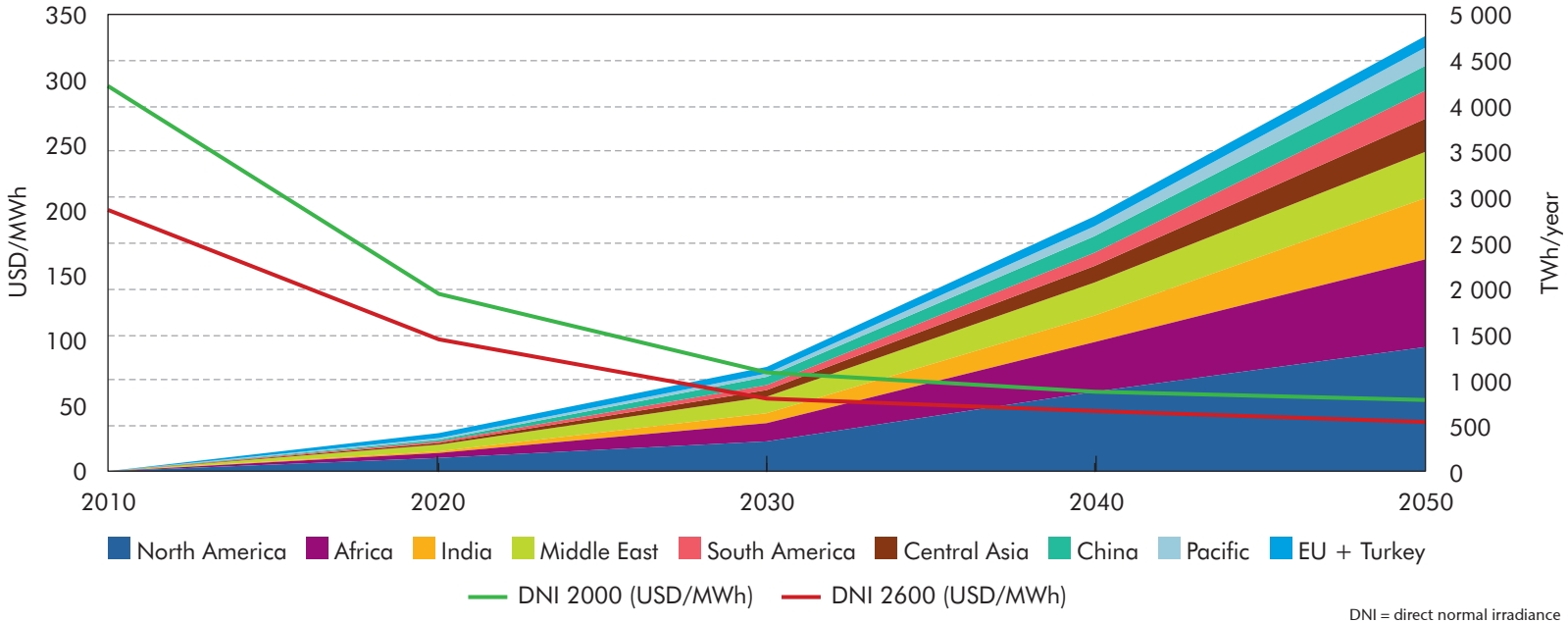
CONCENTRATING SOLAR POWER ROADMAP

International Energy Agency

Decreasing cost and increasing production

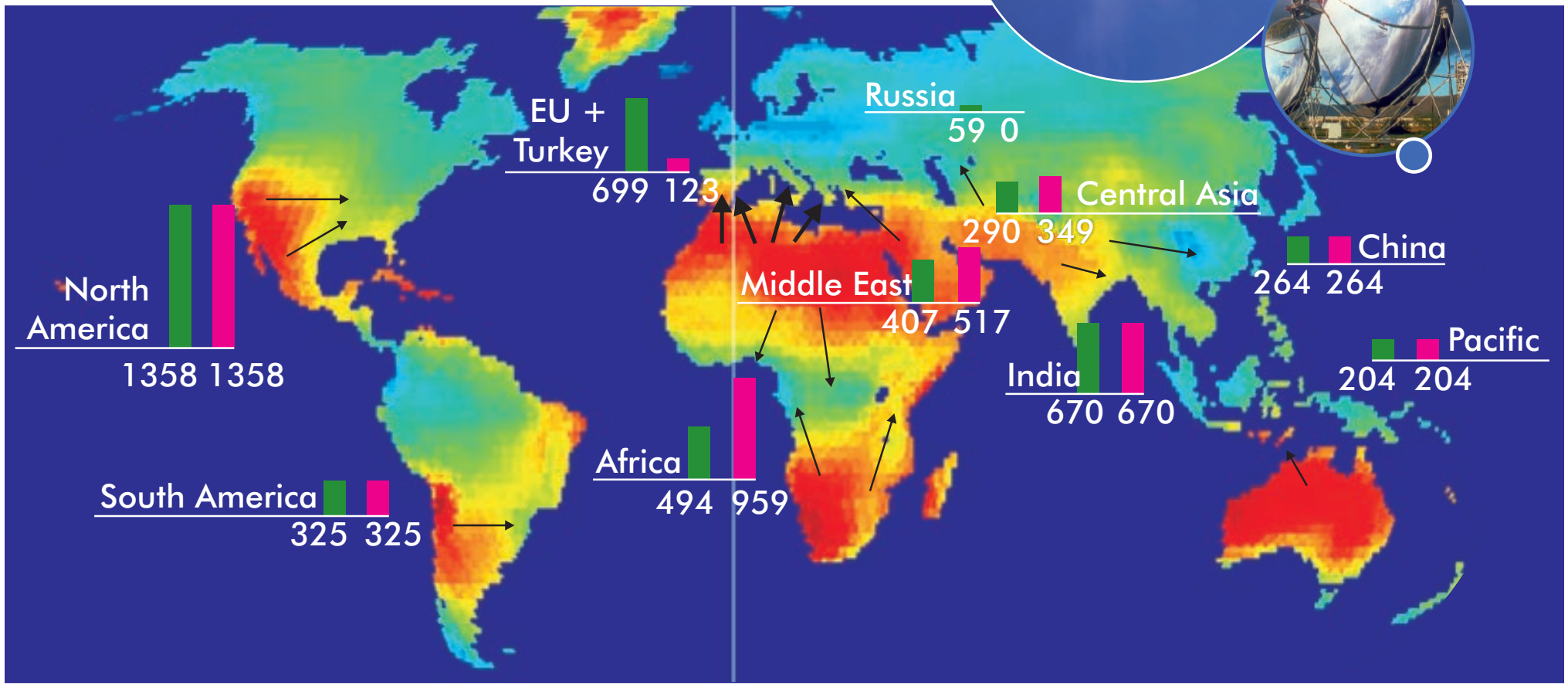


DNI = direct normal irradiance

Key findings

- By 2050, with appropriate support, CSP could provide 11.3% of global electricity, with 9.6% from solar power and 1.7% from backup fuels (fossil fuels or biomass).
- In the sunniest countries, CSP can be expected to become a competitive source of bulk power in peak and intermediate loads by 2020, and of base-load power by 2025 to 2030.
- The possibility of integrated thermal storage is an important feature of CSP plants, and virtually all of them have fuel-power backup capacity. Thus, CSP offers firm, flexible electrical production capacity to utilities and grid operators while also enabling effective management of a greater share of variable energy from other renewable sources (*e.g.* photovoltaic and wind power).
- This roadmap envisions North America as the largest producing and consuming region for CSP electricity, followed by Africa, India and the Middle East. Northern Africa has the potential to be a large exporter (mainly to Europe) as its high solar resource largely compensates for the additional cost of long transmission lines.
- CSP can also produce significant amounts of high-temperature heat for industrial processes, and in particular can help meet growing demand for water desalination in arid countries.
- Given the arid/semi-arid nature of environments that are well-suited for CSP, a key challenge is accessing the cooling water needed for CSP plants. Dry or hybrid dry/wet cooling can be used in areas with limited water resources.
- The main limitation to expansion of CSP plants is not the availability of areas suitable for power production, but the distance between these areas and many large consumption centres. This roadmap examines technologies that address this challenge through efficient, long-distance electricity transportation.
- CSP facilities could begin providing competitive solar-only or solar-enhanced gaseous or liquid fuels by 2030. By 2050, CSP could produce enough solar hydrogen to displace 3% of global natural gas consumption, and nearly 3% of the global consumption of liquid fuels.

Production and consumption of CSP electricity by 2050



Repartition of the direct normal irradiance (DNI) in kWh/m²/y, and of the production and consumption of CSP electricity (in TWh) by world region in 2050 as foreseen in this roadmap. Arrows represent transfers of CSP electricity from sunniest regions or countries to large electricity demand centres.

Sources: Breyer & Knies, 2009 based on DNI data from DLR-ISIS and IEA Analysis.

Key actions in the next ten years

Concerted action by all stakeholders is critical to realising the vision laid out in this roadmap.

Governments

- *Ensure long-term funding for additional RDD&D in: all main CSP technologies; all component parts and all applications at all scales.*
- *Facilitate the development of ground and satellite measurement/modelling of global solar resources.*
- *Support CSP development through solar-specific incentives. These could include any combination of feed-in tariffs or premiums, binding renewable energy portfolio standards with solar targets, capacity payments and fiscal incentives.*
- *Where appropriate, require state-controlled utilities to bid for CSP capacities.*
- *Avoid establishing arbitrary limitations on plant size and hybridisation ratios (but develop procedures to reward only the electricity deriving from solar energy, not the portion produced by burning backup fuels).*
- *Streamline procedures for obtaining permits for CSP plants and access lines.*

Industry

- *Pursue cost reduction potential for all systems through:*
  - *New components*
  - *New transfer fluids*
  - *Higher working temperatures*
  - *Mass production*
- *Pursue cost reduction potential of heliostat fields with immediate control loop from receivers and power blocks to address transients*
- *Further develop heat storage, in particular three-step storage systems for direct steam generation solar plants, whether LFR, troughs, or towers*
- *Further develop central receiver concepts, notably superheated steam, molten salts and air receivers*
- *Work collaboratively with turbine manufacturers to develop new turbines*

Utilities

- *Provide certainty to investors with long-term power purchase agreements or bidding procedures*
- *Reward firm capacities of CSP plants*
- *Facilitate grid access for CSP developers*
- *Participate actively in project development*

CSP Capacities, generation and consumption

Capacity (GW)

	Africa	Middle East	North America	Central Asia	India	China	Pacific	South America	EU+ Turkey	Russia	World
2020	23	23	50	7	7	9	4	5	18	0	**147**
2030	62	50	94	20	33	26	10	19	23	0	**337**
2040	136	91	225	49	76	47	28	38	25	0	**715**
2050	219	118	310	80	152	60	47	74	28	0	**1 089**

Generation (TWh)

	Africa	Middle East	North America	Central Asia	India	China	Pacific	South America	EU+ Turkey	Russia	World
2020	66	64	141	20	19	26	12	14	52	0	**414**
2030	211	170	319	67	113	88	34	66	79	0	**1 147**
2040	531	356	876	190	294	185	109	149	98	0	**2 788**
2050	959	517	1 358	349	670	264	204	325	123	0	**4 770**

Consumption from CSP (TWh)

	Africa	Middle East	North America	Central Asia	India	China	Pacific	South America	EU+ Turkey	Russia	World
2020	34	49	141	16	19	26	12	14	98	4	**413**
2030	111	136	319	52	113	88	34	66	212	15	**1 146**
2040	293	293	876	155	294	185	109	148	400	35	**2 788**
2050	494	407	1 358	290	670	264	204	325	699	59	**4 770**

Analysis for this roadmap is consistent with the IEA *Energy Technology Perspectives 2010* BLUE Map Hi REN scenario, which describes how annual CO_2 emissions can be reduced by 50% from 2005 level, with renewable energy sources providing up to 75% of the global electricity production.

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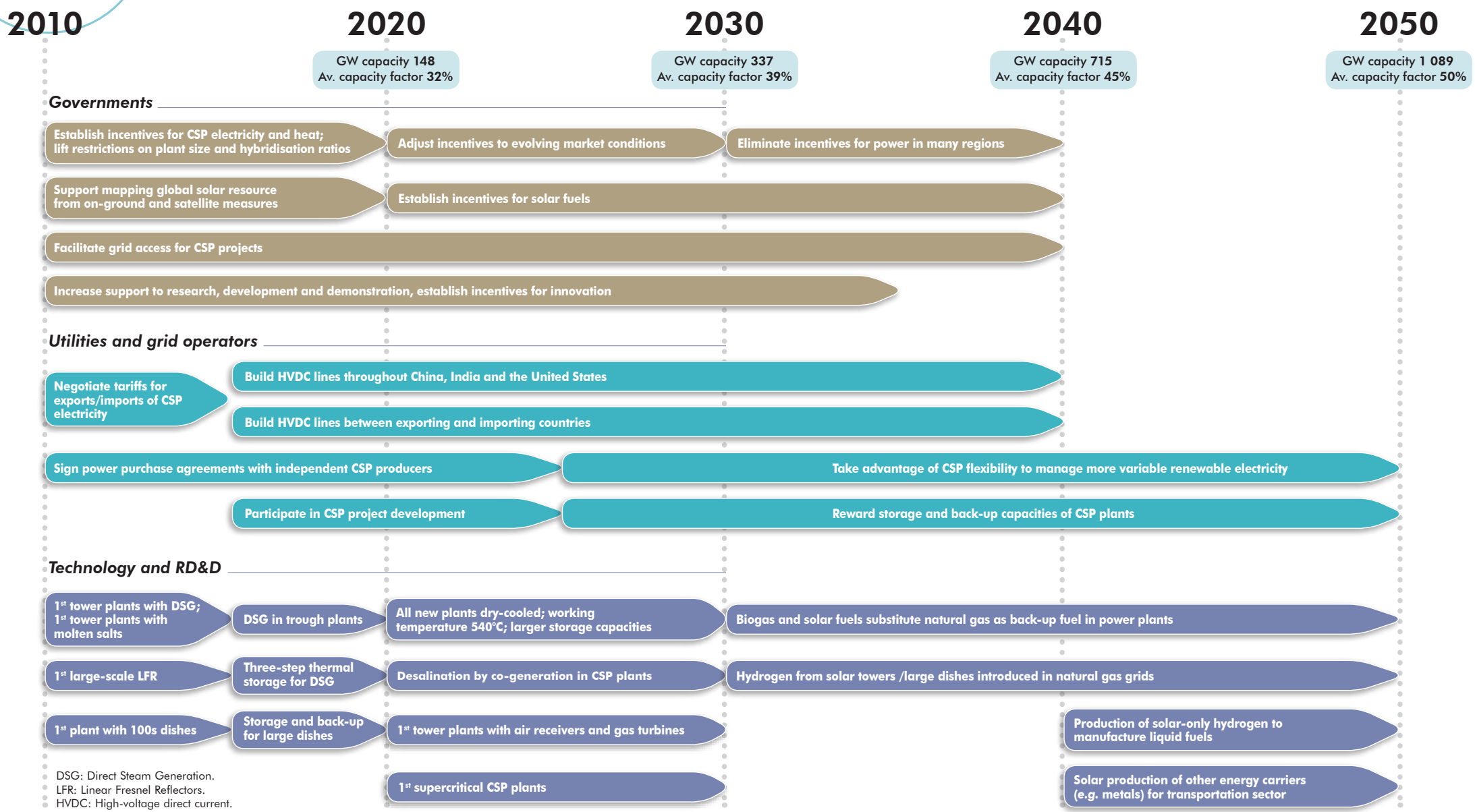
Concentrating solar power roadmap milestones



DSG: Direct Steam Generation.
LFR: Linear Fresnel Reflectors.
HVDC: High-voltage direct current.

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