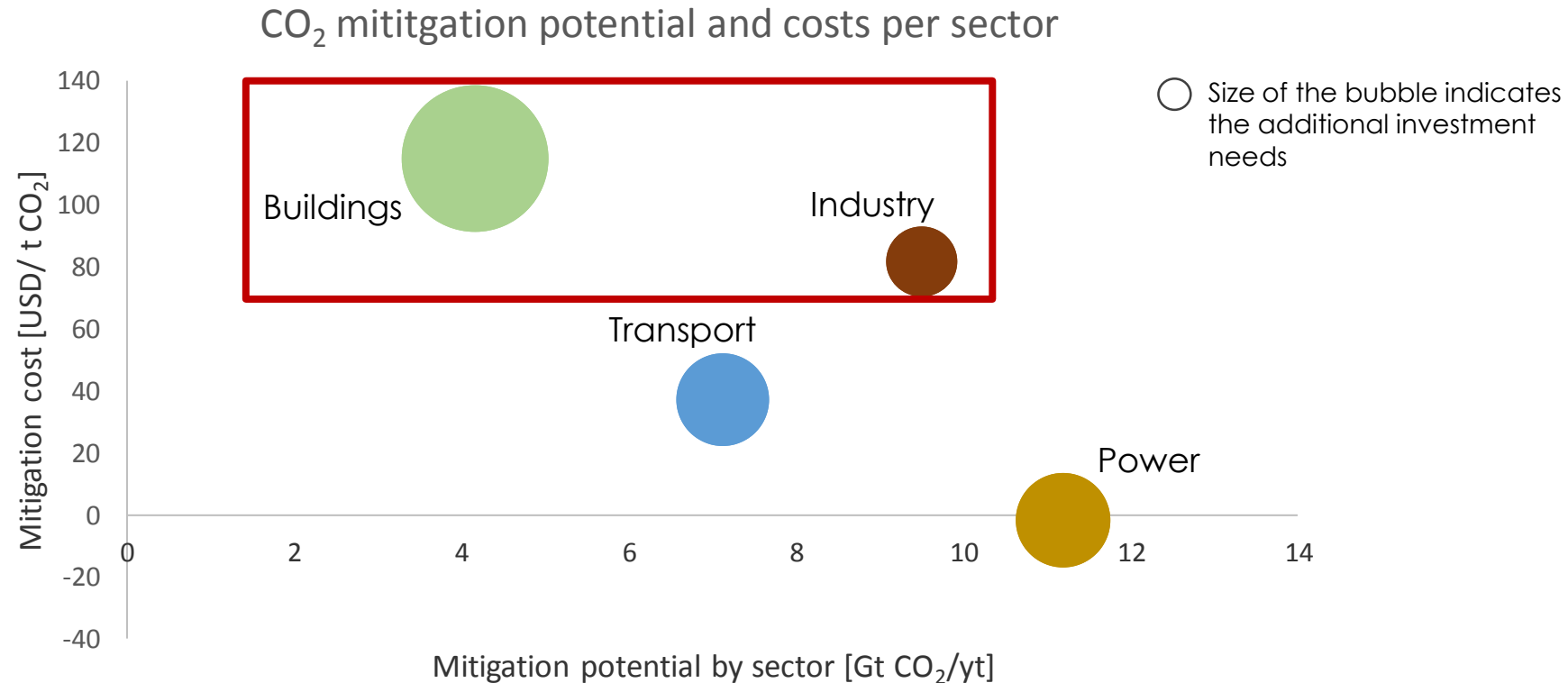
- Study on bioenergy potential in Southeast Asia – focus on feedstocks that do not compete with food production or lead to increased emissions
- Focus is “Sustainable Intensification” – 15 EJ additional potential, if half achieved by 2050 could be combusted to provide around 6 EJ heat, or converted to liquid biofuel and provide 3 EJ

Key global emissions reduction by sector



- By 2050, total energy-related CO₂ emissions will need to decrease to ~10-12 Gt
- CO₂ emissions from the power and buildings sectors will be almost eliminated
- Industry and transport would be the main sources of emissions in 2050
- Emission reductions are 90% from RE and EE

Mitigation potential and costs by sector



- Industry is the most challenging sector where more attention is required to utilise its potential and reduce the costs of technologies.
- Largest investments for decarbonisation will be needed for buildings.

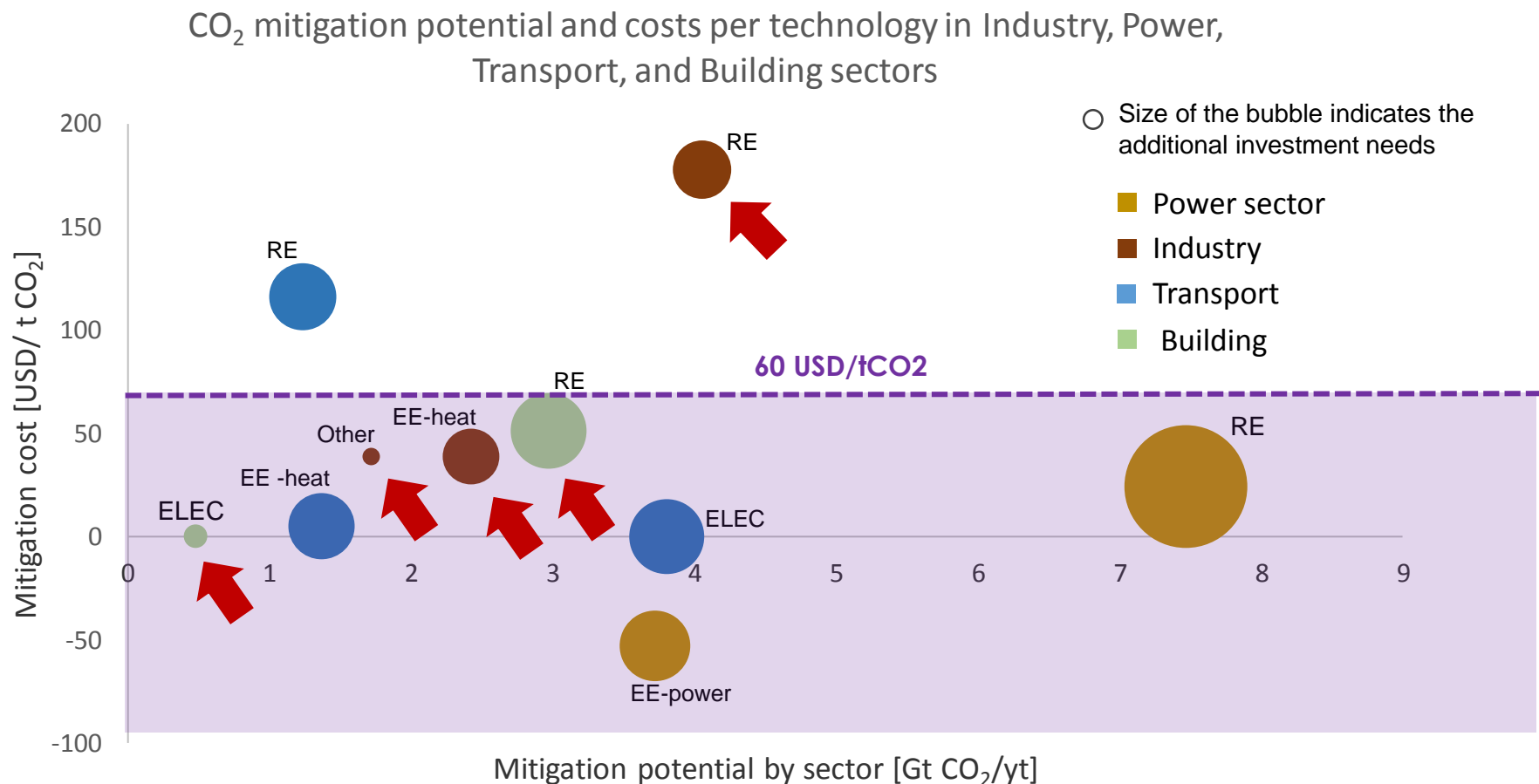
Mitigation potential and costs by technology

What it means for innovation?

- Urgent R&D needs for RE solutions in buildings and transport sectors
- Power sector going Ok
- A CO₂ price around 60 USD/tCO₂ may unlock most of the RE potential

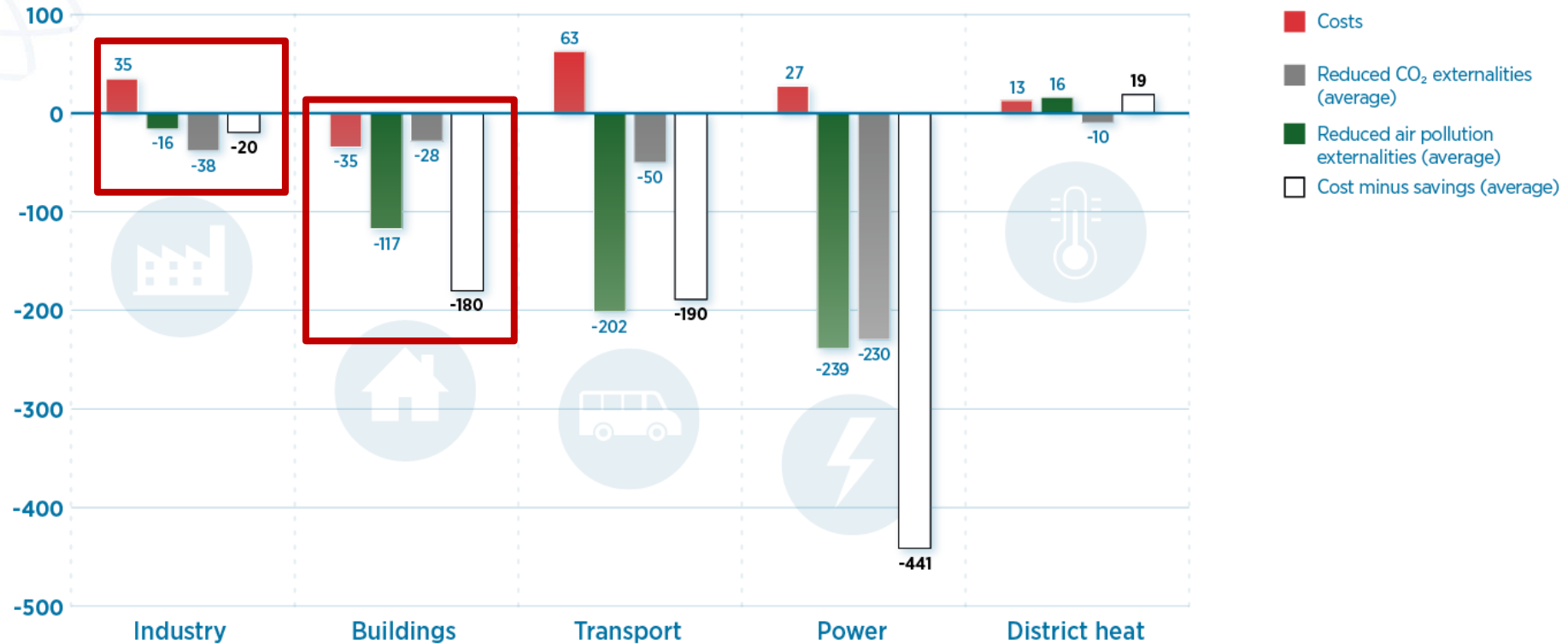
Not included

- Additional cost-savings from reduced adverse effects on health
- Positive GDP and job impacts as well



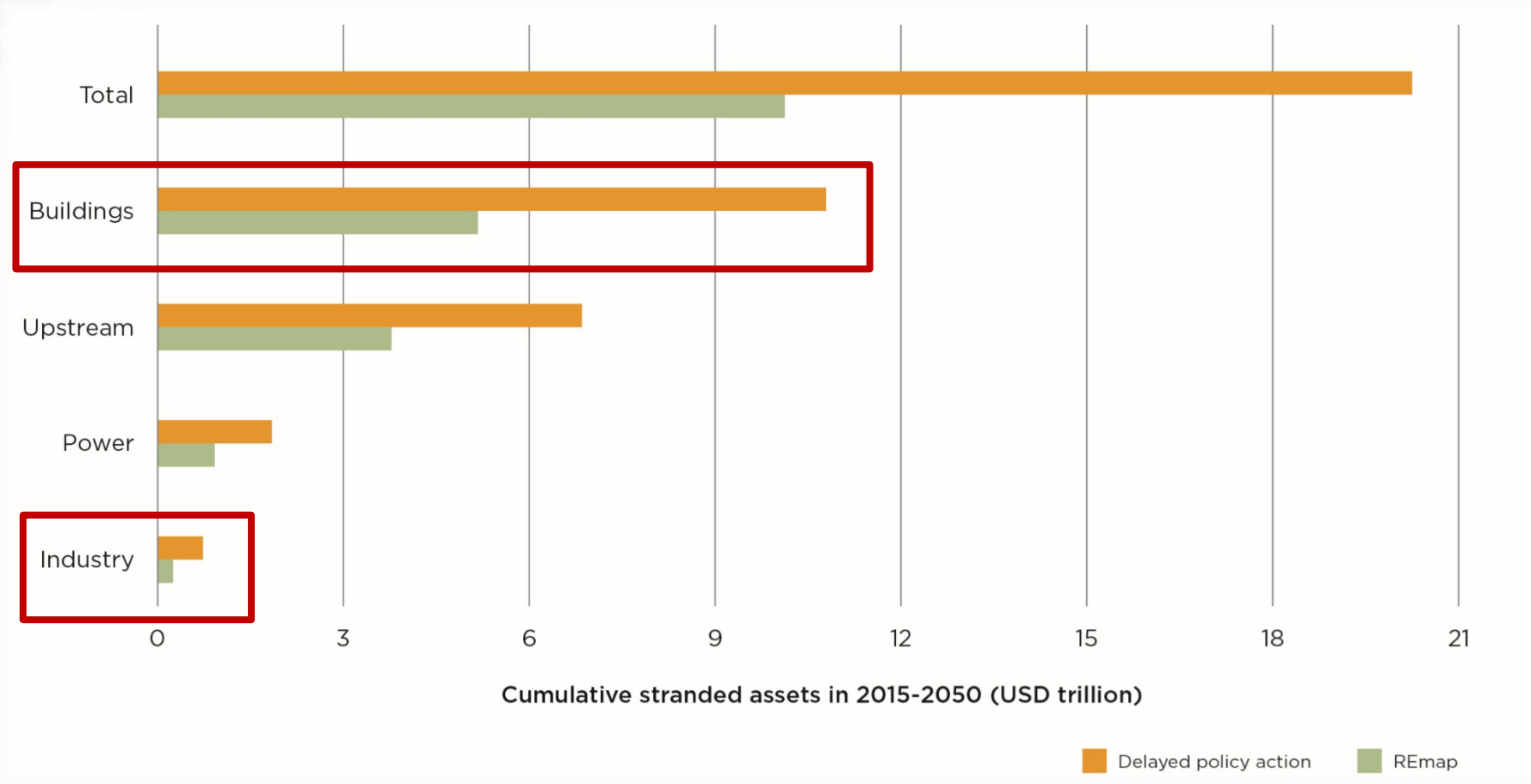
Costs vs benefits in 2030

Costs and savings of renewables by sector in 2030
(USD bln per year)



- Industry has incremental energy system costs to 2030, but savings resulting from reduced CO₂ (SCC) and avoidance of adverse health impacts due to lower air pollution would result in net savings of USD 20 billion annually by 2030
- Buildings view to 2030 is slightly different than to 2050 – there are savings in energy system of around USD 35 billion to low hanging fruits i.e. solar thermal and modern cooking – and large reduction in air pollution associated costs (i

Stranding of assets by 2050



- Delaying action on climate will result in an additional USD 10 trillion in stranded assets.
- Largest is in the building sector

Areas for action in ASEAN

- Not presented here is the in-depth technology view, costs and benefits, policies and barriers overview in IRENA/ACE report “Renewable Energy Outlook for ASEAN” and IRENA’s “Renewable Energy Prospects for Indonesia”

ACTION AREAS FOR ENABLING ASEAN’S RENEWABLE ENERGY POTENTIAL

Accelerating the deployment of renewable energy technologies must take national circumstances into account. There is therefore no single set of solutions suited to the needs of the entire ASEAN region. Suggestions can, however, be grouped broadly into four areas:

1 Action area 1: increase power system flexibility in the ASEAN region while using renewables to provide modern energy access for all



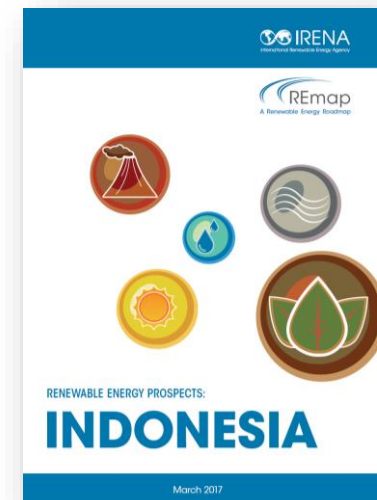
2 Action area 2: expand efforts for renewable energy uptake for the power sector and for heating, cooking and transport sectors



3 Action area 3: create a sustainable, affordable and reliable regional bioenergy market



4 Action area 4: address the information challenge by increasing the availability of up-to-date renewable energy data and the sharing of best practice for renewable energy technologies



Thank you!

High-level action areas

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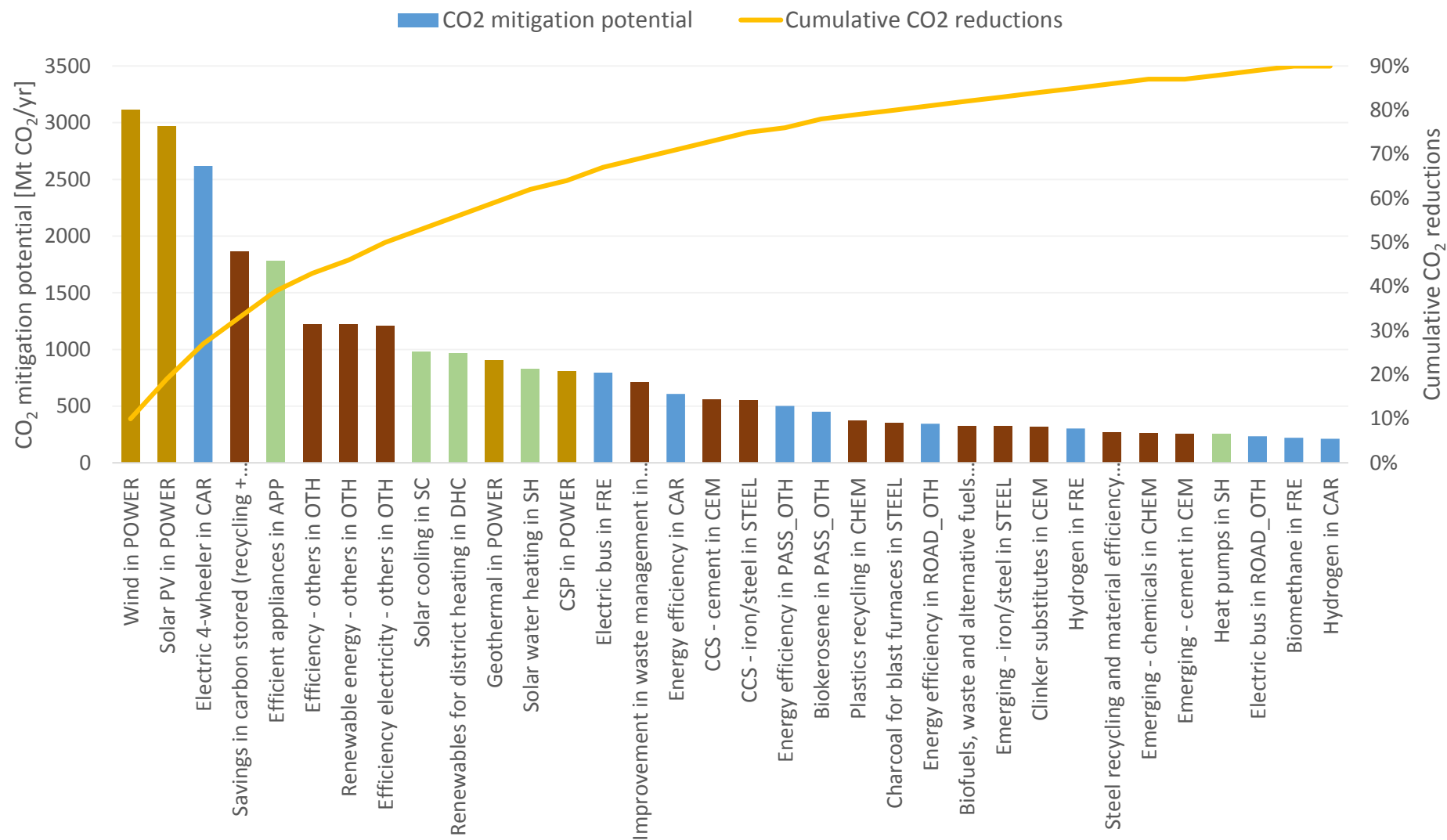
3 Action area 3: create a sustainable, affordable and reliable regional bioenergy market



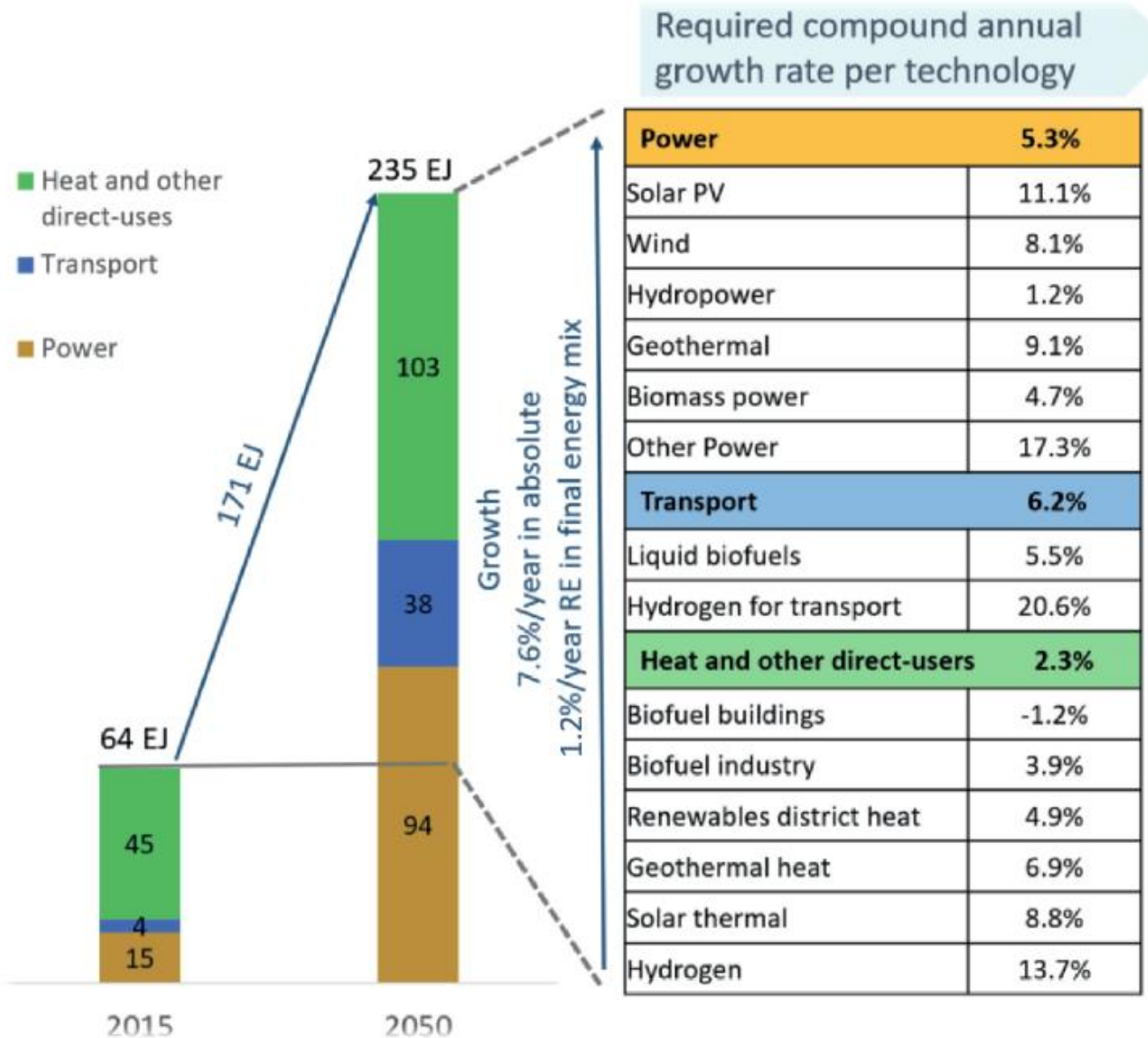
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Contribution to mitigation by technology and sector



Breakdown of renewable energy technology growth 2015-2050



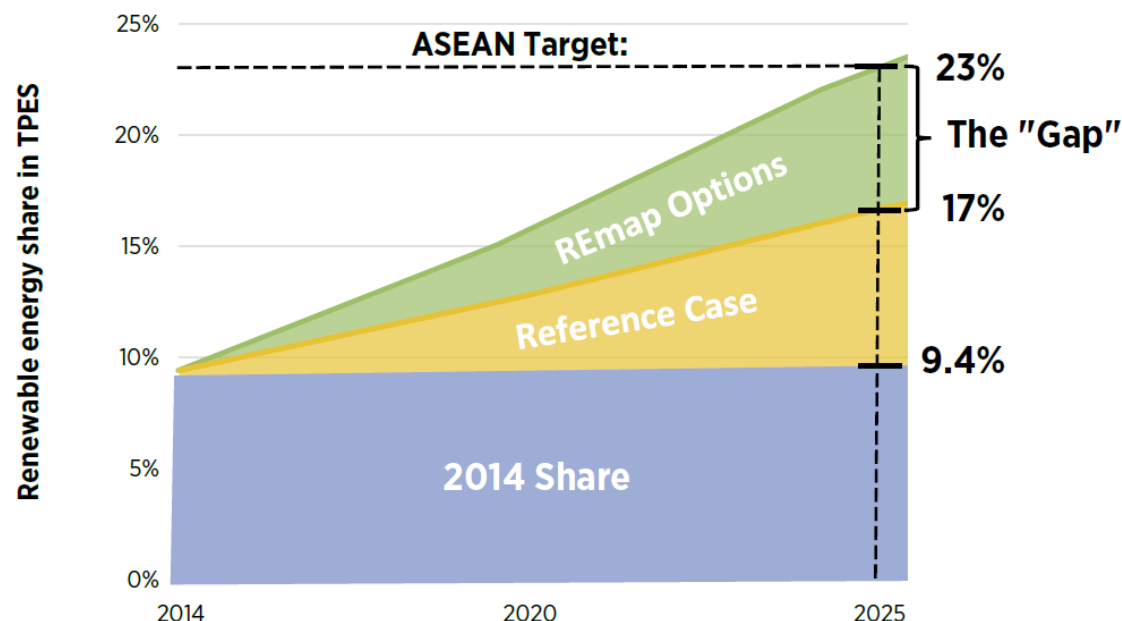
Power sector and end-use sector renewables deployment must grow

ASEAN's 23% aspirational renewables target

Set forth in October 2015 as part of ASEAN Plan of Action for Energy Cooperation

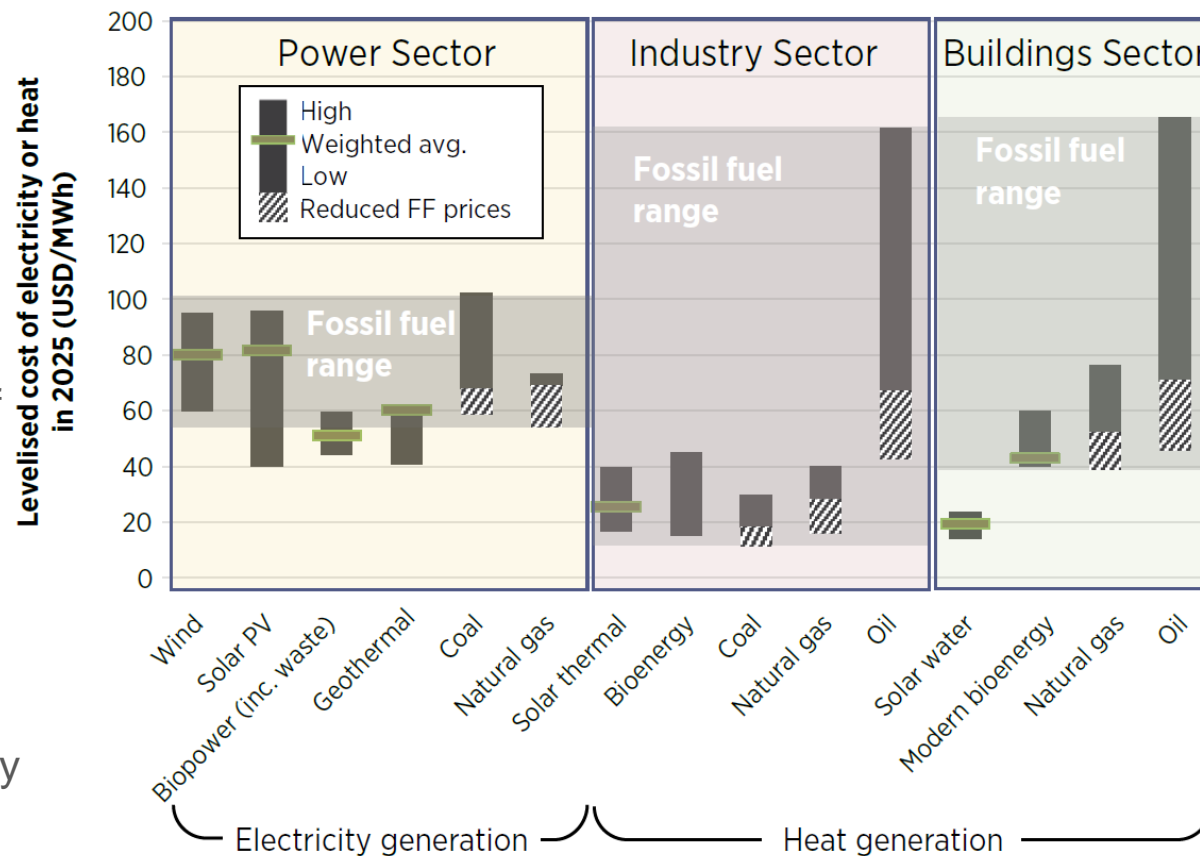
- 23% renewable energy share¹⁾ in total primary energy supply (TPES) by 2025
- ACE Energy Outlook (2015):
 - 2014 – 9.4%
 - 2025 BAU – 10%
 - 2025 Advanced Policy Scenario (APS) – 15.4%
- IRENA Reference Case – 16.9% (APS + latest country updates)
- 6% point gap to the 23% target

1) excluding traditional uses of bioenergy, including all hydropower



Drivers for a renewable revolution in the region

- The region has some of the best renewable energy resources in the world
- 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

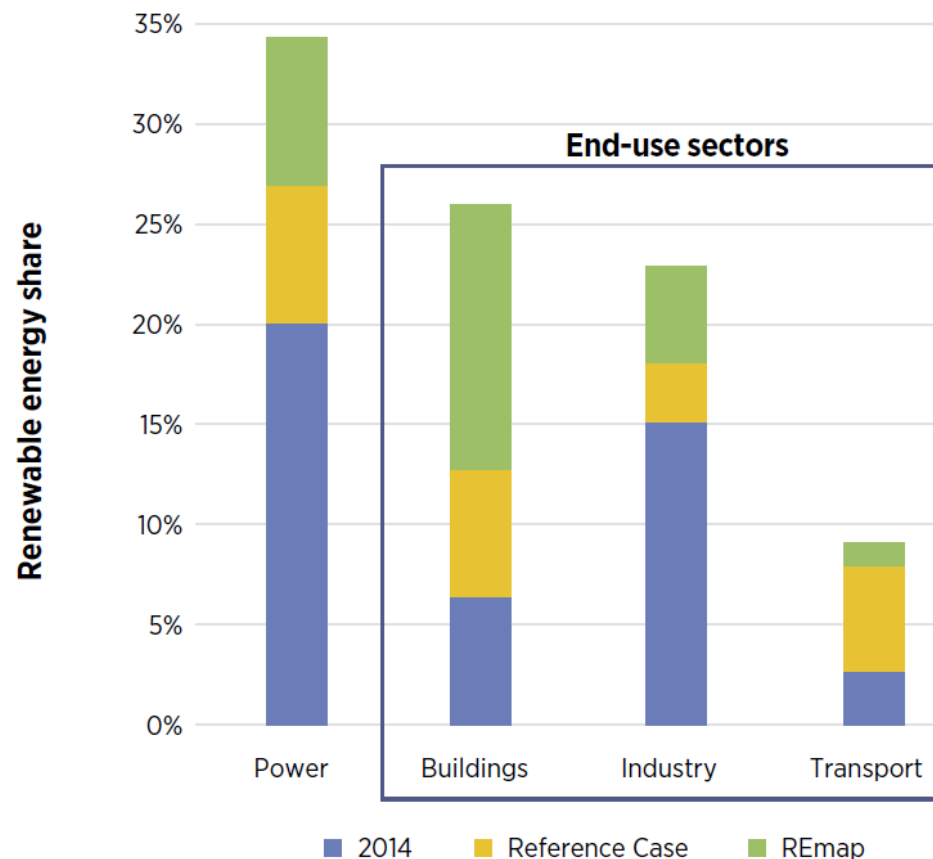


Note: reduced fossil fuel (FF) prices assumes lower average commodity prices for fossil fuels for coal (-10%), natural gas (-20%) and oil (-30%)

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
- 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

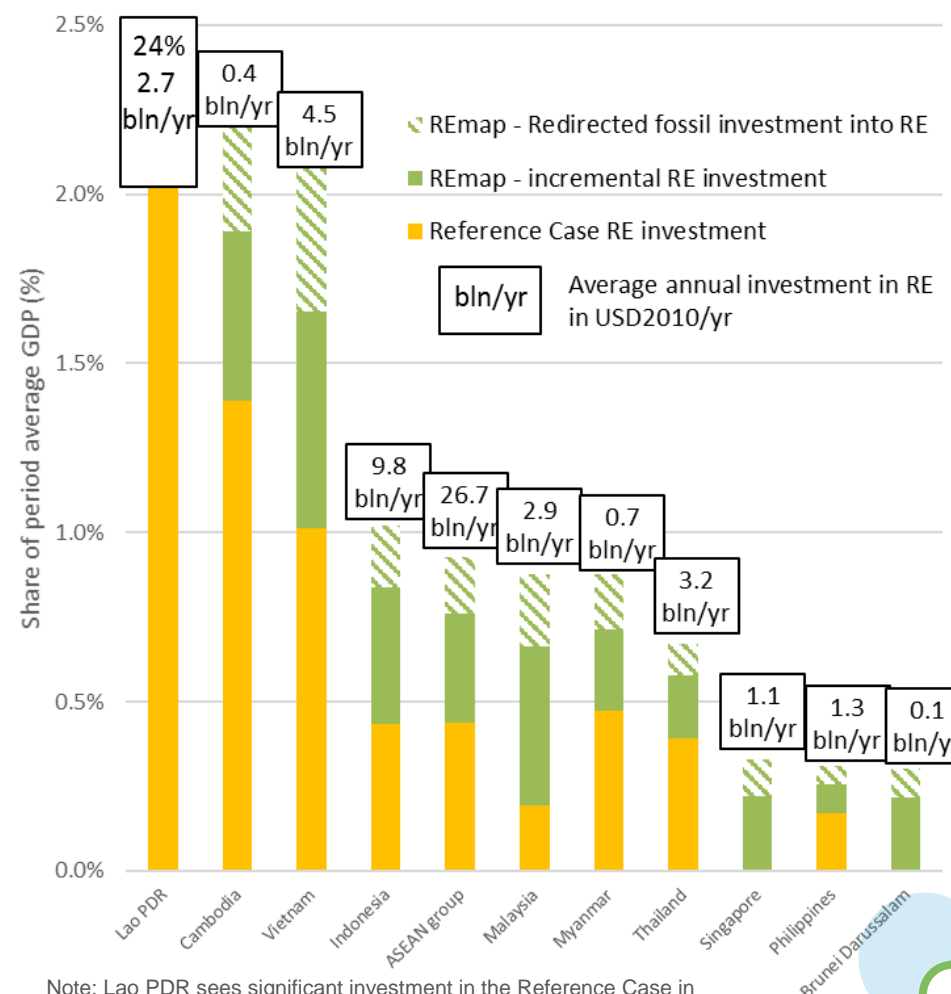


Note: End-use sectors include the consumption of electricity sourced from renewables. Shares presented in figure exclude traditional uses of bioenergy.

Investment needs for realizing the target

The region will need to invest 1% of its GDP annually into renewable energy capacity to reach its 23% target

- Average annual investment would total USD 27 billion
- This is split equally between the Reference Case and REmap Options for closing the gap
- One-third of the additional investment needed for REmap Options will be redirected from fossil fuels
- Three-quarters of all renewable energy investment is for power sector



Note: Lao PDR sees significant investment in the Reference Case in hydropower, much of it meant for export

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 far exceed additional costs
 - Energy-related CO2 emissions will rise by 60% in the Reference Case. With the renewable energy target reached, growth is restrained to 47%
- **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
- On-going discussion on integration of REMAP analysis for ASEAN into the 5th ASEAN Energy Outlook (5th AEO)

High-level action areas

ACTION AREAS FOR ENABLING ASEAN'S RENEWABLE ENERGY POTENTIAL

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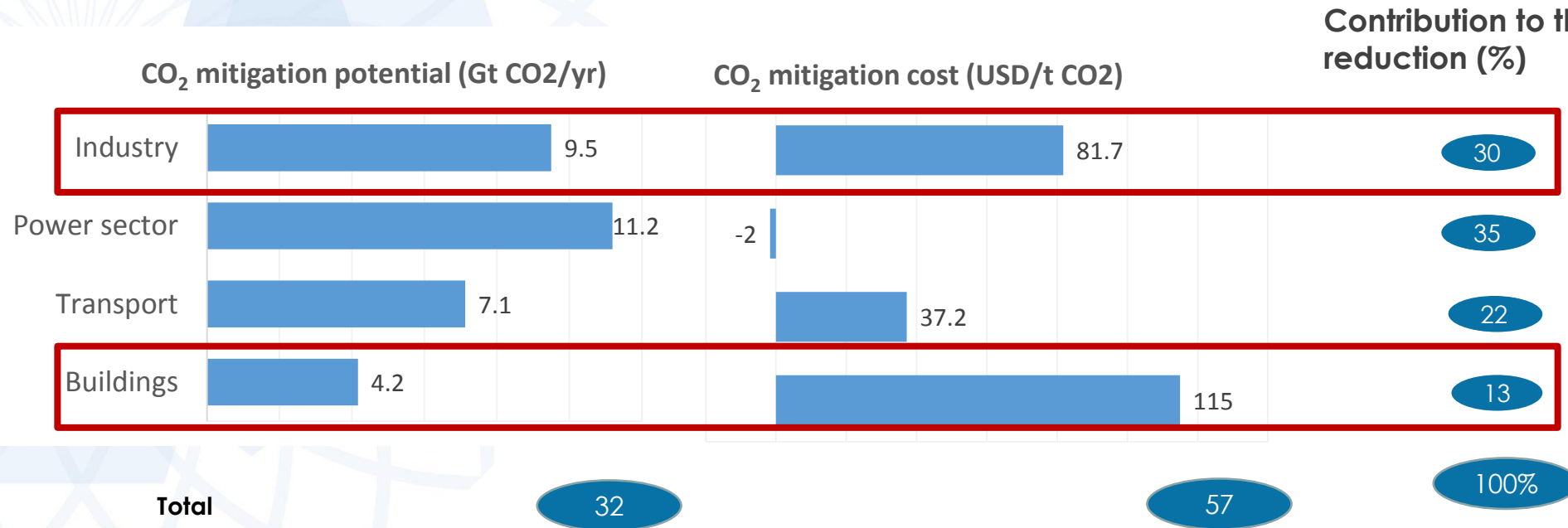
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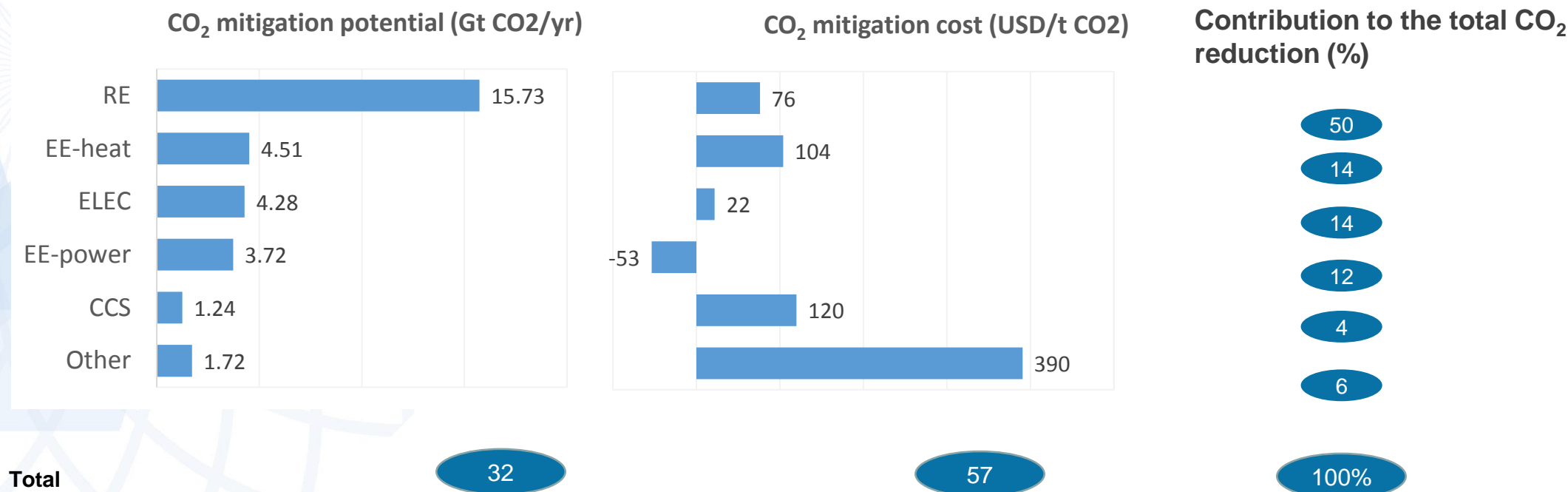


Mitigation potential and costs by sector



- Average abatement cost of technologies are highest in the building and industry sectors
- Industry technologies require

Mitigation potential and costs by technology



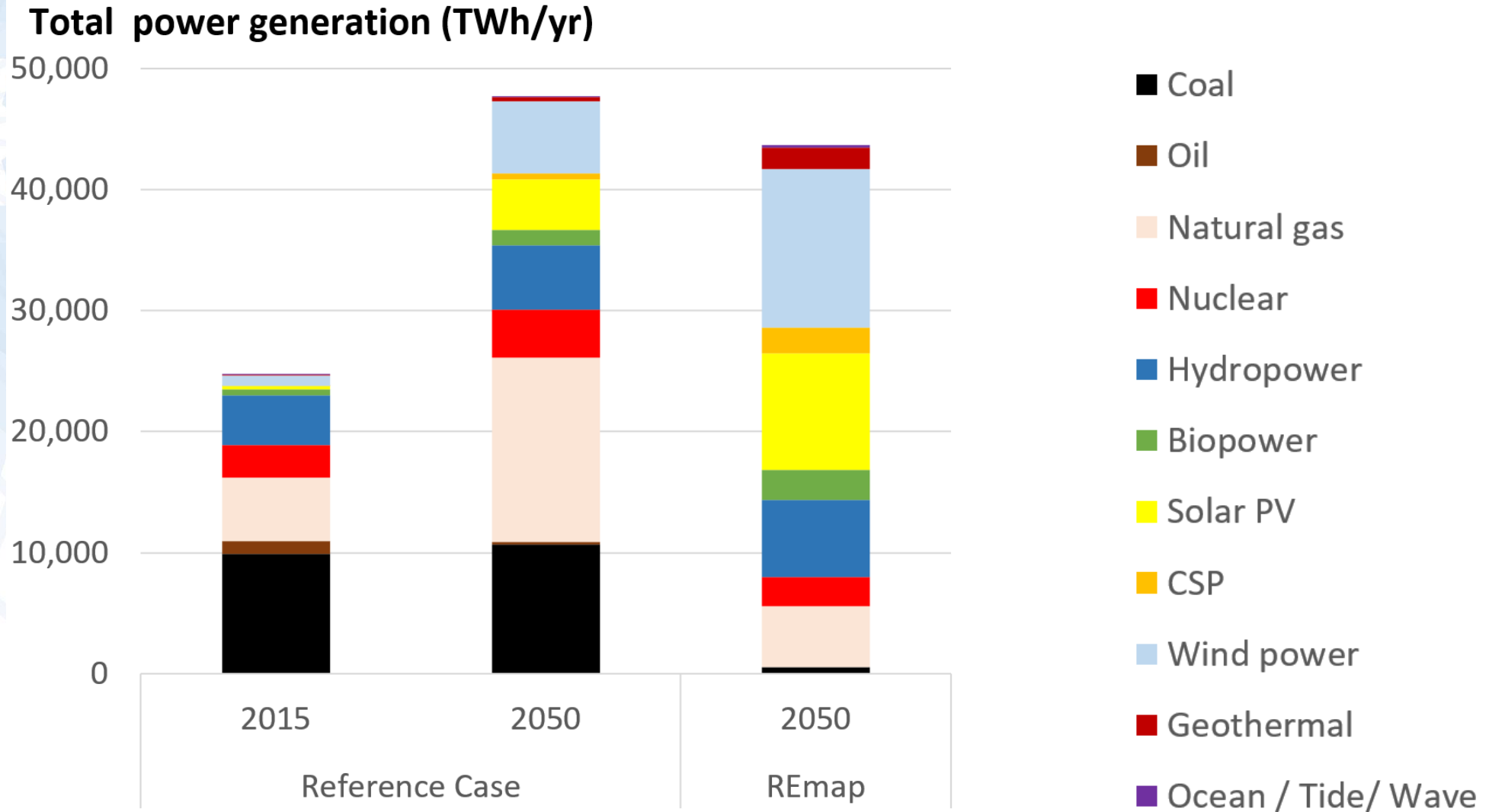
Renewable energy will represent half of all the emission reductions required for decarbonisation. Renewable energy technology costs vary, with RE grid integration measures and biomass-based heating/transport technologies requiring further development focus on cost-reduction as they raise the average cost of renewable energy

Energy efficiency accounts for bulk of the other half, followed by CCS and other low-carbon technologies such as material efficiency improvements

PRELIMINARY FINDINGS

Electrification leads to savings, assuming that electric vehicle costs will be on par with internal combustion engines

Main implications for the power sector

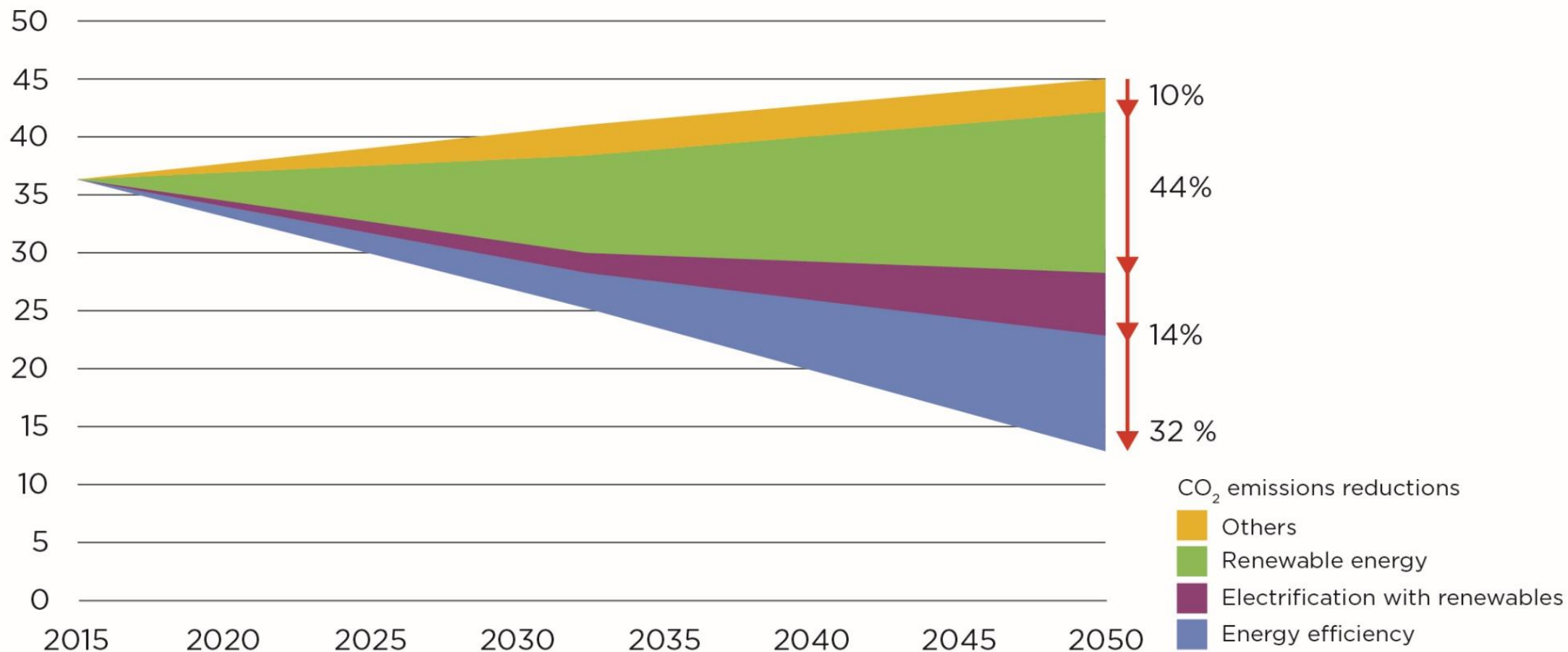


The power sector will see the highest share of renewables.

In REmap by 2050, a diverse mix of renewables will provide more than 80% of electricity.

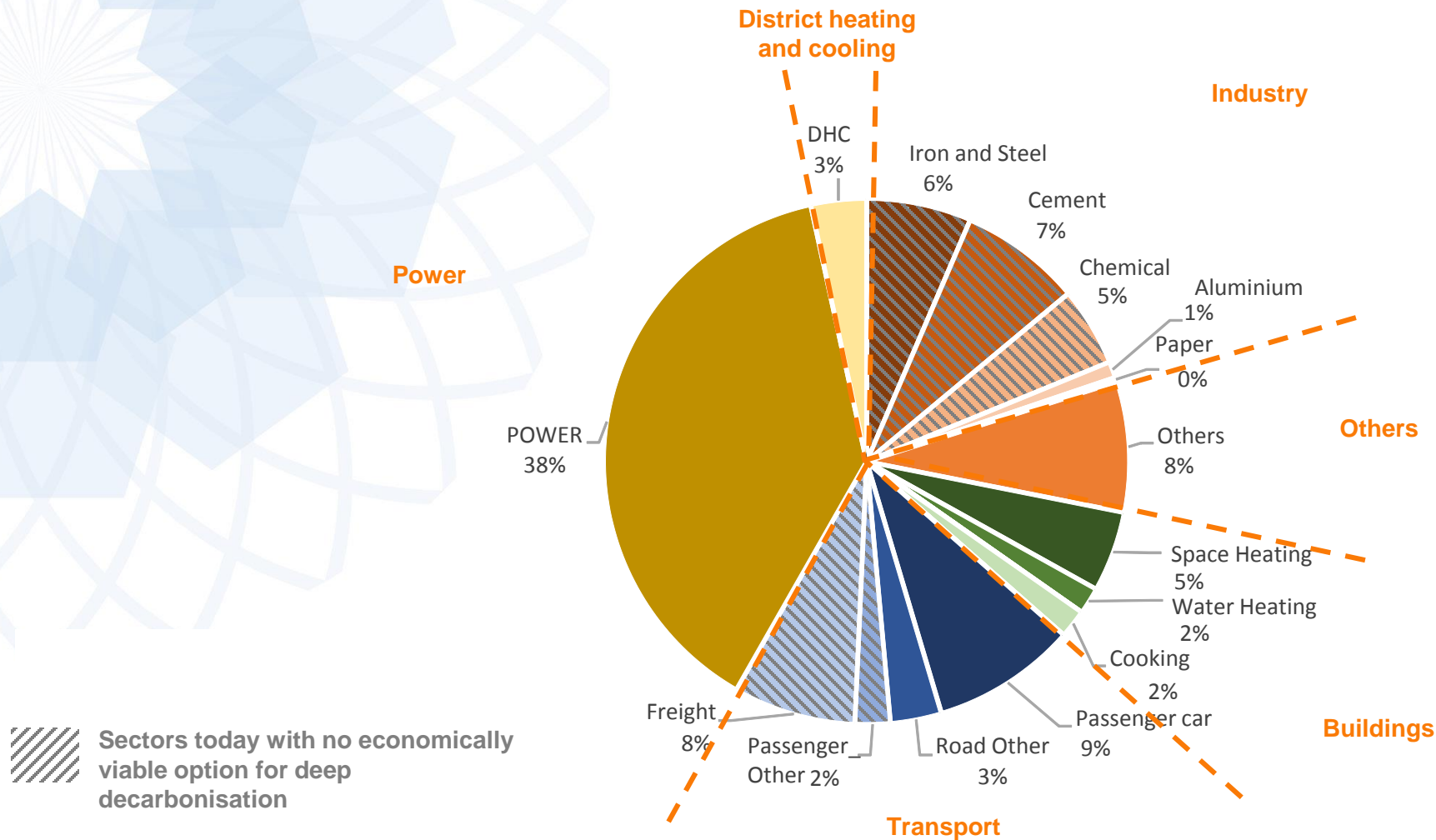
Reducing global CO₂ emissions in the energy sector

Total CO₂ emissions
from all sectors
(Gt CO₂/yr)



Renewables and energy efficiency account for 90% of emission reduction potential

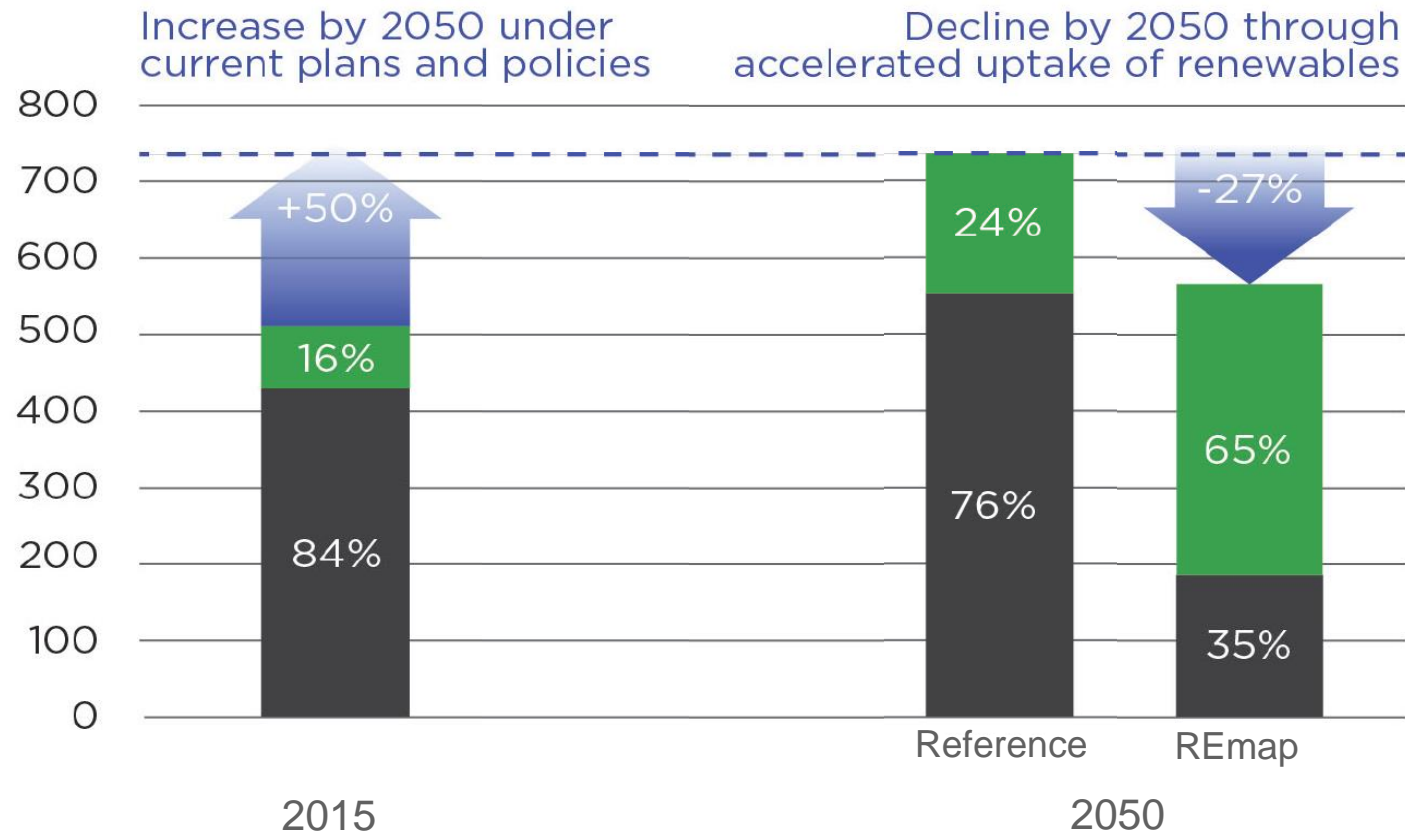
Breakdown of global CO₂ emissions by sector in 2015



Around one third of energy-related emissions in the Reference Case in 2050 currently have no economically viable options for decarbonisation

Breakdown of total global primary energy supply

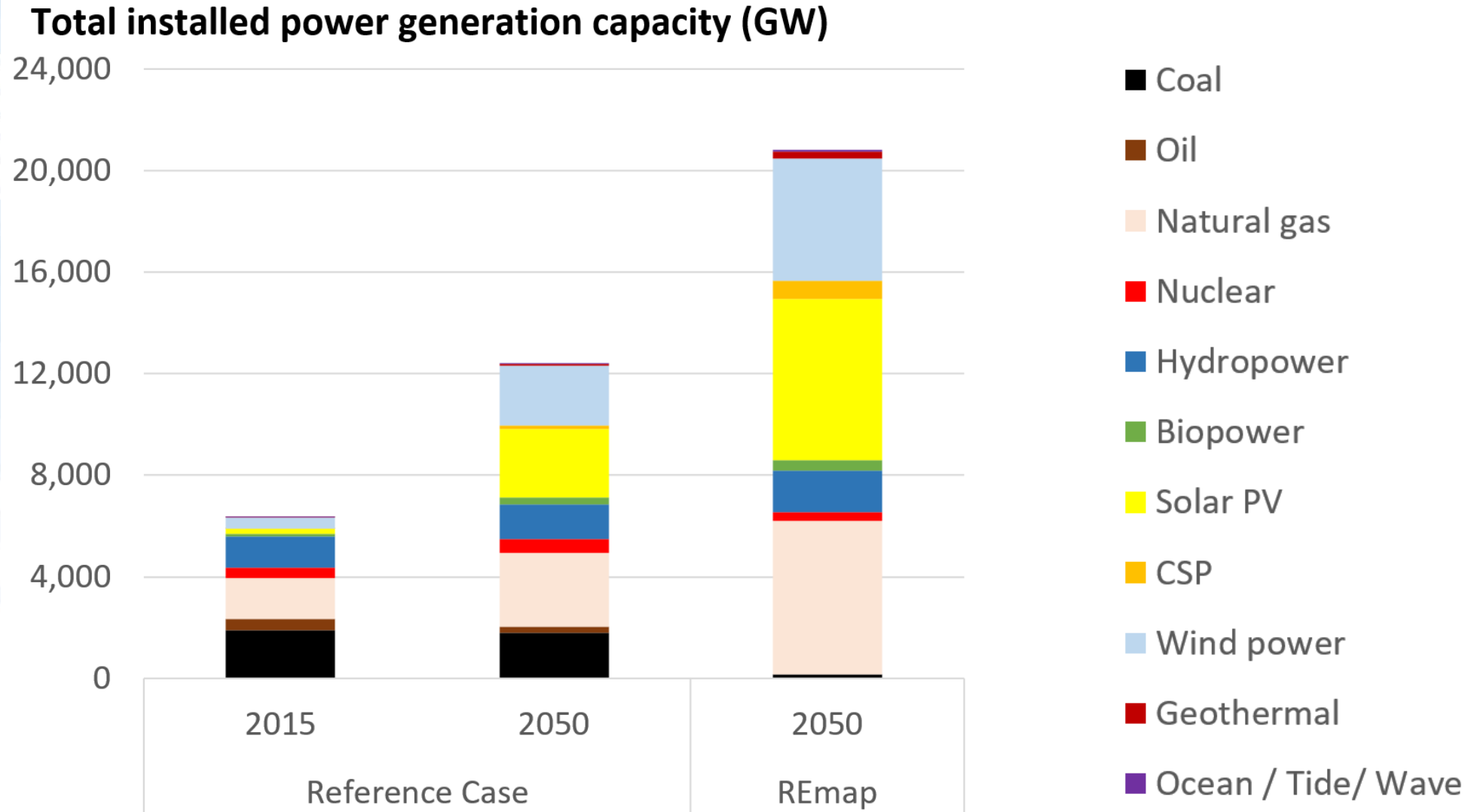
Total primary
energy supply
(EJ/yr)



Renewable energy would be the largest source of energy supply under REmap in 2050, representing two-thirds of the energy mix.

This requires a seven-fold increase in the annual growth of renewables' share in energy compared to recent years.

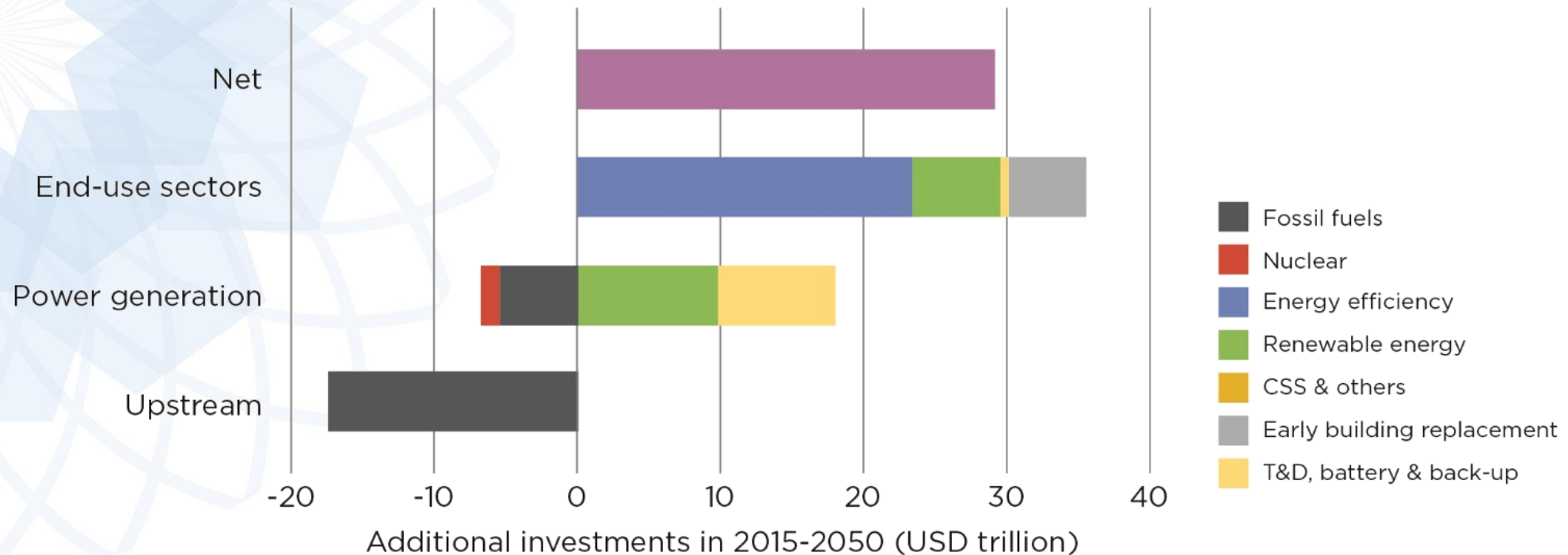
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Additional investment needs



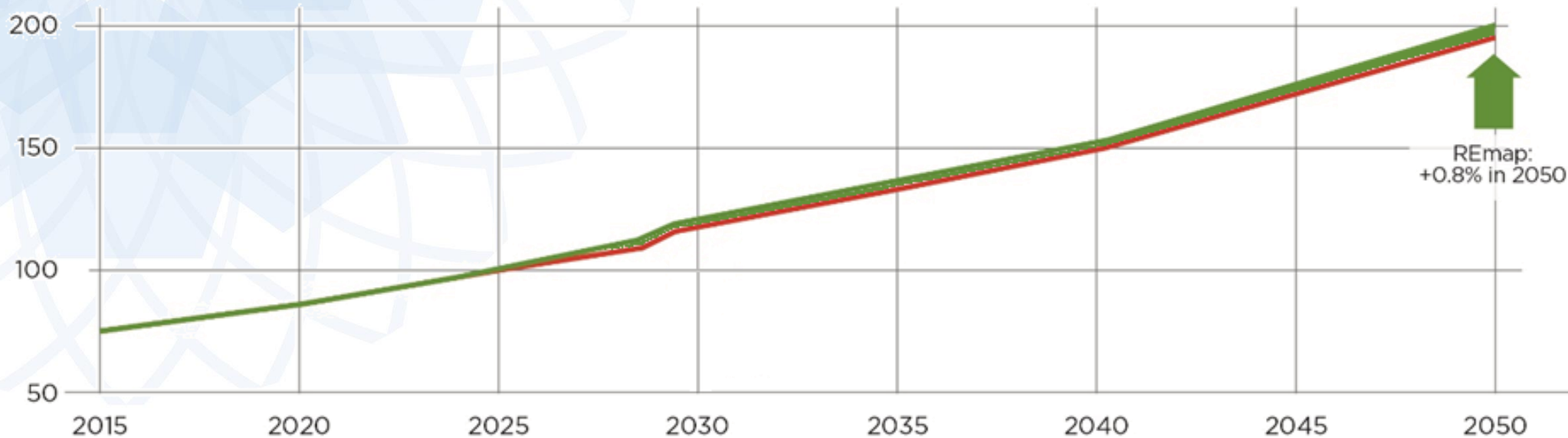
Until 2050, the transition requires investing an additional USD 29 trillion (compared to the Reference Case), less than 1% of global GDP per year.

The largest additional investment needs are in energy efficiency, followed by renewables.

The total investment requirements, however, are reduced by the avoided investments in fossil fuels upstream and conventional power generation.

Global GDP impacts of the REmap energy transition: absolute

Global GDP in
Reference Case
and REmap
(trillion USD)



Additional
GDP
in 2050:
USD 1.6 trillion
~ sum of GDP
of Indonesia and
Turkey today



Decarbonising the energy sector in line with REmap increases global GDP by around 0.8% in 2050 compared to the Reference Case, equivalent to 1.6 trillion USD.

Global GDP impacts of the REmap energy transition: additional

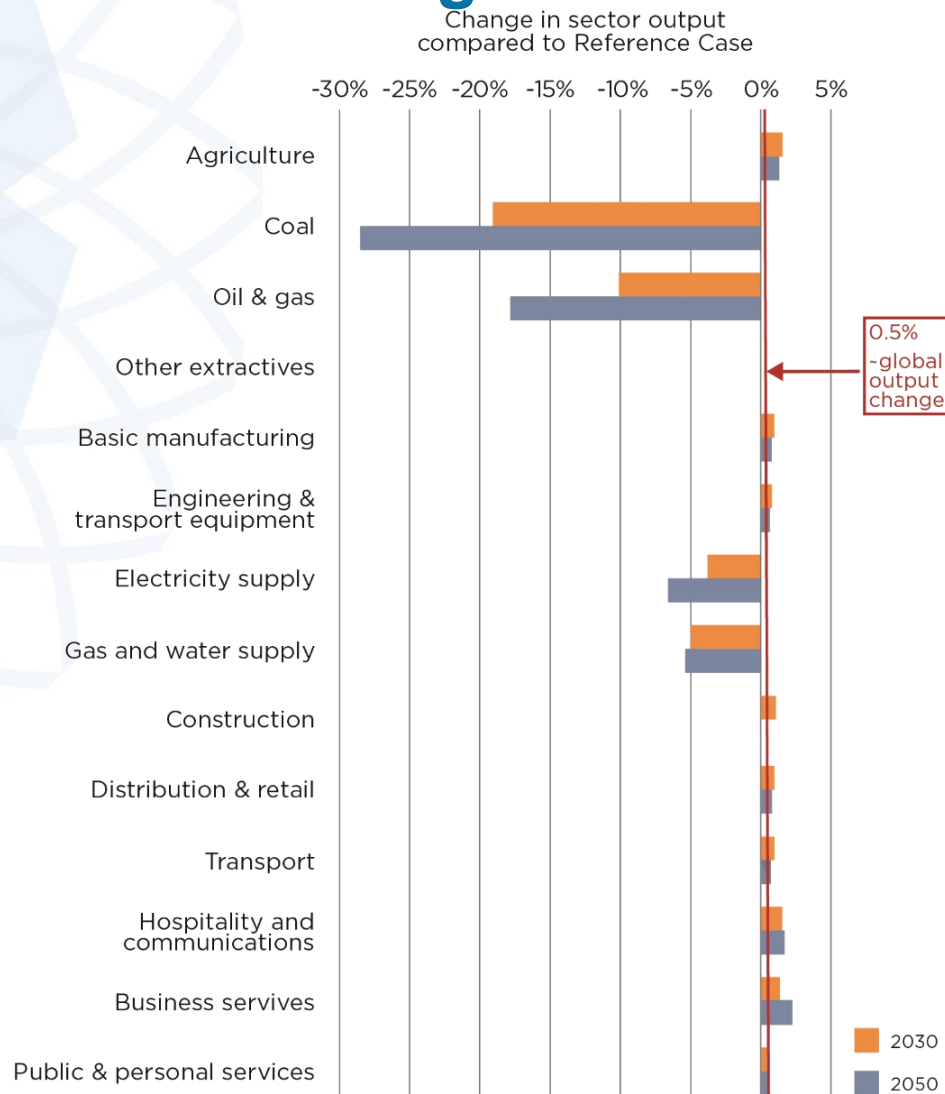
Additional GDP
in REmap
(trillion USD)



Additional
GDP
(cumulative):
USD 19 trillion
~ value of
all companies
on **NYSE**

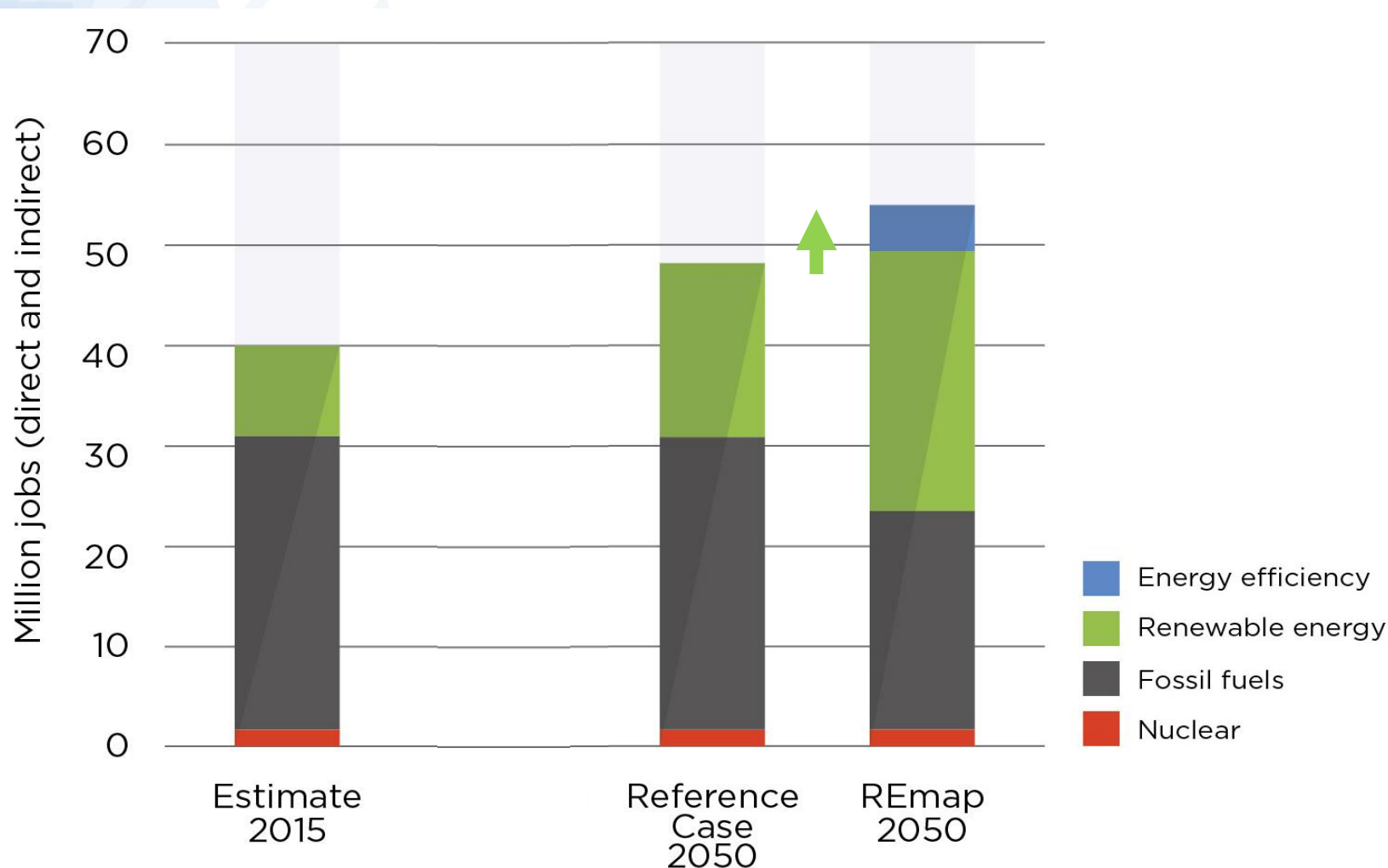
In cumulative terms this constitutes almost USD 19 trillion in increased economic activity between today and 2050.

The energy transition will change the structure of the economy



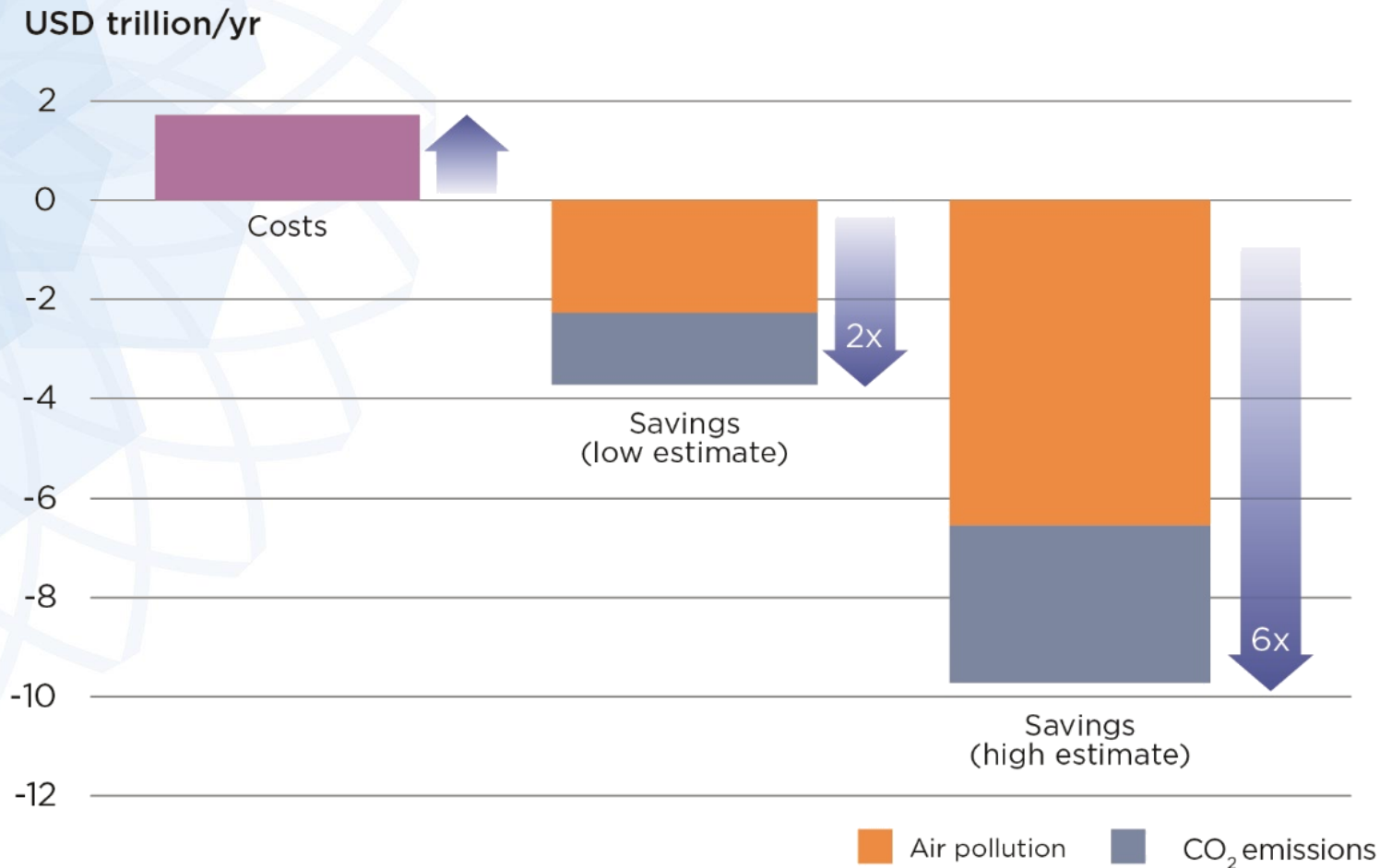
Fossil fuel industries see the largest reductions in sectoral output, while the highest increases are in sectors related to capital goods, services and bioenergy.

The transition creates jobs



New jobs in renewables and energy efficiency more than offset job losses in fossil fuel sectors.
Renewable jobs reach 26 million in 2050, from over 9 million today
GDP improvement induces further job creation in other economic sectors

Welfare benefits exceed the costs of decarbonisation



Benefits from reduced externalities exceed the costs of decarbonisation by a factor between two and six in 2050.

Health benefits from reduced air pollution health alone exceed the costs.

Policy Implications

- **Early action is critical** to limit climate change to 2°C, to maximise the benefits of the transition, and to reduce the risk of stranded assets.
- **Deep emission cuts in the power sector** are needed and require sound policy frameworks and market designs to achieve a flexible and resilient system.
- Enact **policies targeted at end-use sectors** (e.g. renewables for heating and cooling and transport, sector coupling, holistic approach, synergies with energy efficiency).
- Need for adequate **energy pricing**, including pricing of externalities (e.g. carbon emissions).
- **Needs to accelerate innovation** to allow time for developing the fundamental new solutions for different sectors and processes, ahead of long investment cycles.
- **A comprehensive approach to policymaking** is needed, including energy, climate and broader economic policies.

Questions

- How significant is the decarbonisation imperative for future decisions on sustainable energy investments?
- How best can IRENA's work on the energy transition (e.g. policy, technology, innovation, finance, best practices) be designed to support members?
- What are the key aspects of end-use sectors' transformation that IRENA should prioritise in its analyses?
- Are there specific aspects of the findings that IRENA should analyse in more depth?



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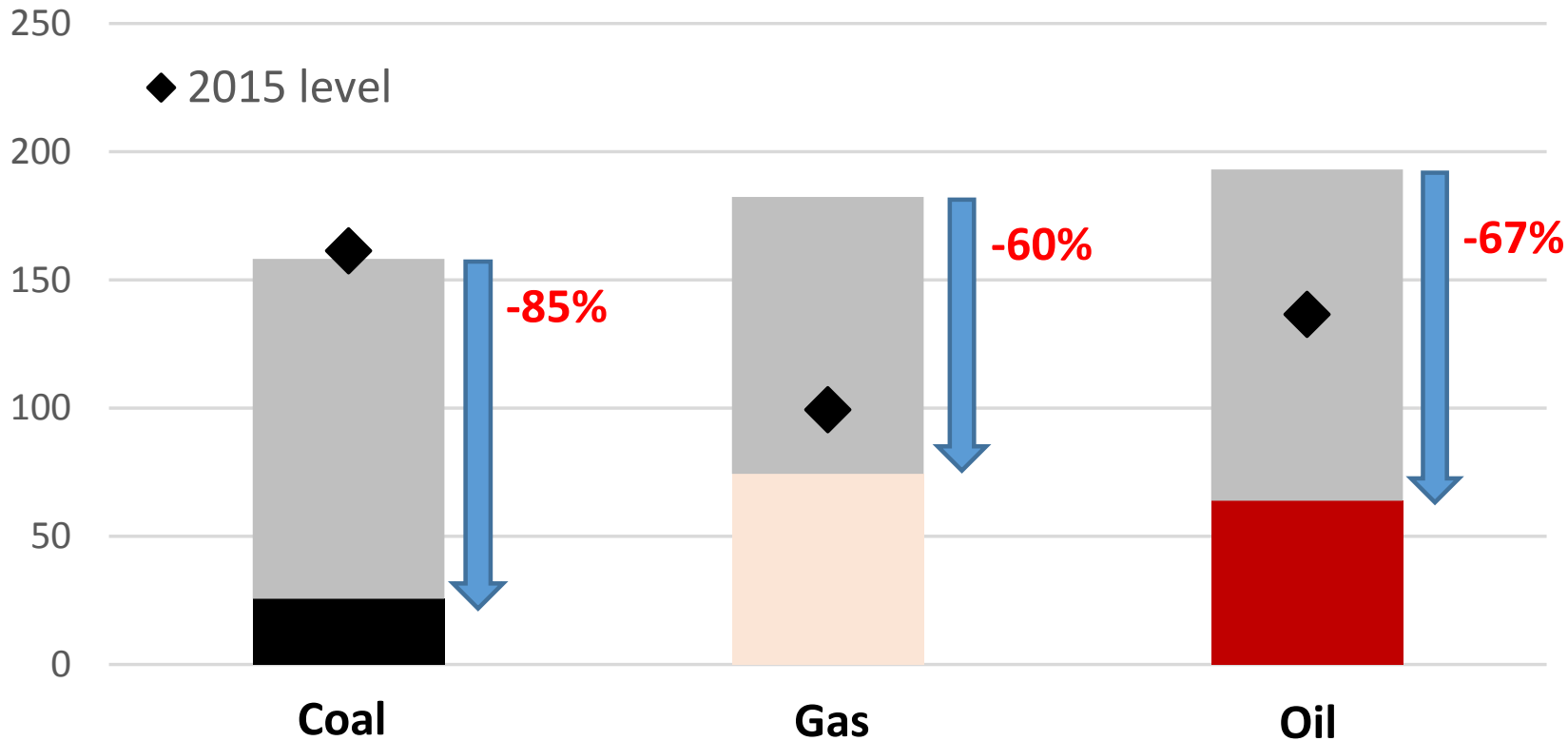
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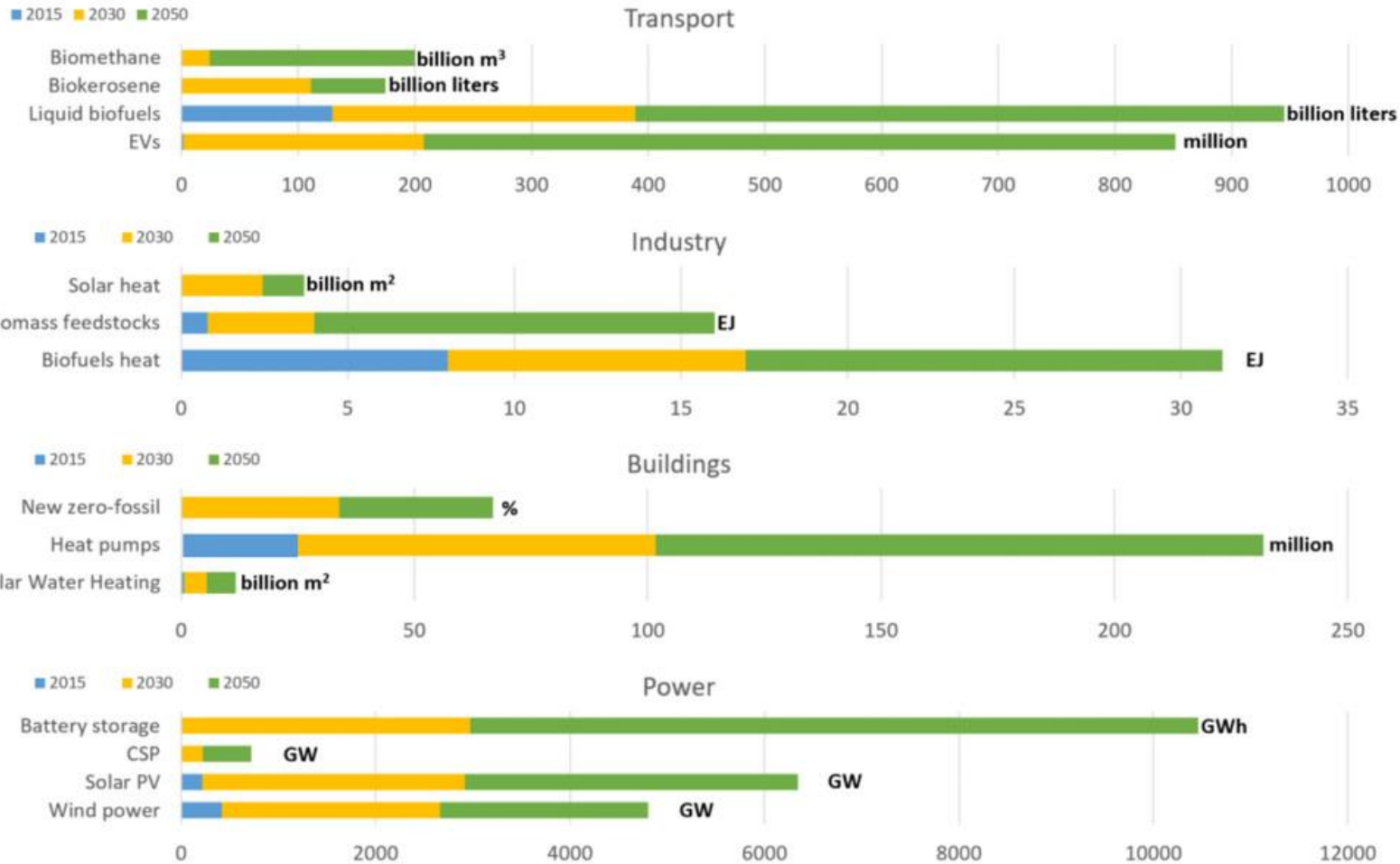
Global change in primary energy supply in REmap

Total primary energy supply (EJ/yr)



Fossil fuel use would be reduced by 60%-85% in REmap compared to the Reference Case in 2050.
Gas demand stays at today's level.

The end-use sectors transition: untapped area and market opportunity



Transport

- Will traditional car makers able to catch up?
- Significant biofuel trade
- Materials needs (e.g. rare earth for EVs)

Industry

- Industry is the most challenging sector

Buildings

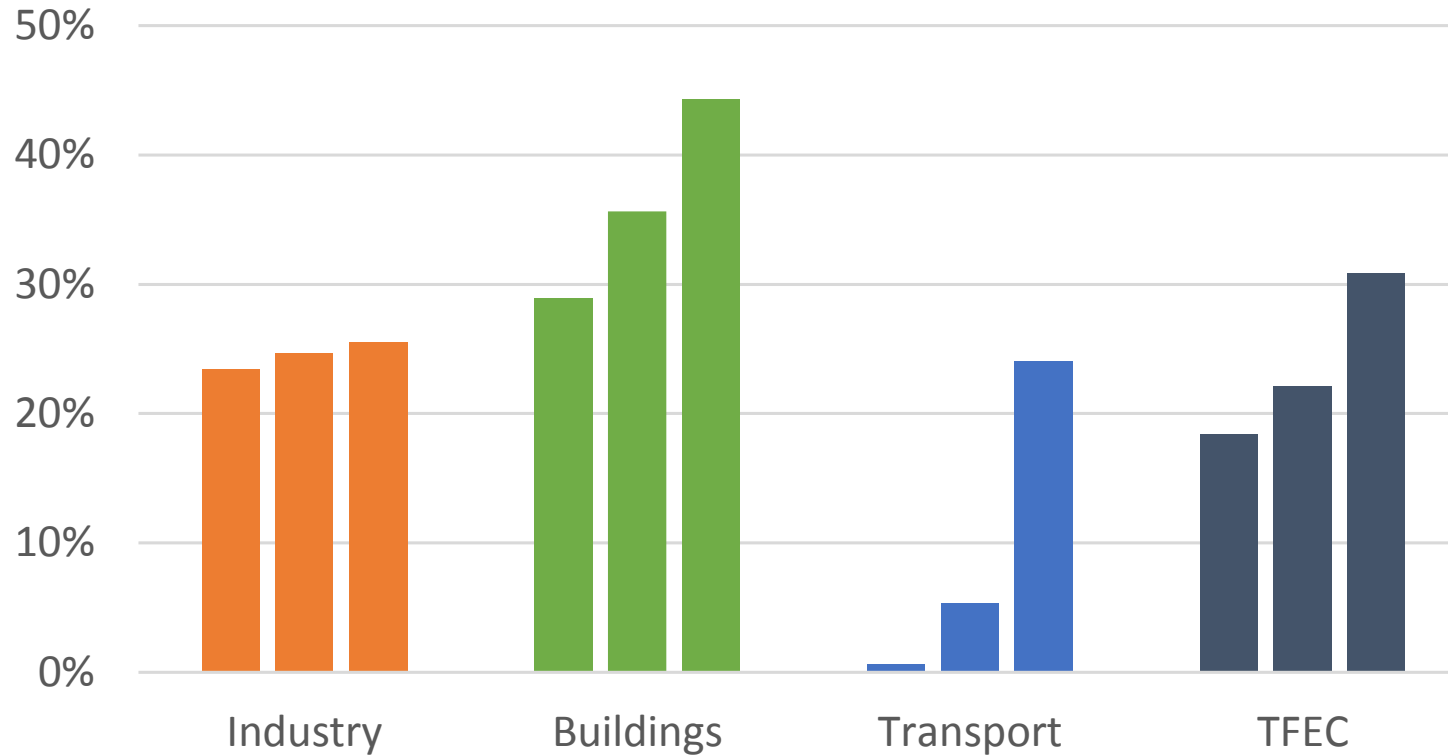
- Significant acceleration of buildings renovation

Power

- Growing equipment industries
- Materials needs (e.g. for batteries, inverters)

Electricity share in total final energy consumption

**Electricity share in TFEC
2015, 2030, 2050**

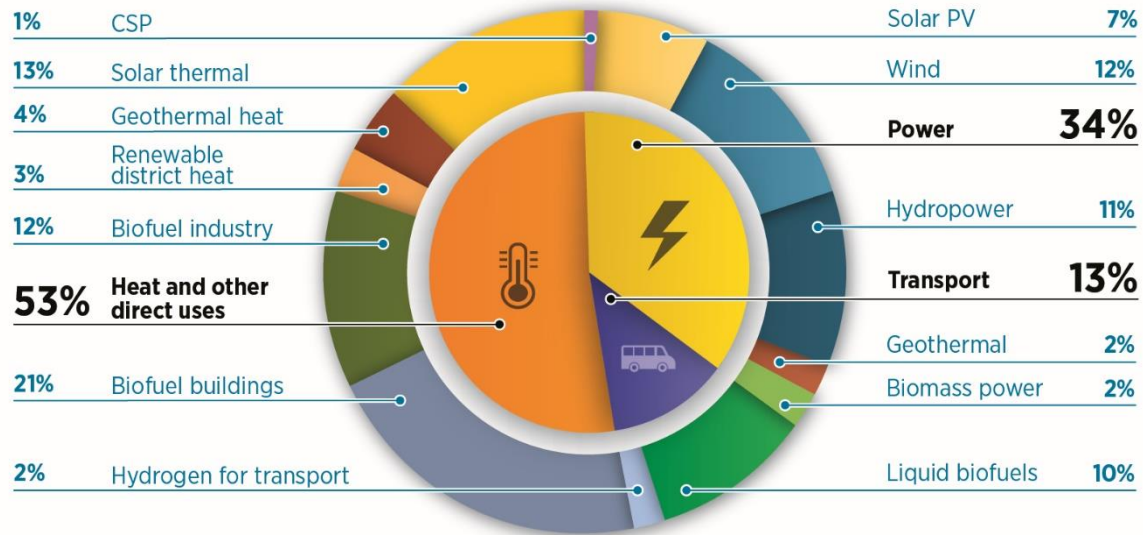


The share of electricity in the total final energy consumption will grow exponentially in transport sector and continue to increase in all other sectors.

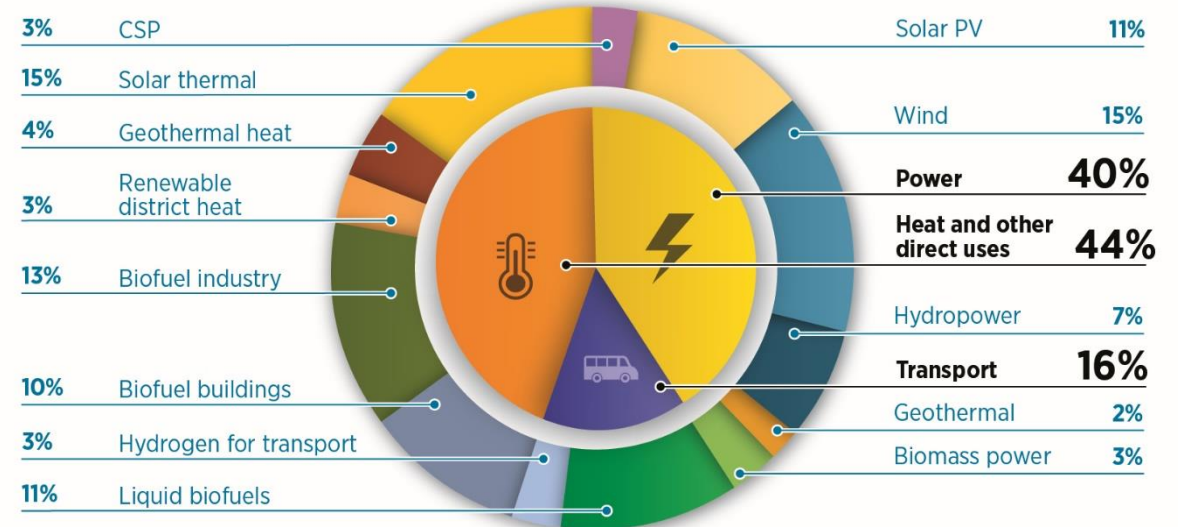
In the total energy system, it will reach 30% by 2050 compared to less than 20% today.

Final renewable energy use by sector and technology in REmap

REmap 2030
145 EJ

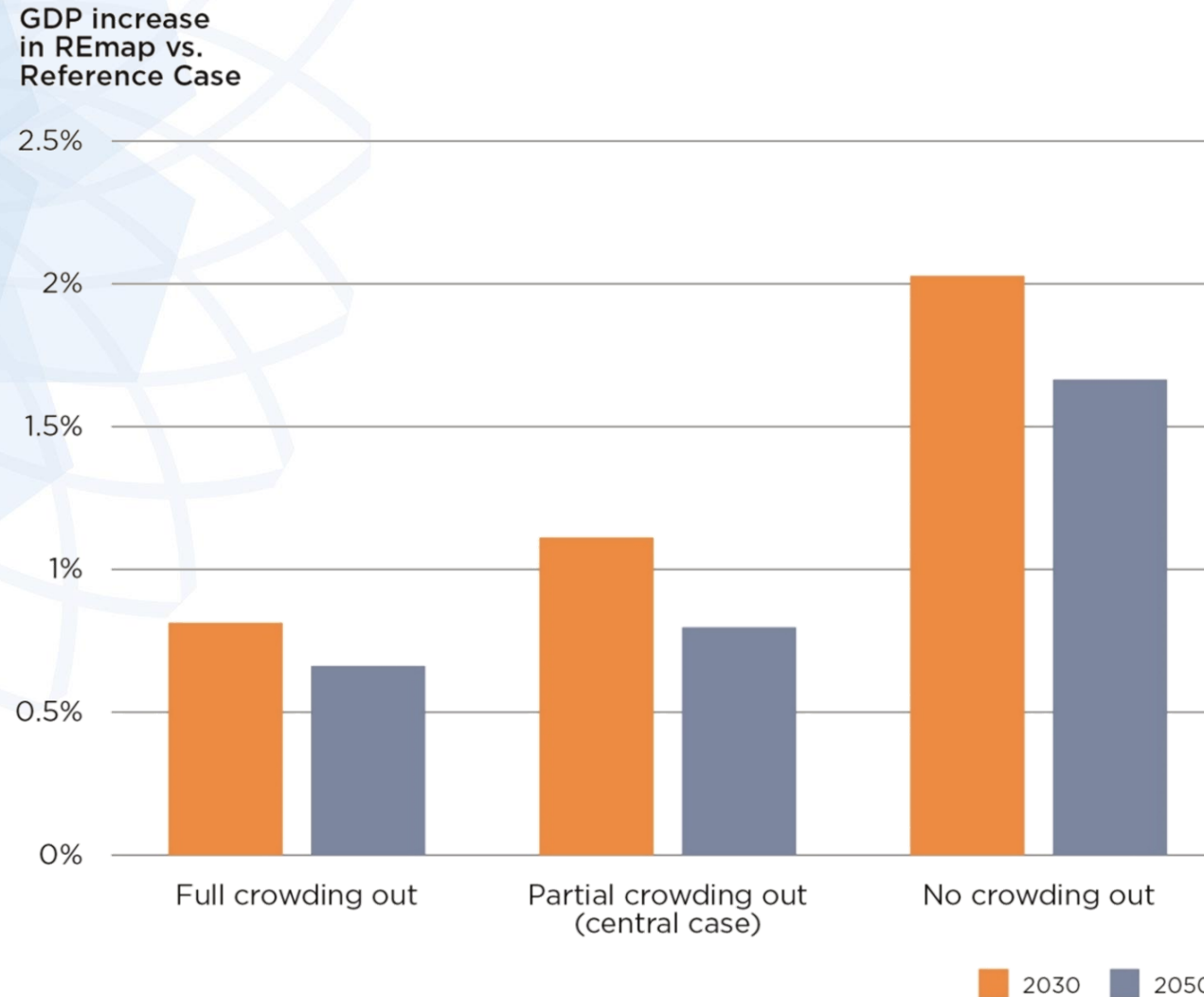


REmap 2050
235 EJ



Under REmap, final renewable energy use is four-times higher in 2050 than it is today. Power and heat consume about 40% and 44% of the total renewable energy, respectively, while transport uses about 16%.

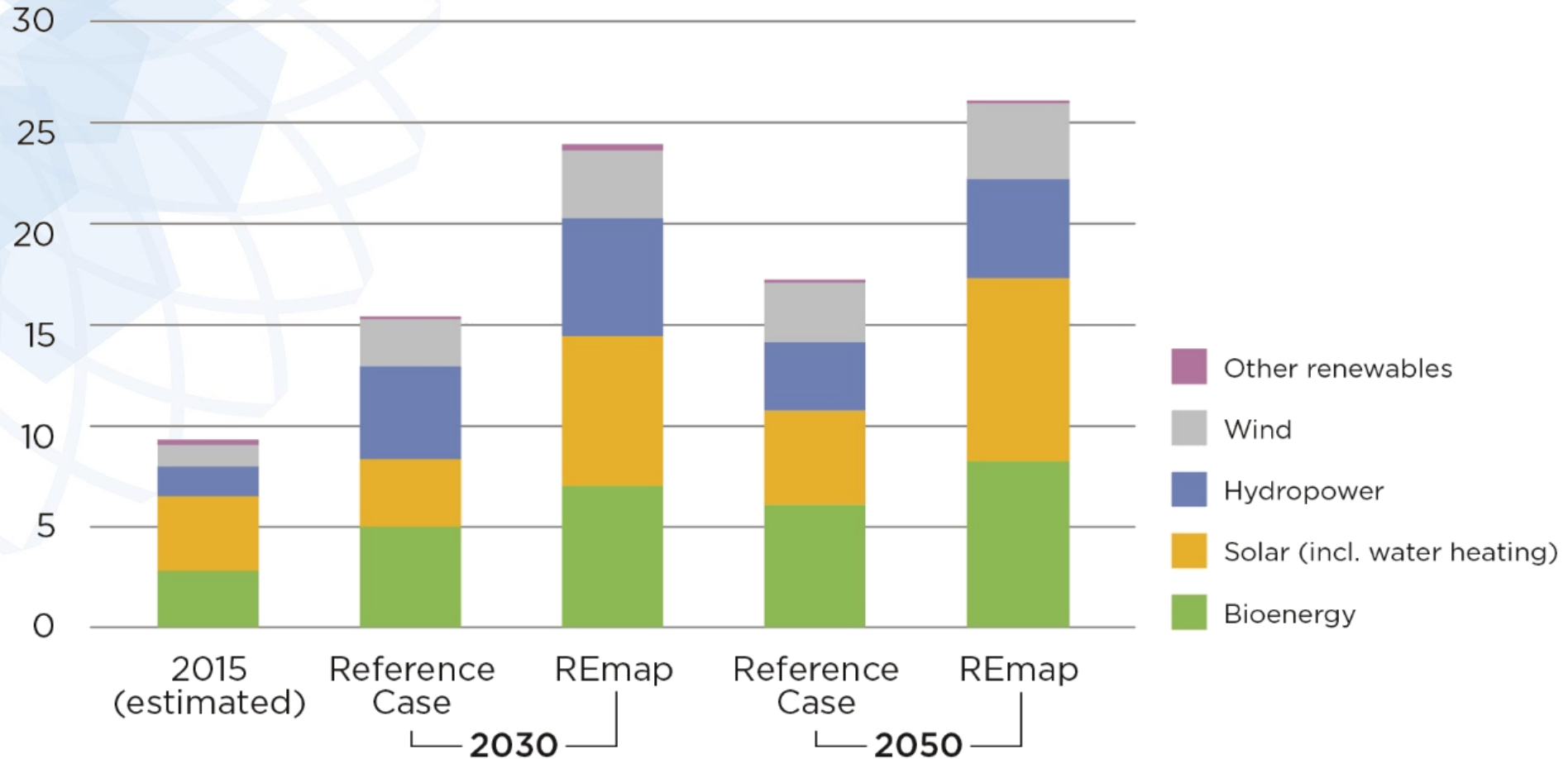
Global GDP impacts in different capital crowding out cases



In the worst-case scenario (full crowding out of capital), GDP impacts are small; otherwise (if dedicated finance is available), GDP impacts are more positive.

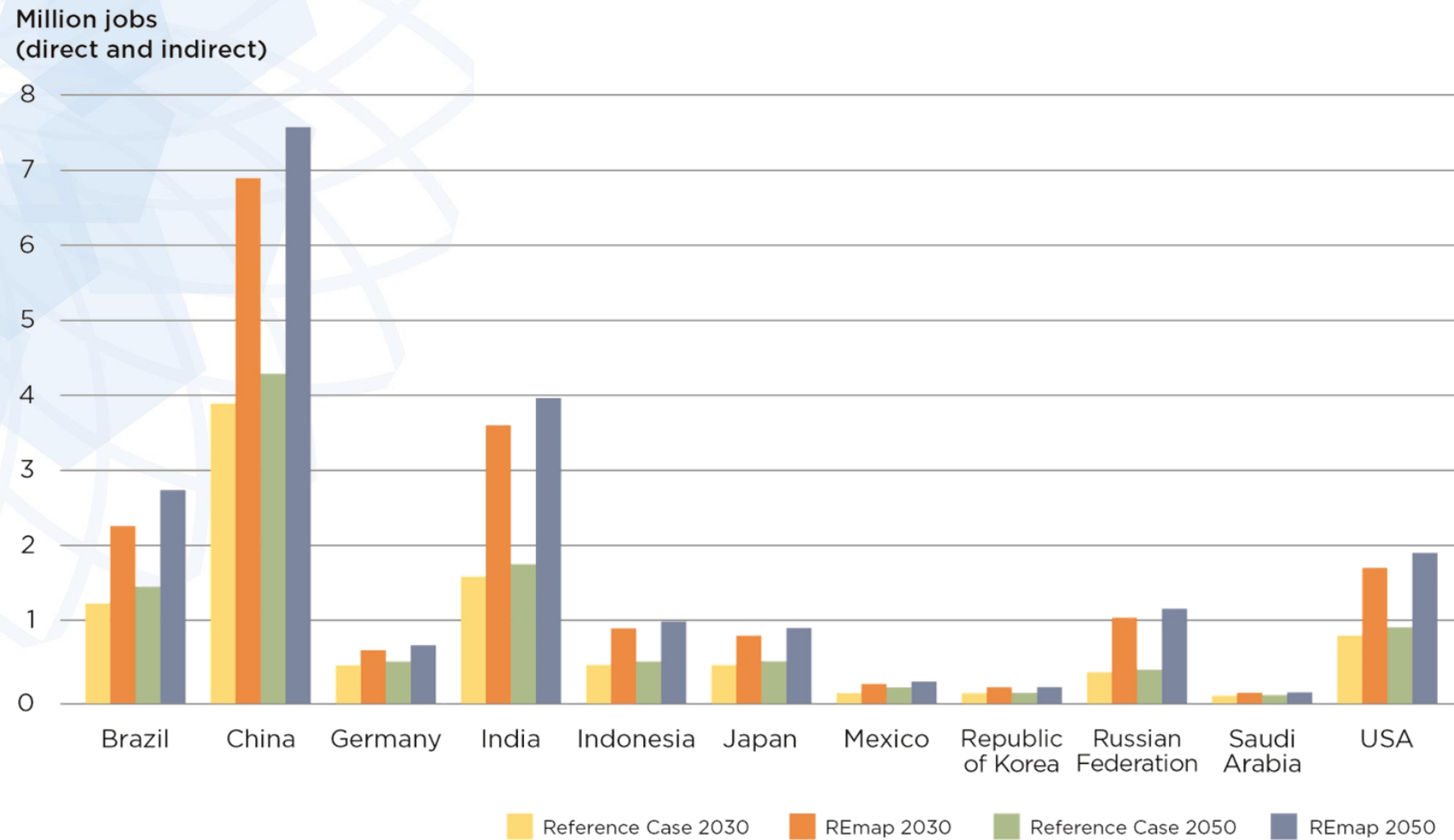
Renewable energy employment by technology

Million jobs
(direct and indirect)



Renewable energy jobs can reach around 26 million by 2050, with solar and bioenergy being the main employers.

Renewable energy jobs in the highest employing countries



The largest renewable energy employers are all G20 countries.