GLOBAL ENERGY TRANSFORMATION

A ROADMAP TO 2050
About IRENA

Established in 2011.

160 Members; 23 States in accession.

Mandate: to promote the widespread adoption and sustainable use of all forms of renewable energy

Scope: All renewable energy sources produced in a sustainable manner

IRENA serves as:

• Centre of excellence for knowledge and innovation
• Global voice of renewables
• Network hub
• Source of advice and support
Drivers for the energy transition: the role of renewable

- Local pollution, per capita emissions, floods
- Economy diversification: GDP dependence from oil&gas industry

- Competitiveness, decreasing costs of renewables, fostering green growth
- Income and quality - jobs

ENERGY TRANSFORMATION by 2050

- REDUCED EXTERNALITIES & ECONOMIC GAIN
  for every $1 spent there would be a payoff between 3$-7$

- IMPROVEMENTS IN ENERGY SECURITY
  -64% demand of fossil fuels

- REDUCTION OF CARBON EMISSIONS
  70% emissions reductions

- FALLING COSTS OF RENEWABLES
  Renewables fully competitive

- JOB CREATION
  7 million additional jobs

- FULL ENERGY ACCESS
  100% energy access

- Drivers for the energy transition:
  • Local pollution, per capita emissions, floods
  • Economy diversification: GDP dependence from oil&gas industry
What’s happening now?

• Limited energy transition progress during the past decades

• GHG emissions continue to rise while 1.5 degrees becomes more pertinent

• Global energy transition needed in the coming 30 years – much faster than before

• Disagreement on how such a transition can be achieved and what it should look like
  • 2 degrees or 1.5 degrees, and their Gt CO₂ pathway implications

• Complex questions:
  • CCS/CCUS uses and costs, Nuclear costs, “clean” coal, LNG and fuel switching
  • Solar PV and wind are cheap, now what?
  • Role of hydrogen and PtX: potentially very important but uncertain; electrification and batteries; biofuels

• Specific sectors with particular challenges: Aviation, shipping, petrochemicals, cement, etc.

• Energy transition will have a profound impact on fossil fuel supply and demand
Monitoring the energy transition, mixed indicators

Current plans – as reflected in Nationally Determined Contributions to meet climate goals – point in the right direction yet still fall short of what is needed to meet international climate goals. Serious action is needed to accelerate the energy transition.
IRENA’s energy transition series

• One of IRENA’s flagship publications.

• Third edition launched at the Berlin Energy Transition Dialogue 2019.

• Joint report of IRENA’s Renewable energy roadmaps (REmap) programme of Innovation and Technology Centre (IITC) and socio-economic footprint of Knowledge, Policy and Finance Centre (KPFC).

• However main focus of REmap efforts are renewable energy and energy transition roadmaps for regions and countries, currently completed/ongoing roadmaps for 15 countries, 5 regions
PATHWAY FOR THE TRANSFORMATION
The global carbon budget is set to run out by 2030 based on current and planned policies.

Energy-related emissions would need to fall by 3.5% per year to the world to meet the Paris Agreement.
Recent trends vs. Reference Case vs. REmap

- Annual energy-related CO2 emissions could range from **10 Gt to over 50 Gt by 2050**
Key enabling solutions: Renewables and energy efficiency, boosted by substantial electrification

- Annual energy-related CO₂ emissions under current and planned policies – the Reference Case – are expected to remain flat but must be reduced by 70% to bring temperature rise to the well-below 2°C climate goal.

- Electrification, renewable energy and energy efficiency measures provide over 90% of the reductions required by 2050. Renewable power and electrification of heat and transport alone reduce emissions by 75%.

Note: “Renewables” implies deployment of renewable technologies in the power sector (wind, solar PV, etc.) and end-use direct applications (solar thermal, geothermal, biomass). “Energy efficiency” contains efficiency measures deployed in end-use applications in industry, buildings and transport sectors (e.g., improving insulation of buildings or installing more efficient appliances and equipment). “Electrification” denotes electrification of heat and transport applications, such as deploying heat pumps and EVs.
Renewable energy shares increase in all end-use sectors

- By 2050, renewables could dominate the transport and buildings sectors reaching 57% and 81% of the sectors’ final energy consumption.

- Electricity would account for the largest share of renewable energy use, complemented by biomass, geothermal and solar thermal.
Renewable Energy: Recent cost evolution

- Average LCOE of all renewable power generation technologies, except CSP fall in fossil fuel cost range
- Bioenergy, geothermal, hydro and onshore wind all at lower end of fossil cost range
- Solar PV rapidly falling towards lower end.
- Offshore wind and CSP have much lower deployment. Data suggests costs will continue to fall.
Electrification paired with renewables is a major solution for decarbonisation

By 2050:

- Electricity becomes the central energy carrier
- 86% of electricity generation will come from renewables

A transformed energy system: Scaling up renewables not just for power, but also for heat and transport
Scaling up electricity from renewables will be crucial for the decarbonisation of the world’s energy system.
A transformed energy system: Renewables growth must increase six-fold

- The share of renewables in the world's total final energy consumption has to increase six times faster to meet agreed climate goals.

Note: DH refers to district heat and ppt refers to percentage points per year.
A transformed energy system: Energy intensity improvement needs to increase by a third, to 3.2% per year

- Energy intensity can be improved by:
  - Scaling up solar, wind and other renewables,
  - Improving energy efficiency,
  - Electrifying transport and heat,
  - Structural change in transport and industry.
## Tracking progress to achieve the global energy transformation

### TOTAL FOSSIL FUEL DEMAND

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>TODAY</th>
<th>REMAP CASE</th>
<th>ON/OFF TRACK</th>
<th>IMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil demand</td>
<td>87 bbl/day</td>
<td>95 bbl/day</td>
<td>60 bbl/day</td>
<td>41 bbl/day</td>
<td>22 bbl/day</td>
</tr>
<tr>
<td>Natural gas demand</td>
<td>3307 bcm/yr</td>
<td>3752 bcm/yr</td>
<td>4000 bcm/yr</td>
<td>3400 bcm/yr</td>
<td>2250 bcm/yr</td>
</tr>
<tr>
<td>Coal demand</td>
<td>4963 Mte/yr</td>
<td>5357 Mte/yr</td>
<td>3190 Mte/yr</td>
<td>2000 Mte/yr</td>
<td>713 Mte/yr</td>
</tr>
<tr>
<td>Total fossil fuel reduction relative to today</td>
<td>-20%</td>
<td>-41%</td>
<td>-64%</td>
<td>Off track</td>
<td>End subsidies for fossil fuels. Support training programmes to retrain displaced workers from fossil fuel industries.</td>
</tr>
</tbody>
</table>

### ENERGY-RELATED CO₂ EMISSIONS

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>TOTAL CO₂ reduction relative to today</th>
<th>Emissions per capita</th>
<th>Hydrogen production with renewable electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-27%</td>
<td>4.3 t CO₂ per cap</td>
<td>3 EJ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-48%</td>
<td>4.6 t CO₂ per cap</td>
<td>8 EJ</td>
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<tr>
<td></td>
<td></td>
<td>-71%</td>
<td>2.9 t CO₂ per cap</td>
<td>10 EJ</td>
</tr>
</tbody>
</table>

Notes: 1) TFEC – total final energy consumption; 2) Utility and distributed solar PV total additions (new as well as repowering); 3) Onshore and offshore wind total additions (new as well as repowering); 4) Passenger cars exclude 2/3 wheelers, buses and other electric mobility transport modes; 5) Heat pump estimates based on available data.
The REmap Case increases investments in the global energy system by USD 15 trillion, and shifts investment into electrification, renewable energy and energy efficiency technologies, which together, would make up four-fifths of the cumulative energy sector investments over the period to 2050.
Investments are widespread around the world.

The **renewables share in the energy mix will need to increase in all regions up to 2050.** Sub-Saharan Africa (89%), Oceania (85%), South-East Asia (75%) and Latin-America (73%) and Europe (71%) will see the highest share. East Asia and North America will, however, require almost 50% of the total energy investment over the period in the REmap Case due to increasing energy demand.
• For every dollar spent for the energy transition, the payoff amounts to at least three dollars and, depending on how externalities are valued, up to seven dollars.

• As renewables rise, net energy subsidies fall, as do health costs from air pollution and climate impacts. Half of the USD 21 trillion in additional expenditures, including investment and operational costs, could be covered by the savings on avoided subsidies.
Decline global demand for fossil fuels

With accelerated uptake of renewables, both oil and coal demand decline significantly and continuously, with natural gas demand peaking around 2025. Natural gas would be the largest source of fossil fuel in 2050.
If Paris Agreement aims are met, the resulting stranded assets would amount to **almost USD 12 trillion by 2050.** This equals about one-third of additional investment needs or around 3% of today’s global capital stock. **Delaying action, however, would increase those losses to as much as USD 20 trillion.**
Stranded assets estimates and definitions in different scenarios vary significantly because definitions vary

IRENA definition: Remaining book value of assets substituted or abandoned before the end of their anticipated technical lifetime and without recovery of any remaining value to stay within the carbon budget limit

Stranded assets in different climate scenarios

<table>
<thead>
<tr>
<th>Source</th>
<th>Stranded Oil (USD 50/bbl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEA - 2DS</td>
<td>0</td>
</tr>
<tr>
<td>IRENA: Remap</td>
<td>1300 bln bbl</td>
</tr>
<tr>
<td>IRENA: Delayed policy action</td>
<td>USD 50/bbl</td>
</tr>
<tr>
<td>Climate Disclosure Standards Board</td>
<td>USD 50/bbl</td>
</tr>
<tr>
<td>Carbon Tracker</td>
<td>1300 bln bbl</td>
</tr>
</tbody>
</table>

IRENA definition: Remaining book value of assets substituted or abandoned before the end of their anticipated technical lifetime and without recovery of any remaining value to stay within the carbon budget limit.
There is a correlation between renewable energy share and energy demand

- Scenarios with higher renewable energy shares also have higher energy efficiency, resulting in lower overall energy demand and emissions.
The socio-economic footprint of the energy transition

- Both the energy and socio-economic systems will evolve during the transition, with multiple feedback loops between them.
- IRENA uses an integrated Energy-Economy-Environment model to evaluate the socio-economic footprint that results from the interactions among different combinations of the energy transition roadmap and the socio-economic outlook.
The energy transformation boosts global GDP

- To gain insight about the structural elements underpinning the evolution of GDP as a consequence of the interactions between the energy transition and the socio-economic system, the macroeconomic modelling undertaken by IRENA disaggregates the evolution of GDP into four main drivers: Trade, consumer expenditure due to tax rate changes, consumer expenditure due to indirect and induced effects and investment.
Global employment increases by 0.2% (7 million jobs).

To gain insight about the structural elements underpinning the evolution of Employment as a consequence of the interactions between the energy transition and the socio-economic system, the macroeconomic modelling undertaken by IRENA disaggregates the evolution of Employment into three main drivers: Trade, consumer expenditure (including tax rates and indirect and induced effects) and investment.
Sector views
The rising importance of solar and wind energy in the power sector

- Gross power generation would almost double, with 86% coming from renewables.
Power sector key indicators infographic

**Power**

**RENEWABLE ENERGY AND ELECTRIFICATION SHARES**

- Renewable share in the total electricity generation: 24% (2016) → 86% (REmap Case 2050)

- Electricity demand: 24330 TWh/yr (2016) → 55188 TWh/yr (REmap Case 2050)

**INSTALLED POWER GENERATION CAPACITY**

- **Hydropower**
  - Total: 1287 GW (2016) → 2147 GW (REmap Case 2050)
    - Of which pumped hydro: 155 GW (2016) → 325 GW (REmap Case 2050)

- **Wind**
  - Onshore: 474 GW (2016) → 6044 GW (REmap Case 2050)
    - Offshore: 459 GW (2016) → 5044 GW (REmap Case 2050)

- **Solar**
  - PV: 297 GW (2016) → 8519 GW (REmap Case 2050)
  - CSP: 5 GW (2016) → 309 GW (REmap Case 2050)

- **Bioenergy**
  - Heat: 100 GW (2016) → 685 GW (REmap Case 2050)

- **Geothermal**
  - Others (incl. marine, hybrid): <1 GW (2016) → 511 GW (REmap Case 2050)

**HYDROPOWER**

**WIND**

**SOLAR**

**BIOENERGY**

**GEOTHERMAL**

**OTHERS**

**ENERGY-RELATED CO₂ EMISSIONS**

- Energy related CO₂ emissions: 11.3 Gt CO₂/yr

- Avoided CO₂ emissions in 2050 compared to Reference Case: 8.2 Gt CO₂/yr

**INVESTMENT**

- Total investments for the period 2016-2050:
  - Power generation (fossil): 4 USD trillion
  - Power generation (renewable): 22 USD trillion
  - Power system flexibility and grids: 13 USD trillion

**STRANDED ASSETS**

- Total stranded assets between 2016-2050:
  - Delayed Policy Action: 1.4 USD trillion
  - REmap Case 2050: 0.7 USD trillion
Actions needed now - Power

ACCELERATE RENEWABLES CAPACITY ADDITIONS:
- Identify and map renewable energy resources and develop a portfolio of financeable projects.
- Construct no new coal power plants and plan and implement the phase-out of coal capacities approaching end of its lifetime.

PLAN FOR THE POWER SECTOR TO ACCOMMODATE INCREASING SHARES OF VARIABLE RENEWABLE ENERGY:
- Prioritize to improve flexibility of power system (with flexible supply, storage, demand response, power-to-X, electric vehicles, digital and information and communication technologies, etc.). Update grid codes.
- Deploy microgrids to improve resilience of the grid and energy access rate with renewable sources. Deploy super grids to strengthen the interconnections among countries within a region.
- Deploy cost-reflective tariff structures by properly readjusting the balance between volumetric charges (USD/kWh), fixed charges (e.g., USD/meter-month) and, where applicable, demand charges (USD/kW).

SUPPORT THE DEPLOYMENT OF DISTRIBUTED ENERGY RESOURCES:
- Incentivise energy consumers to become prosumers.
- Support regulatory and pricing policies including the right to generate and sell electricity, tariff regulation and grid-arrival policies.
- Enable energy aggregators to foster the deployment of distributed energy resources.
The increasing use of renewable electricity in buildings

- Renewable electricity would reach a 58% share in the buildings sector by 2050.
- Together with modern biomass, solar thermal and district heating, overall renewables could ramp up to 81%, from 36% today.
Buildings sector key indicators infographic

**RENEWABLE ENERGY AND ELECTRIFICATION**

- **Renewable share in final energy use in buildings**
  - 2016: 36%
  - REmap Case 2050: 81%

- **Electricity share in final energy use in buildings**
  - 2016: 31%
  - REmap Case 2050: 68%

**ENERGY RELATED CO₂ EMISSIONS**

- 2.9 Gt CO₂/yr
- 0.4 Gt CO₂/yr
- Avoided CO₂ emissions in 2050 compared to Reference Case: 2.2 Gt CO₂/yr

**INVESTMENT**

- Total investments for decarbonisation over the period 2016-2050: 32 USD trillion
- REmap Case 2050: 32 USD trillion

**STRANDED ASSETS**

- Total stranded assets between 2016 and 2050: 10.9 USD trillion
- Delayed Policy Action: 10.9 USD trillion
- REmap Case 2050: 7.5 USD trillion
Actions needed now - Buildings

REDUCE ENERGY CONSUMPTION IN BUILDINGS:
- Establish and improve energy efficiency building codes and standards (incl. appliances (eg. air conditioners), lighting (eg. LED lights) and equipment (eg. efficient boilers)).
- Adopt programmes for retrofitting/renovation including financing schemes.
- Align renewable heat and energy efficiency policies to leverage synergies and to accelerate the pace of energy efficiency improvements.

SUPPORT AND FOSTER THE DEPLOYMENT OF DISTRIBUTED ENERGY RESOURCES:
- Remove regulatory barriers for prosumers that restrict them from taking an active role in the energy system transformation. Capitalise on smart-homes and digitalisation to allow demand management.
- Promote community ownership models and innovative financing schemes.
- Accelerate rollout of smart meters.

SCALE UP RENEWABLE SHARE UPTAKE IN THE BUILDINGS SECTOR:
- Promote low-carbon heating technologies: heat pumps, solar heating, modern bioenergy for heating). Apply these renewable technologies for district heating.
- Establish a long term strategy for heat decarbonisation.
- Incentivise renewable based cooling solutions.
- Phase out traditional biomass as cooking fuel and replace with clean and efficient cookstoves (biogas, modern solid biomass and electricity).
Increasing electrification in the transport sector

- Renewable electricity use could increase significantly in the transport sector by 2050, providing 37% of total transport energy consumption and, due to higher efficiency, covering 60% of the overall transport activity.
Transport sector key indicators infographic

**RENEWABLE ENERGY AND ELECTRIFICATION**

- **Renewable share in final energy use in transport**: 3% (2016) vs. 56% (REmap Case 2050)
- **Electricity share in final energy use in transport**: 1% (2016) vs. 43% (REmap Case 2050)

**ELECTRIFICATION**

- **Electric passenger cars**: 1.2 million units (2016) vs. 1,109 million units (REmap Case 2050)
- **Electric buses and light duty vehicles**: 0.02 million units (2016) vs. 58 million units (REmap Case 2050)
- **Electric 2/3 wheelers**: 200 million units (2016) vs. 2,402 million units (REmap Case 2050)
- **Battery Storage available to grid from EVs**: 0.5 GWh (2016) vs. 14,065 GWh (REmap Case 2050)

**BIOFUELS**

- **Ethanol**: 94 billion litres (2016) vs. 366 billion litres
- **Biodiesel**: 35 billion litres (2016) vs. 180 billion litres
- **Aviation biofuel**: 0 billion litres (2016) vs. 105 billion litres
- **Biomethane**: 0.4 billion m³ (2016) vs. 13 billion m³

**ENERGY RELATED CO₂ EMISSIONS**

- **8.5 Gt CO₂/yr** (2016) vs. **2.4 Gt CO₂/yr** (REmap Case 2050)

**INVESTMENT**

- **Total investments for decarbonisation over the period 2016-2050**: 14 USD trillion

1 Considering 10% grid connected Electric passenger cars and 25% grid connected Electric 2/3 wheelers by 2050
**Actions needed now - Transport**

**REDUCE THE ENERGY NEED FOR TRANSPORT:**
- Deploy advanced digital communication technologies to reduce the transport needs (e.g., teleconferencing over traveling) and to improve efficiency of transport by better utilizing the assets (e.g., re-routing due to traffic).
- Promote mobility services: Promote vehicle sharing and autonomous driving.
- Accelerate modal shift from passenger cars to public transport (electric railways or trams or electric buses).

**ACCELERATE THE UPTAKE OF ELECTRIC MOBILITY:**
- Establish minimum standards for vehicle emissions. Give the priority for electric vehicles for city access.
- Incentivise charging infrastructure rollout.
- Strengthen link between the power and transport sectors for integrated planning and policy designs (vehicle-to-grid services).
- Deploy low-emissions city trucks.

**FOSTER BIOFUELS IN ROAD, AVIATION AND SHIPPING:**
- Eliminate fossil fuel subsidies and implement carbon pricing to increase the competitiveness of renewable fuels in the shipping and aviation.
- Adopt supporting policies to scale up sustainable production of first- and second-generation biofuels. Introduce specific mandates for advanced biofuels and put in place direct financial incentives along with financial de-risking measures.
• By 2050 the share of renewables in the industrial sector needs to grow by more than 5 times. Renewable electrification would make up around 1/3 of the sector’s energy demand, followed by biomass providing 1/5.
Industry sector key indicators infographic

**RENEWABLE ENERGY AND ELECTRIFICATION**

- Renewable share in final energy use in sector consumption:
  - 2016: 12%
  - REmap Case 2050: 62%

- Electricity share in the total sector consumption:
  - 2016: 25%
  - REmap Case 2050: 42%

**RENEWABLE ENERGY AND ELECTRIFICATION INDICATORS**

- **Biomass**
  - Biomass heat (incl. CHP): 8 EJ/yr
  - Biomass feedstock: 0.8 EJ/yr
- **SOLAR THERMAL**
  - Concentrated solar thermal: 0.1 GWh
  - Solar thermal collector area: 1 million m²
- **GEOTHERMAL**
  - Heat: 0.02 EJ/yr
- **HEAT PUMPS**
  - Heat pumps: 0.2 million units

**ENERGY RELATED CO₂ EMISSIONS**

- Energy related CO₂ emissions: 7.6 Gt CO₂/yr
- Process emissions (including CCS): 2.9 Gt CO₂/yr
- Avoided CO₂ emissions in 2050 compared to Reference Case: 3.2 Gt CO₂/yr

**INVESTMENT**

- Total investments for decarbonisation over the period 2016-2050: 6.08 USD trillion
- REmap Case 2050: 0.72 USD trillion

**STRANDED ASSETS**

- Total stranded assets between 2016 and 2050:
  - Delayed Policy Action: 0.36 USD trillion
  - REmap Case 2050: 0.36 USD trillion
**Actions needed now - Industry**

**REDUCE ENERGY CONSUMPTION IN INDUSTRIES:**
- Promote actions towards circular economy (material recycling, waste management, improvements in materials efficiency and structural changes such as reusing and recycling).
- Incentivise and adopt best available technologies (BAT) and efficiency standards.

**ENABLE CORPORATE SOURCING OF RENEWABLES:**
- Support a credible and transparent system for certification and tracking of renewable energy attributes.
- Consider an energy market structure that allows for direct trade between companies of all sizes and renewable energy developers – such as through PPAs.
- Work with utilities or electric suppliers to provide green corporate procurement options.
- Empower companies to engage in direct investment for self-generation.

**ACCELERATE THE DEPLOYMENT OF LOW-CARBON TECHNOLOGIES IN INDUSTRIAL PROCESS HEATING:**
- Remove existing barriers and incentivise low-carbon heating technologies deployment: Solar thermal heating/modern bioenergy and heat pumps.
- Support emerging technologies in biomass and hydrogen. Use renewable-produced hydrogen to replace fossil fuel-based feedstocks and process heat (e.g., iron and steel sub-sectors, ammonia production).
- Implement appropriate carbon pricing in line with the real costs of the externalities and the elimination of existing subsidies for carbon-intensive fuels (where those still exist).

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**Final energy consumption (EJ/yr)**

- **INDUSTRY**
  - 14% Renewables (incl. electricity)
  - 63% Renewables (incl. electricity)

**RE-Electrification:**
- Heat pumps
- Hydrogen for industrial heat and process.
- Direct use of electricity for industrial heating processes.
- Distributed Solar PV and small scale wind.

**Renewables (direct-uses):**
- Solar heating
- Biomass for process heat
- Biomass feedstocks

**Energy efficiency:**
- Improvements in process
- Re-use and recycling
- Improvements in materials efficiency
- Efficient motors

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**REmap Case 2050**
Conclusion
Key actions needed

- The power sector needs to be transformed to accommodate growing shares of variable renewables.

- Accelerating the electrification of the transport and heating sectors is crucial for the next stage of energy transformation.

- Hydrogen produced from renewable electricity could help to reduce fossil-fuel reliance.

- Supply chains are key to meet growing demand for sustainable bioenergy.

- Decarbonising the global energy system requires swift and decisive policy action
  - With best of available technologies, policies should create right conditions to accelerate clean energy investments.
  - Foster innovations and technology advancements.
  - Need for better alignment and co-ordination between energy and climate policies (SDGs, NDCs).
  - Close co-operation between the public and private sectors will be key.
Continued reports and activities for Global Energy Transformation Roadmap

Global energy transformation: The REmap transition pathway (+background report)

- Status of the energy transition
- Perspective for the global energy system to 2050 based on current and planned policies (the Reference Case).
- Detailed REmap transition pathway to 2050 – an energy pathway aligned with the well-below 2°C target of the Paris climate goals.

Wind roadmap to 2050

- Technology deployment pathway.
- Annual and cumulative investments.
- Cost reductions and improvements in capacity factor.
- Innovations and technology advancements.
- Employment, supply chain and market expansion
- Emissions reduction potential.

Clean energy investments

- Pathway for the global energy transformation by 2050.
- Investment needs to achieve Paris Climate goals – sectors and regions.
- Socio-economic footprint of the energy transformation.
- Drivers and barriers to meet the clean energy investments.
- Input for UN Climate summit in September 2019.

Solar PV roadmap to 2050

- Technology deployment pathway.
- Annual and cumulative investments.
- Cost reductions and improvements in efficiency of modules.
- Innovations and technology advancements.
- Business models.
- Employment.
- Supply chain and market expansion.
- Emissions reduction potential.

Available online

Forthcoming in Nov 2019

• Status of the energy transition
• Perspective for the global energy system to 2050 based on current and planned policies (the Reference Case).
• Detailed REmap transition pathway to 2050 – an energy pathway aligned with the well-below 2°C target of the Paris climate goals.
Thank you!

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