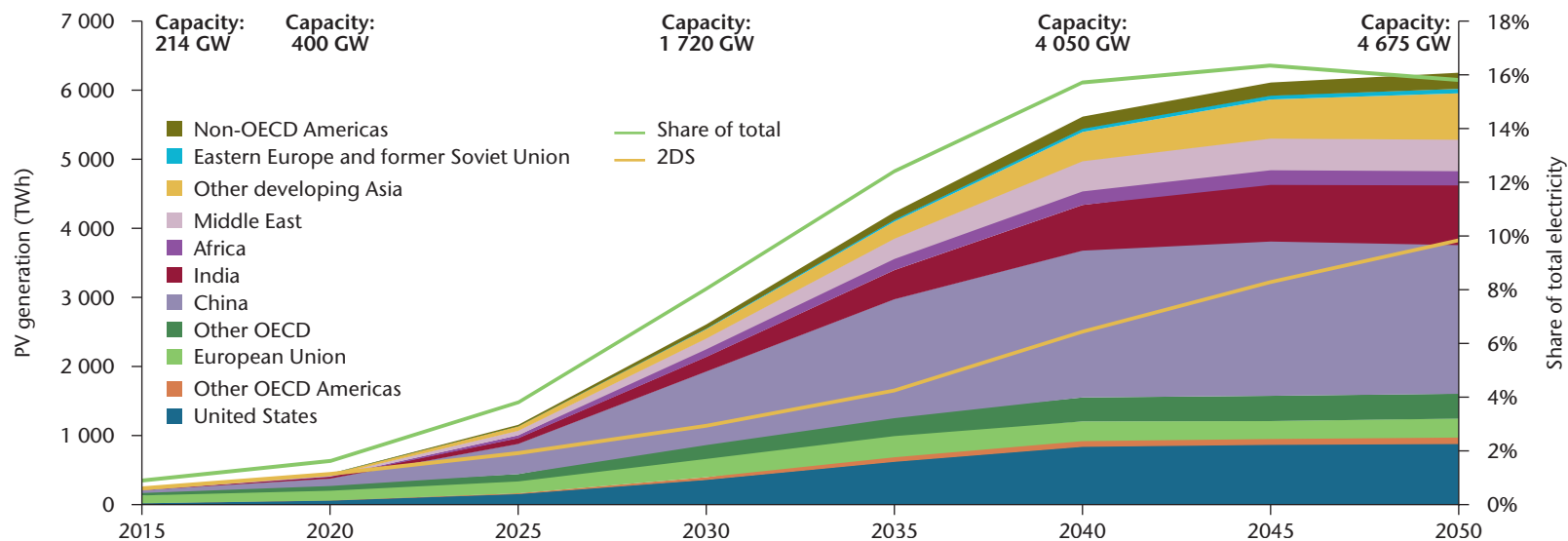


Regional electricity production from solar PV in TWh and share of global electricity

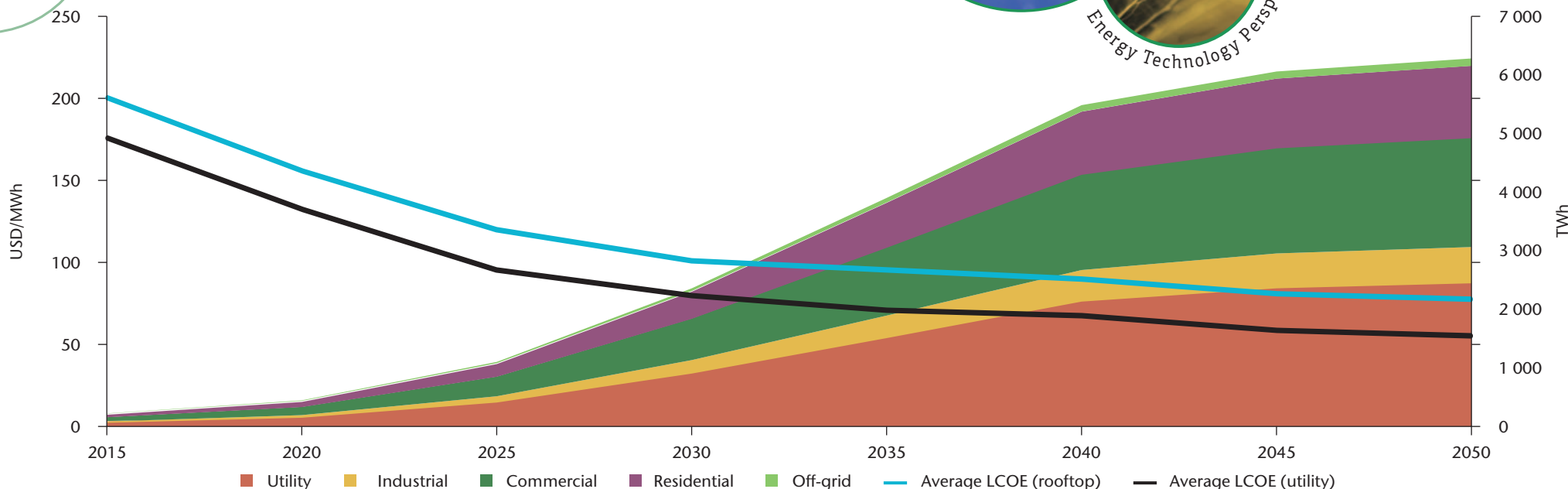


Selected key findings

- ▶ Since 2010, the world has added more solar photovoltaic (PV) capacity than in the previous four decades. New systems were installed in 2013 at a rate of 100 megawatts (MW) of capacity per day. Total global capacity overtook 150 gigawatts (GW) in early 2014.
- ▶ While a few European countries, led by Germany and Italy, initiated large-scale PV development, PV systems are now expanding in other parts of the world, often under sunnier skies. Since 2013, the People's Republic of China has led the global PV market, followed by Japan and the United States.
- ▶ PV system prices have been reduced by a factor of three in six years in most markets, and module prices by a factor of five. The cost of electricity from new built systems varies from USD 90 to USD 300/MWh depending on the solar resource and the costs of systems and of capital.
- ▶ This roadmap envisages that PV's share of global electricity will reach 16% by 2050, a significant increase from the 11% goal in the 2010 roadmap. PV generation would contribute 20% of all renewable electricity. China is expected to continue leading the global market, accounting for about 37% of global capacity by 2050.
- ▶ Achieving this roadmap's vision of 4 600 GW of installed PV capacity by 2050 would avoid the emission of up to 4 gigatonnes (Gt) of carbon dioxide (CO₂) annually.
- ▶ This roadmap assumes that the costs of electricity from PV in different parts of the world will converge as markets develop, with an average cost reduction of 25% by 2020, 45% by 2030, and 65% by 2050, leading to a range of USD 40 to 160/MWh, assuming a cost of capital of 8%.
- ▶ Utility-scale systems and rooftop systems will each have roughly half of the global market. Rooftop systems are currently more expensive but the value of electricity delivered where it is consumed or nearby is greater. Rate changes ensuring full grid cost recovery and fair allocation of costs might be considered but should be carefully designed to maintain incentives for energy efficiency and the deployment of rooftop PV.
- ▶ The variability of the solar resource, is a challenge. All flexibility options – interconnections, demand-side response, flexible generation, and storage – need to be developed to meet this challenge. PV has to be deployed as part of a balanced portfolio of all renewables.
- ▶ Despite recent falls in the cost of PV electricity, transitional policy support mechanisms will be needed in most markets to enable PV electricity costs to reach competitive levels, as long as electricity prices do not reflect climate change or other environmental factors.
- ▶ Manufacturing of PV systems is concentrated in Asia, particularly in China and Chinese Taipei, based mainly on economies of scale. Future progress is likely to be driven first by technology innovation, keeping open the possibility of global deployment of manufacturing capabilities.
- ▶ Appropriate regulatory frameworks – and well-designed electricity markets, in particular – will be critical to achieve the vision in this roadmap. Market and regulatory frameworks that fail to provide robust long-term price signals are unlikely to deliver investments in volumes consistent with this roadmap.

Cost reductions, deployment and investments

Levelised cost of electricity from new-built PV systems and generation by sectors



Notes: Weighted average LCOE values rest on 8% real discount rates. Sectoral break-down of PV capacities are indicative only.

KEY POINT: Electricity from PV systems will become progressively competitive on many more markets.

Projections for LCOE for new-built rooftop PV systems to 2050 (USD/MWh) in the hi-Ren Scenario

USD/MWh	2013	2020	2025	2030	2035	2040	2045	2050
Minimum	135	108	80	63	55	51	48	45
Average	201	157	121	102	96	91	82	78
Maximum	539	422	301	231	197	180	171	159

Projections for LCOE for new-built utility-scale PV plants to 2050 (USD/MWh) in the hi-Ren Scenario

USD/MWh	2013	2020	2025	2030	2035	2040	2045	2050
Minimum	119	96	71	56	48	45	42	40
Average	177	133	96	81	72	68	59	56
Maximum	318	250	180	139	119	109	104	97

Note: All LCOE calculations in both tables rest on 8% real discount rates as in ETP 2014. Actual LCOE might be lower with lower WACC.

Cumulative investments in PV in hi-Ren (Billion USD 2012)

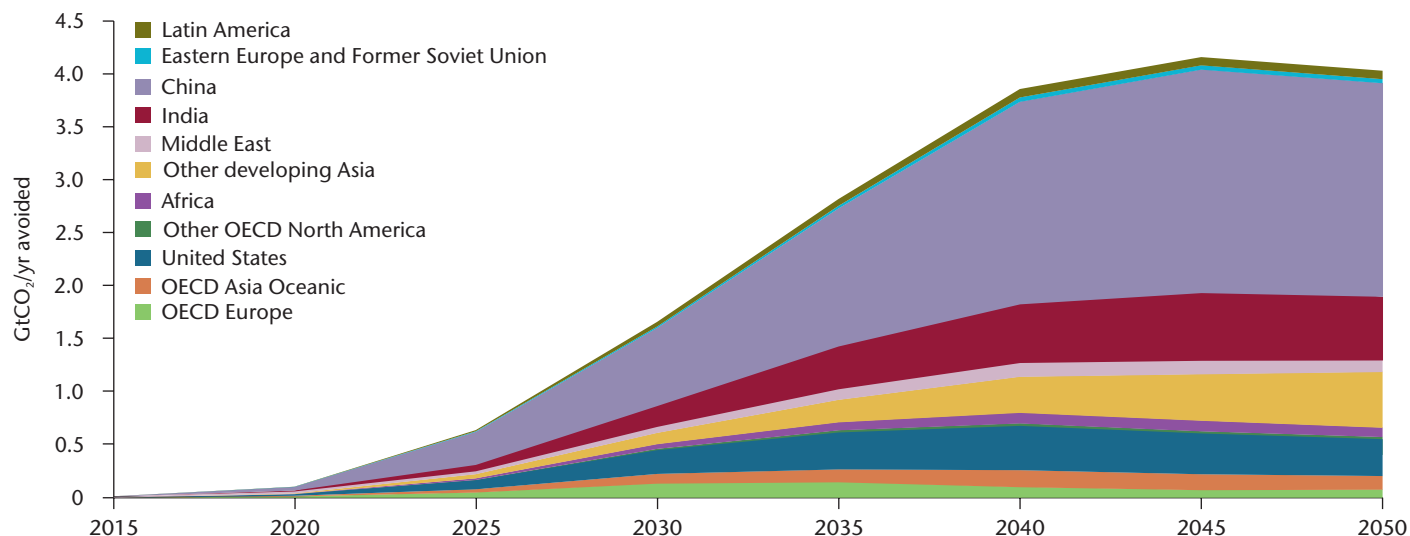
	2011-30	2031-50	2011-50
United States	456	769	1 225
OECD Europe	268	241	509
Other OECD	323	356	679
China	894	1529	2 423
India	275	735	1 010
Latin America (excluding Chile)	49	125	174
Other dev. Asia	160	695	855
Mid East Africa	266	483	749
Other non-OECD	20	76	96
Total	2 711	5 010	7 721

Selected key actions for the next 5 years

- ▶ Set or update long-term targets for PV deployment, consistent with national energy strategies and national contributions to global climate change mitigation efforts.
- ▶ Support these targets with predictable market structures and regulatory frameworks to drive investment.
- ▶ Address non-economic barriers. Develop streamlined procedures for providing permits.
- ▶ Identify the cost structure of current projects. Implement specific actions to reduce excessive costs.
- ▶ In emerging PV markets:
 - Implement priority connection to the grid and priority dispatch of PV electricity.
 - Implement support schemes with fair remuneration for investors but predictable decrease in the level of support.
 - When parity with retail electricity prices is achieved in some market segments, provide incentives for distributed PV generation through net energy metering and/or tariffs for energy.
- ▶ In mature markets:
 - Progressively increase short-term market exposure of PV electricity while ensuring fair remuneration of investment.
 - Provide incentives for self-consumption and excess generation at peak times through time-of-use electricity rates and time-of-delivery payments.
 - Improve forecasts and reform energy-only electricity markets for better synchronisation of supply and demand.
 - Design and implement investment markets for new-built PV systems and other renewables, and markets for ancillary services.
 - Progressively reform rate structures to encourage generation and discourage consumption during peak times, ensuring the recovery of fixed costs of the transmission and distribution grids while preserving the incentives for efficiency and distributed PV.
 - Avoid retroactive legislative changes.
 - Work with financing circles and other interested parties to reduce financing costs for PV deployment, in particular involving private money and institutional investors.

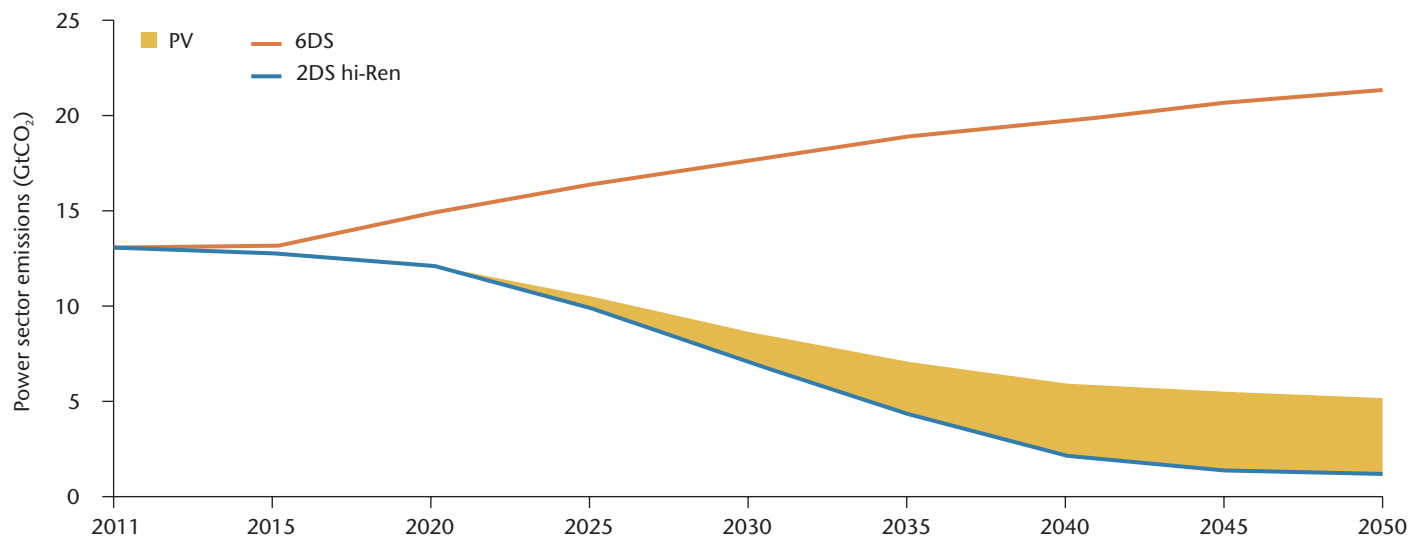
CO₂ emission reductions from solar photovoltaic energy

CO₂ abatement through PV in this roadmap over the 6DS, 2015-50



KEY POINT: China delivers one-half of the CO₂ emission abatement through PV over the 6DS.

The contribution of solar PV to avoided CO₂ emissions in this roadmap over the 6DS, 2015-50



KEY POINT: In 2050, power sector CO₂ emissions rise to 21.4 GtCO₂/yr in the 6DS and fall to 1.2 GtCO₂/yr in the 2DS hi-Ren. Solar PV provides 4 GtCO₂/yr (20%) of the difference.

Photovoltaic energy roadmap milestones

