



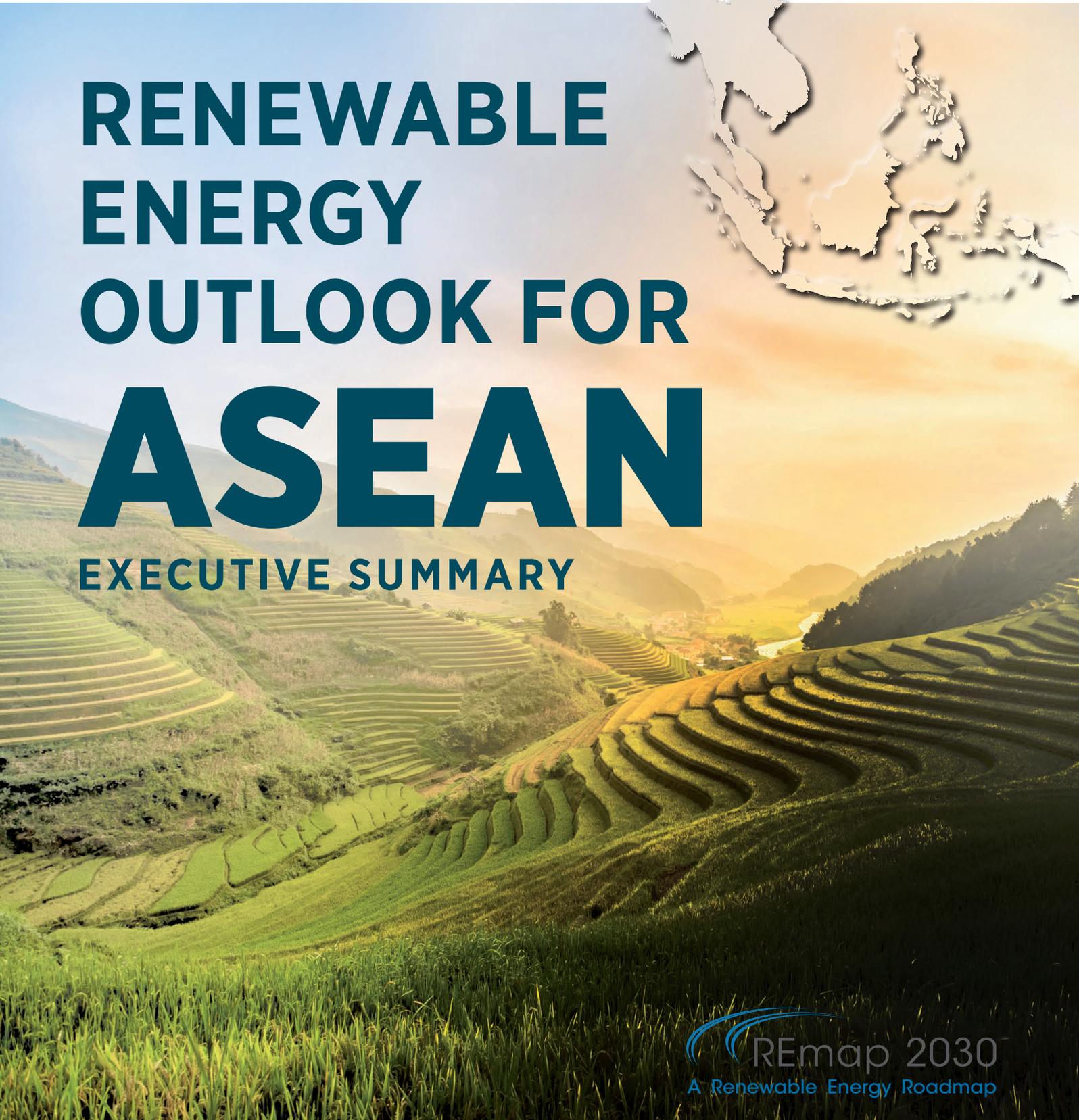
ASEAN Centre for Energy
One Community for Sustainable Energy



IRENA
International Renewable Energy Agency

RENEWABLE ENERGY OUTLOOK FOR ASEAN

EXECUTIVE SUMMARY



REmap 2030
A Renewable Energy Roadmap



A REMAP ANALYSIS

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

About ACE

Established on 1 January 1999, the ASEAN Centre for Energy (ACE) is an intergovernmental organisation that independently represents the 10 ASEAN Member States' (AMS) interests in the energy sector. The Centre serves as a catalyst for the economic growth and integration of the ASEAN region by initiating and facilitating multilateral collaborations as well as joint and collective activities on energy. It is guided by a Governing Council composed of Senior Officials on Energy from each AMS and a representative from the ASEAN Secretariat as an *ex-officio* member. Hosted by the Ministry of Energy and Mineral Resources of Indonesia, ACE's headquarter is located in Jakarta.

The Renewable Energy Support Programme for ASEAN (ASEAN-RESP) is a joint project by ACE and GIZ, on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), and it enables regional exchange on renewable energy between ASEAN Member States. IRENA and ACE are grateful to ASEAN-RESP for its financial support for the two REmap ASEAN regional workshops.

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www.irena.org/remap, and are also available at www.irena.org/publications and www.aseanenergy.org/publications

For further information or to provide feedback, please contact the IRENA REmap team at remap@irena.org and ACE team at secretariat@aseanenergy.org

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EXECUTIVE SUMMARY



A TARGET FOR A CLEAN, SUSTAINABLE AND PROSPEROUS FUTURE

The Association of Southeast Asian Nations (ASEAN) has set the aspirational target of securing 23% of its primary energy from modern, sustainable renewable sources by 2025. This objective implies a two-and-a-half-fold increase in the modern renewable energy share compared to 2014. At the same time, power generation will double by 2025, and overall energy demand will grow by almost 50%.

This target is well in line with the global thinking and ambition levels for renewables, but it will require a significant acceleration of renewable energy deployment over the coming decade. In 2014, the ASEAN region's renewables share in total primary energy supply (TPES) was 9.4%. By 2025 it is expected to increase to just under 17% if current policies and those under consideration are followed. Thus, the region must overcome a six percentage-point gap to reach its goal.

The challenge is how to implement this 23% renewable energy target. Doing so will require an understanding of what can individual countries contribute, what can different sectors contribute, and what are the costs and benefits of different technologies. This study explores the potential for

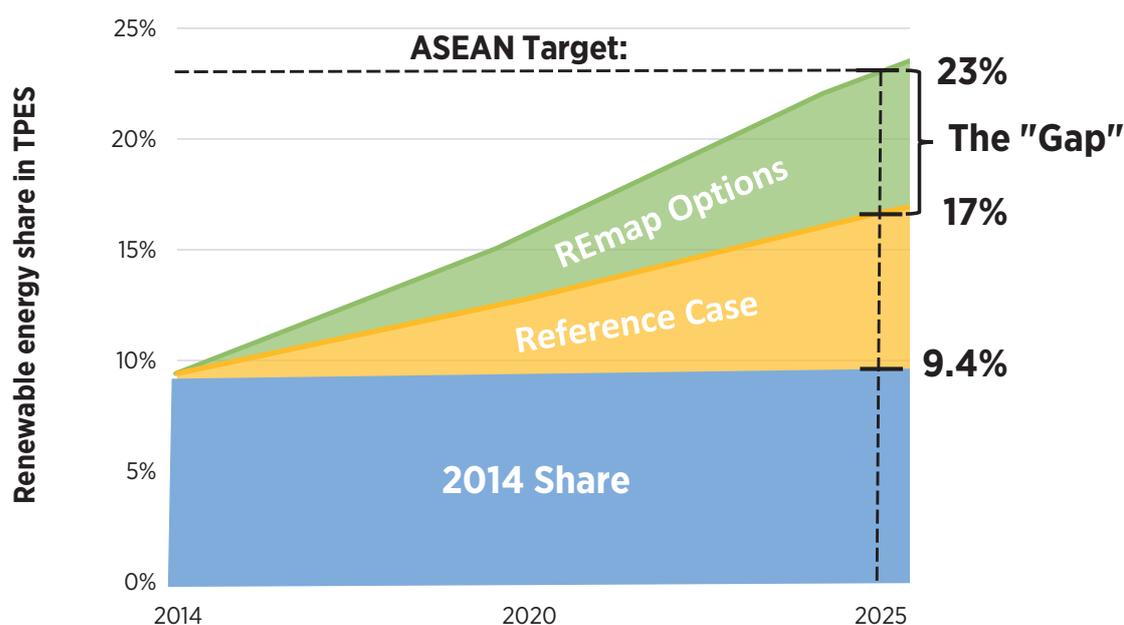
deploying renewable energy technologies across the entire energy system of ASEAN Member States. It also quantifies costs and investments, environmental benefits, and identifies key challenges to ramping up renewables in the region.

GROWING ECONOMIES, POPULATION AND ENERGY DEMAND

The population of the ASEAN region will increase from around 615 million in 2014 to 715 million by 2025. The economy will grow more than 5% per year, resulting in a rapid rise in energy demand. The region will see 4% annual growth in energy demand until 2025, amounting to a rise of 50% over 2014 levels. Electricity demand will double between 2014 and 2025.

The region has insufficient indigenous fossil fuel resources to meet its growing energy demand, and the share of imported fossil fuel will increase, which has important energy security implications.

Figure ES1: Renewable energy share in the ASEAN region in total primary energy supply to 2025



The renewable energy share will need to increase two-and-a-half fold by 2025 with a six percentage-point gap between the Reference Case and 23% target

Energy demand for electricity production will rise at the fastest pace, but fuel demand in industry and transport will also increase rapidly. According to developments likely to occur based on current or planned policies or expected market developments (known in this report as the Reference Case), most demand will be met with fossil fuels, but it also foresees significant growth in hydropower, geothermal power, and some forms of modern bioenergy for heating and cooking.

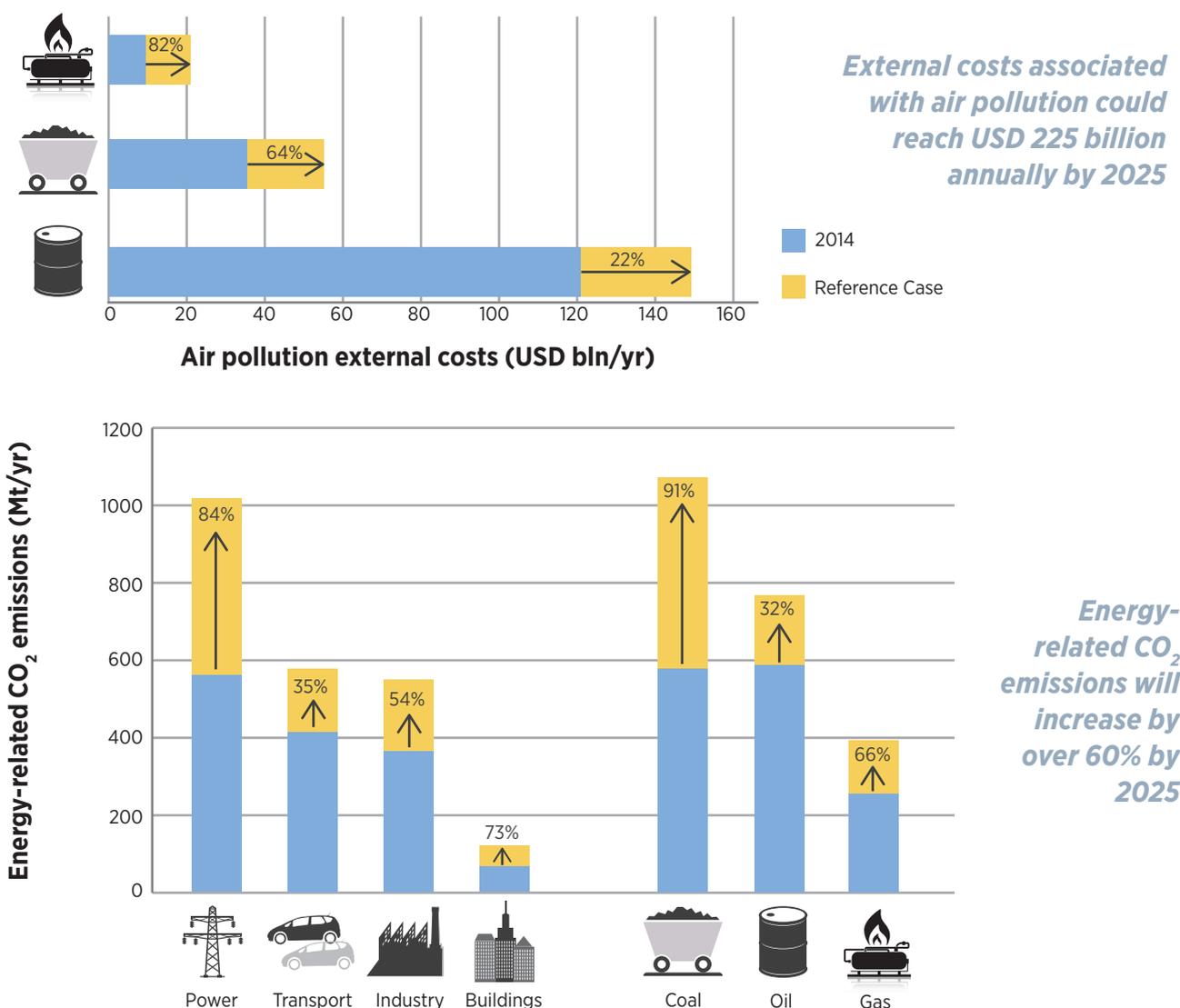
Rising fossil fuel demand will boost carbon dioxide (CO₂) emissions and exacerbate local air pollution. This has global implications. The share of global energy consumed

in the region will increase from 5.7% today to 7.5% by 2025. In the Reference Case, energy-related CO₂ emissions will increase by 61% and total energy-related CO₂ emissions will amount to over 2.2 gigatonnes (Gt) annually in 2025.

External costs related to air pollution from the combustion of fossil fuels will increase by 35%, from USD 167 billion annually in 2014 to USD 225 billion in 2025.

This would equal around 5% of the ASEAN region's gross domestic product (GDP) in 2025. Therefore, the region will see rising costs for energy supply, as well as rising costs from the negative effects of greater fossil fuel use in increasingly urban societies.

Figure ES2: Air pollution external costs (upper figure) and energy-related CO₂ emissions (lower figure) in the ASEAN region, 2014 and Reference Case in 2025



THE CASE FOR RENEWABLES

Renewable energy has emerged as the single largest source of new power capacity additions in recent years.

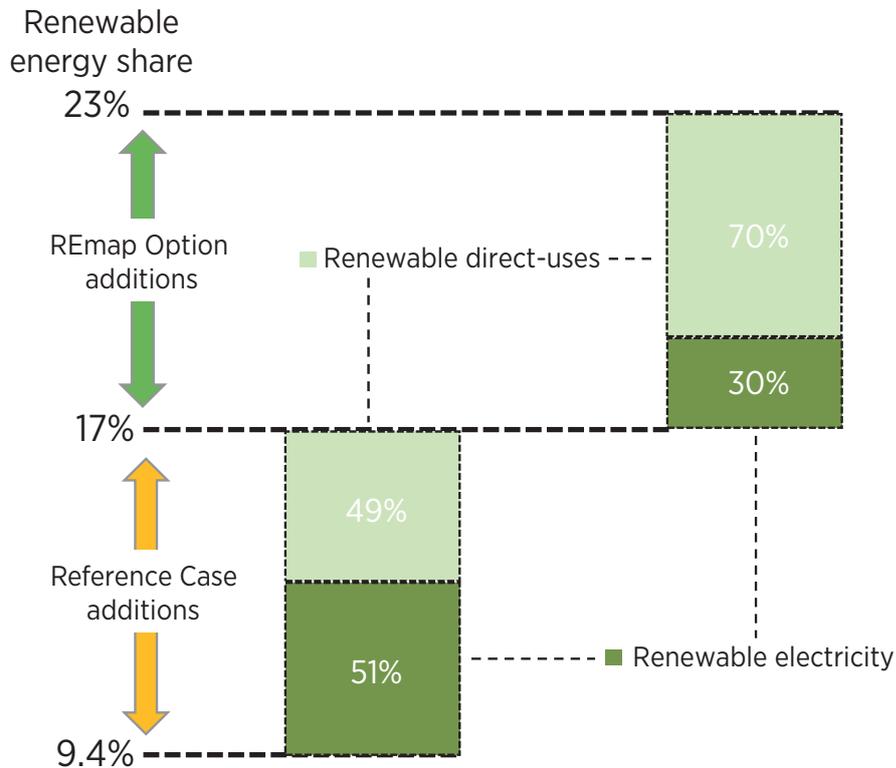
The year 2016 has seen record low prices for utility-scale solar photovoltaics (PV) and onshore wind, as low as USD 0.03 per kilowatt-hour (kWh) for the lowest-cost project proposals. More and more countries are showing how significant shares of variable renewables can be integrated into existing grids, while maintaining or even improving power reliability and quality. This shifting energy landscape also comes at an important time for the climate, with the Paris Agreement entering into force. The shared objective

to keep climate change below 2 degrees Celsius implies a global decarbonised energy system between 2050 and 2070. Renewable energy has a key role to play on the supply side to realise this objective.

ASEAN Member States can benefit from these global trends. This roadmap shows that by 2025 across most of the ASEAN region, renewable power technologies will be able to supply electricity at or below the cost of generation from non-renewable energy sources.

Additionally, the region's ample renewable energy resources can provide opportunities for the cost-effective deployment of renewable technologies for heating and cooking, with large potential for solar thermal and modern bioenergy.

Figure ES3: Renewable energy additions in the Reference Case and REmap Options, by electricity and direct-use



Renewable electricity plays an important role in increasing the region's renewable share, but much of the additional potential identified in REmap comes from direct-uses of renewables for heating, cooking and transport

THE RENEWABLE TECHNOLOGY MIX

The REmap approach covers energy supply and demand – it looks at power, heating, transport and cooking, and at all renewable sources. Given the short time horizon and ambitious ASEAN target for 2025 – which is under a decade away – this broad, multi-sector scope is the best way to find a viable pathway.

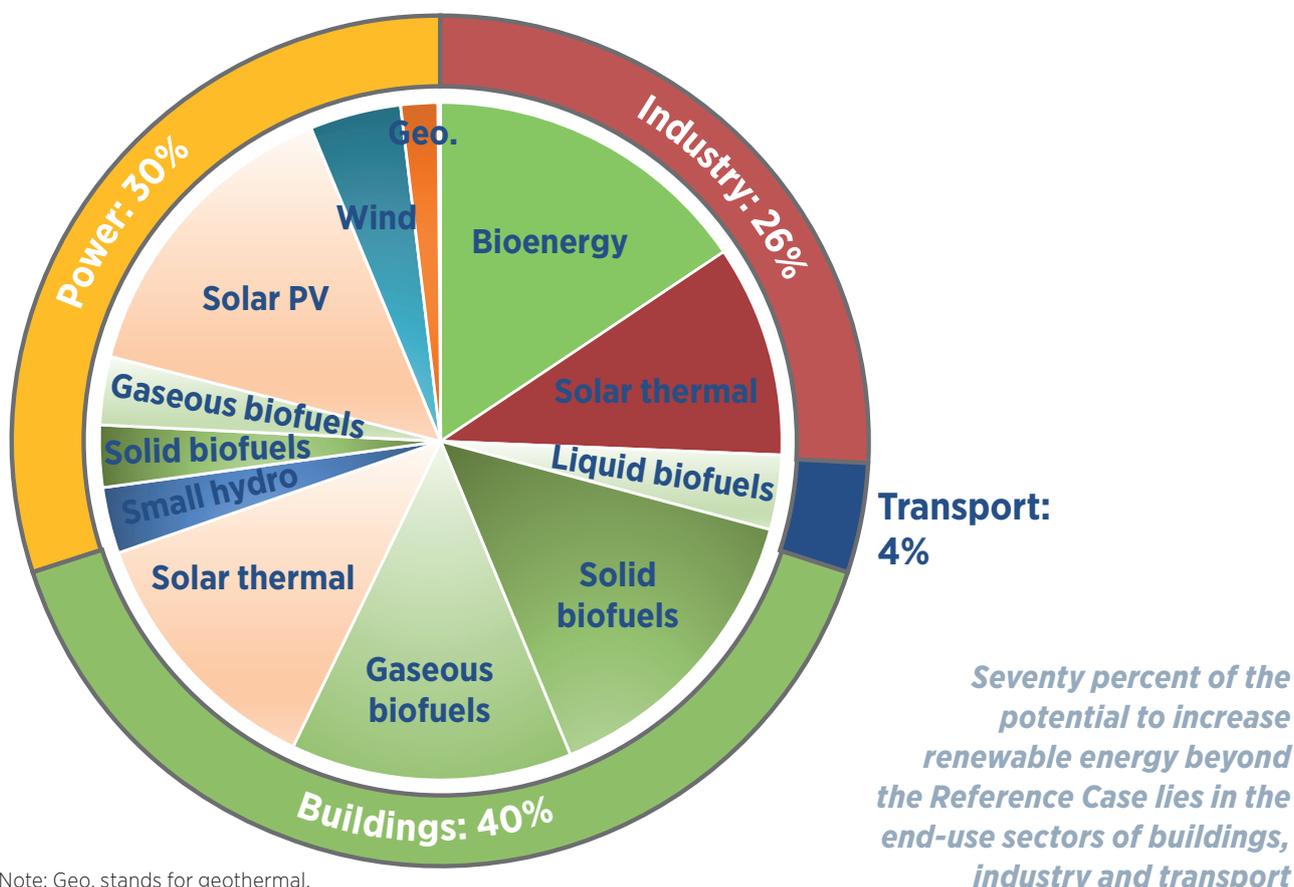
Around half of the modern renewables potential for 2025 is in the power sector. The other half is in end-use sectors, i.e. renewable fuels or direct-uses of renewables for heat, cooking, and transport. However, renewables deployment under government plans, known as the Reference Case, and the additional potential identified in REmap differ significantly.

The Reference Case sees significant increases in hydropower, and more modest growth in geothermal power, liquid biofuels, and a reduction of around one-third in the traditional uses of bioenergy.

The REmap Options, which are the additional potential of renewables on top of the Reference Case, and which close the six percentage-point gap to reach the region’s aspirational target, are made up of about one-third renewable power and about two-thirds renewables in heating, cooking and transport. Around 15% come from solar PV, with another 15% from wind, geothermal and bioenergy-based power. The remainder of the additions are made up of 25% from solar thermal, 35% from mainly biogas and modern bioenergy cookstoves in buildings (residential and commercial), as well as bioenergy used in industry and transport, and 10% from other renewable sources.

The distribution of renewable energy use varies significantly by country and sector, with renewable shares in countries ranging from 4% to 59% in REmap – a wide variation from the regional objective of 23%. The wide range can be attributed to a different resource endowment, different levels and growth rates of energy demand, and different starting points based on today’s levels. Across the ASEAN region, the power sector has the highest share,

Figure ES4: Breakdown of REmap Options by sector and renewable energy source



Note: Geo. stands for geothermal.

followed by buildings, industry and transport. Additional potential for deploying renewables on top of the Reference Case exists in all sectors, but REmap shows that the largest increase can take place in buildings and industry by 2025.

Power

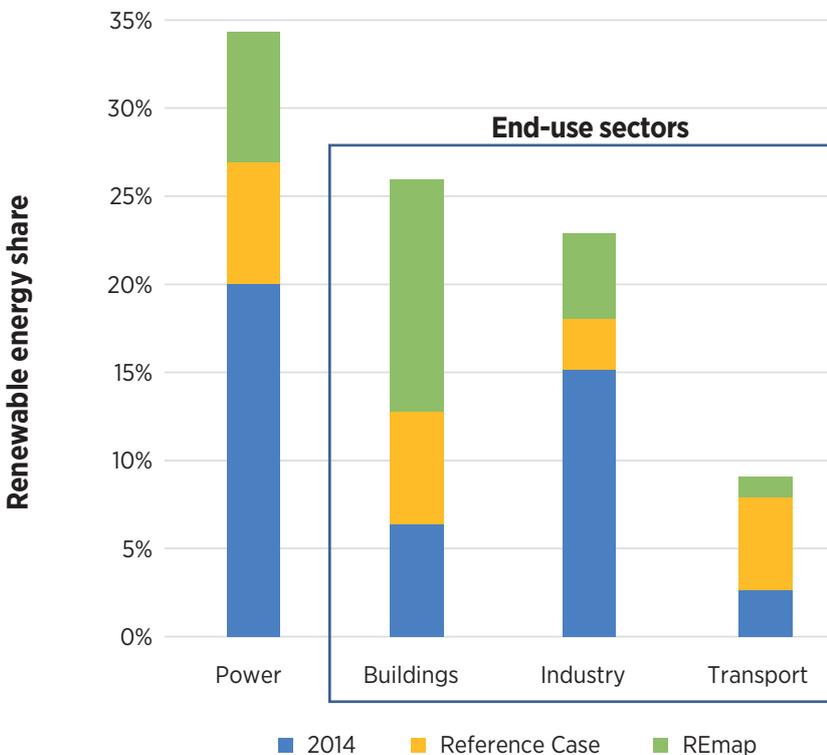
- The renewable energy share of total power generation will increase from 20% in 2014 to 27% in the Reference Case, and further to 34% in REmap by 2025. This would amount to 410 terawatt-hours (TWh) of renewable power growth from 2014 to 2025, 280 TWh of which occurs in the Reference Case and an additional 130 TWh in the REmap Options. Installed renewable capacity would increase from 51 gigawatts (GW) in 2014 to 184 GW by 2025, amounting to 43% of total power generation capacity in 2025.
- The findings indicate that additional renewable energy opportunities remain in power generation beyond what countries plan to deploy in their Reference Cases. More can be done especially with solar PV, both in distributed and in utility scale, which will increase from just 2 GW in



2014 to almost 60 GW in 2025 in REmap. Also bioenergy-based power and wind can grow faster than anticipated.

- The share of variable renewable power (VRE) across the ASEAN region will generally be low, but shares in individual countries and within individual power systems will vary. In some countries, the share of VRE in generation will exceed 10% if all REmap Options are implemented. Experience from other countries shows that such shares can be accommodated with limited grid investments and operational adjustments.

Figure ES5: Renewable energy shares in the ASEAN region by sector to 2025



The highest renewable energy share will be in power, but high shares will also be seen in buildings and industry

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



20 billion litres of total demand. The REmap Options show the significant additional potential of electric vehicles. There would be around 59 million electric two- and three-wheelers, and around 5.9 million electric four-wheel vehicles. Additionally, electrified public transport would grow rapidly within cities and for transit travel. The sector will become more electrified, with the share of transport energy coming from electricity rising from 0.2% in 2014 to 1.6% 2025. However the role of biofuels will still be evident.

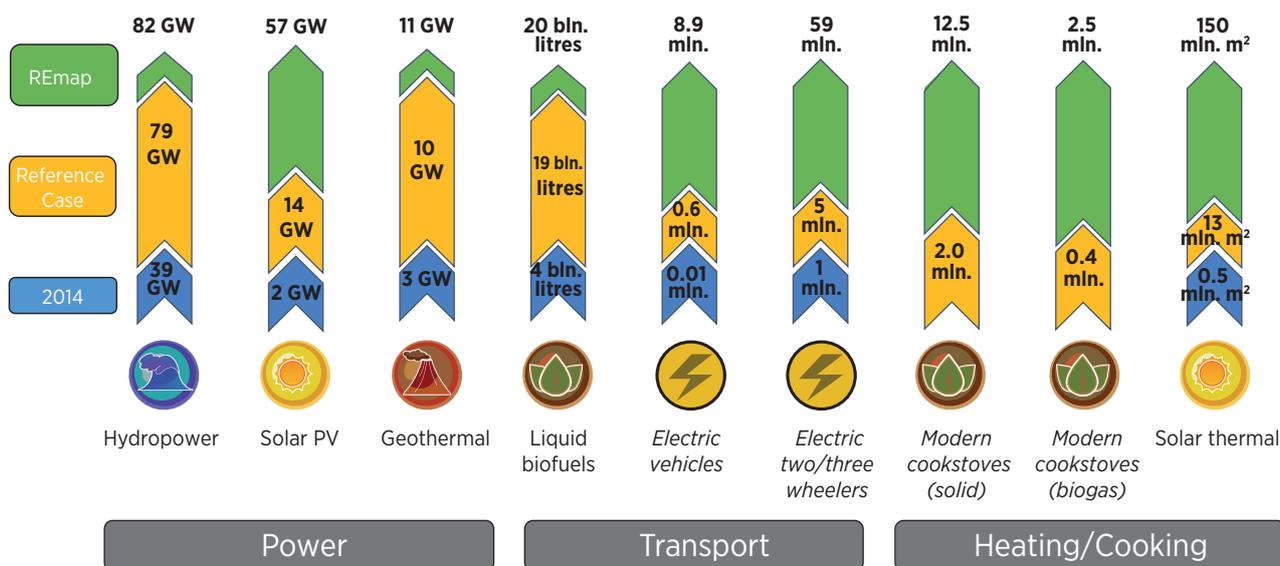
Transport

- The transport sector will see energy demand grow by 45% between 2014 and 2025. The sector has the lowest share of renewables of any sector, but some of the highest renewable growth potential. The share of renewable energy in the sector could triple from just 3% in 2014 to 9% in REmap.
- The technologies that would enable this growth include both biofuels and electric mobility. Most of the increase in the Reference Case will be from biofuels, with around

Buildings

- In buildings, the share of renewable energy from modern renewable energy sources, which excludes traditional uses of bioenergy, increases from 6% to 13% by 2025 in the Reference Case.
- In REmap, the renewable energy share is double that of the Reference Case, reaching 26%. Half of this increase is driven by greater use of modern bioenergy, such as

Figure ES6: Physical capacity growth of select renewable technologies in the Reference Case and REmap Options to 2025



Note: The numbers in figure refer to the total end value in 2014, Reference Case 2025, or REmap 2025. They do not refer to additions taking place in each case.

Hydropower, geothermal and liquid biofuels see significant growth in the Reference Case; most other technologies see the majority of growth take place in the REmap Options

in modern solid and biogas cookstoves, which replace much of traditional use of bioenergy. By 2025 there could be 12.5 million modern cookstoves, 2.5 million biogas cooking installations, and 0.4 million biofuel cookers in operation. The other large source of renewable energy is solar thermal. Total collector area would expand by around 150 million square metres, bringing the region average to 0.2 square metres per capita.

Industry

- Demand for energy will grow by more in the industry sector than in any other end-use sector, rising by more than 60% by 2025. The share of renewables will only increase marginally, by 15%-18% in the Reference Case.

- REmap shows that additional potential lies in increased use of bioenergy to provide process heat generation and in co-generation of power and heat, as well as in solar thermal for lower-temperature industrial processes. The industry sector also provides opportunities for self-generation of power, e.g. from solar PV or bioenergy. The share of renewables in the sector could increase to as much as 23% in REmap.

It is important to note that there are multiple routes through which countries can increase renewables in their energy system. More emphasis could be given to one sector over another, for instance the rapid development of renewable power generation capacity and electrification of transport, cooking and heating. Or more emphasis could be put on deploying higher levels of modern, sustainable bioenergy. Also, regional energy trade for bioenergy fuels or electricity could be expanded and result in a shifting landscape of renewable energy deployment. Therefore, there is no single “true” distribution. The REmap insights can inform a discussion about an economically viable pathway, but variations on this pathway are possible.

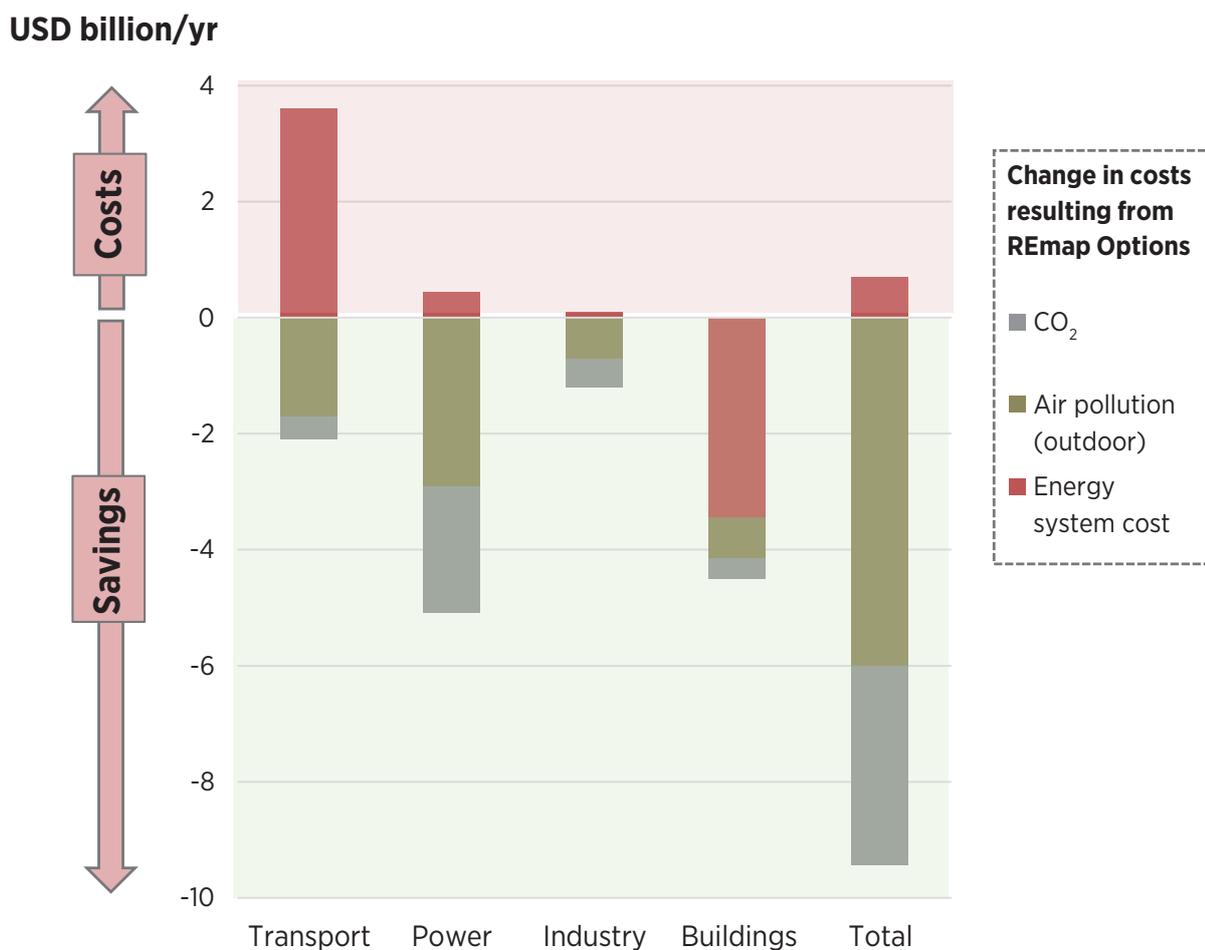


THE COSTS, BENEFITS AND INVESTMENTS NEEDED FOR RENEWABLE ENERGY

The portfolio of renewable options to increase the renewable energy share from the Reference Case level of 17% to ASEAN’s 23% target would cost only USD 1.9 per megawatt-hour (MWh) of final renewable energy in 2025 (equal to around USD 0.7 billion in incremental energy system costs, or just 0.02% of annual GDP in 2025). Of all the REmap Options identified, around 60% are cost-effective, and around 40% result in additional costs.

However, benefits significantly exceed costs if reduced externalities are considered. Reduced externalities from lower levels of outdoor air pollution and CO₂ emissions result in savings at least 10 times higher than the incremental cost of the REmap Options. If indoor air pollution is included, savings increase significantly, to as much as 50 times more than costs. These savings are equal to between 0.2% and 1.0% of ASEAN’s GDP in 2025, depending on whether indoor

Figure ES7: Costs and savings of REmap Options in 2025



Note: Assumes low-end estimates for externalities for outdoor air pollution and CO₂, indoor air pollution excluded from figure.

Reduced externalities resulting from higher deployment of renewables can amount to between 0.2-1.0% of GDP – at a minimum at least 10 times higher than costs

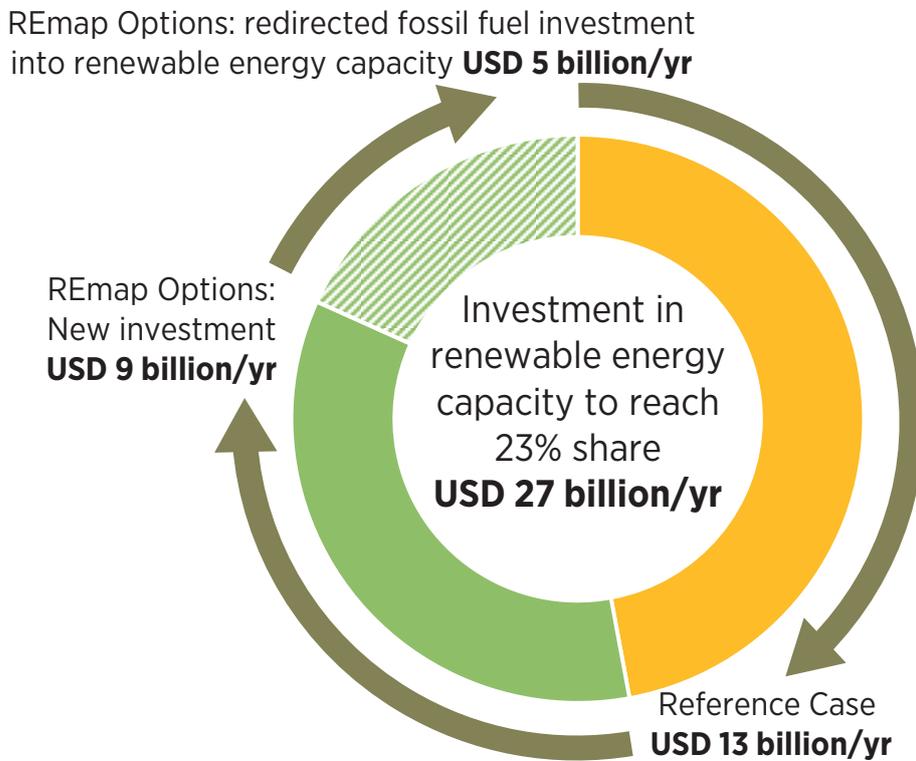
air pollution is considered (included in the higher level). These assessments are also only based on the low-end calculations for external cost reductions. If the high end is assumed, savings as a share of GDP could be over 2.0%. The power sector plays the key role in realising these reductions, as do the savings from air pollution and CO₂ emission reductions. The transport sector is also an important source of savings, resulting from lower levels of air pollution in cities.

CO₂ emissions from energy will rise by 61% in the Reference Case. The REmap Options and closing the gap to ASEAN’s renewable energy target will limit this rise to 47%. Additionally, the energy intensity of the region’s economy will decline by around 30% by 2025 in REmap over 2005 levels, broadly in line with the region’s targets for energy intensity improvement.

The ASEAN region will need to invest USD 27 billion annually, a total of USD 290 billion by 2025, in renewable energy capacity in order to meet the 23% renewable energy goal. Just under half of this will be investment that takes place in the Reference Case, and the remainder will come from the REmap Options. To close the gap, an additional USD 14 billion annually will be required on top of existing government plans. Of this, USD 5 billion annually can be redirected from investments in fossil fuels, but additional mobilisation of USD 9 billion annually will be needed.

The power sector will account for 75% of the average annual investment need of USD 27 billion. USD 7.5 billion per year will need to be invested in solar PV, and USD 6.3 billion in hydropower. The building and industry sectors will require around USD 7 billion annually in investment, focused largely on bioenergy and solar thermal.

Figure ES8: Annual investment needs in renewable energy capacity between 2014 and 2025 in the ASEAN region for Reference Case and REmap Options



The region will need to invest USD 290 billion in renewable energy capacity over the next decade

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



The full report *Renewable Energy Outlook for ASEAN* provides in-depth findings on technology and country-level deployment potential for renewables. It also sheds some insights into the main drivers, costs and benefits, and investments needs for renewable energy. Please visit www.irena.org/remap to download the report.



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