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Solar thermal electricity Vision by 2050

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Renewable Energy Division

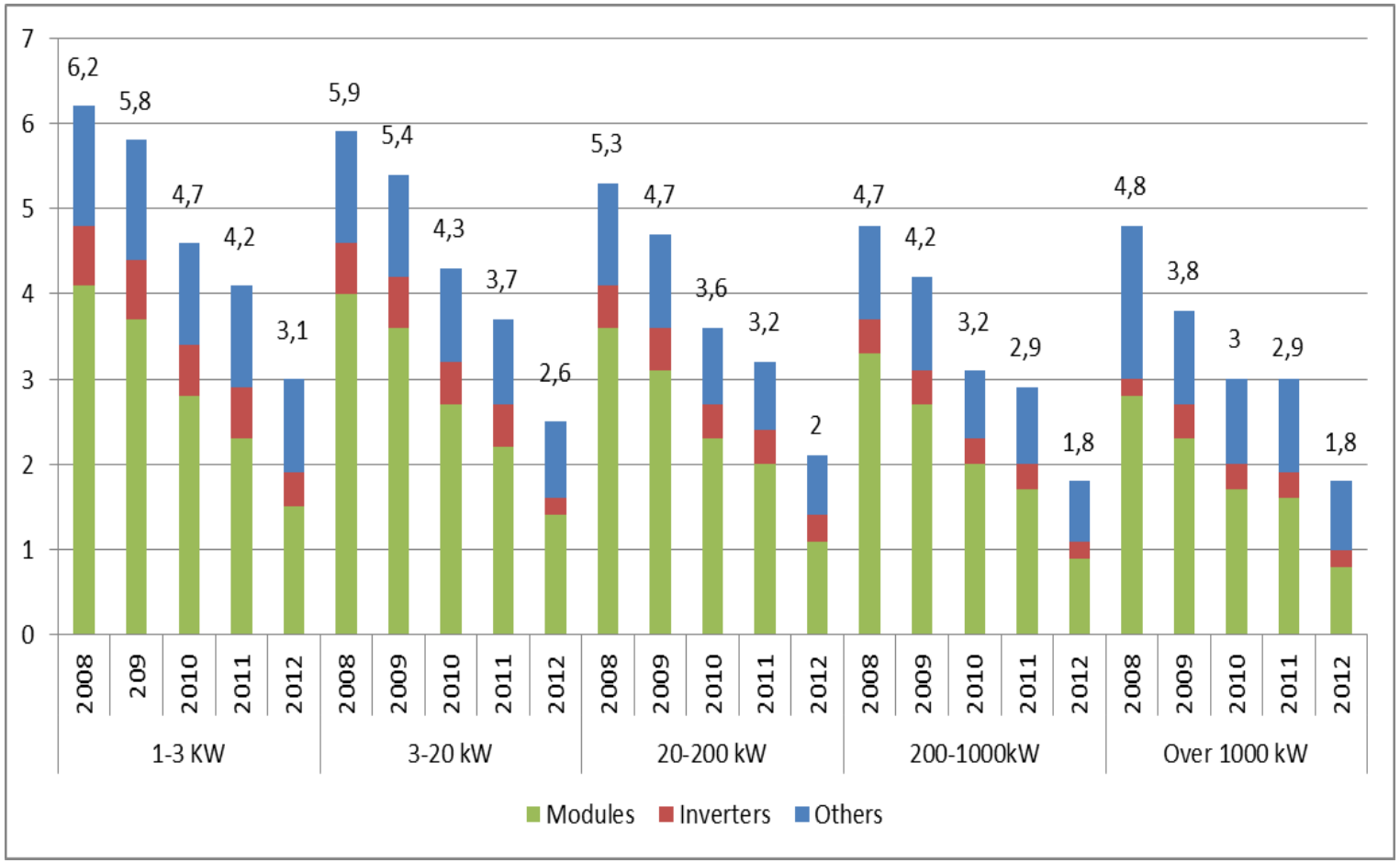
Solar Electricity Roadmap Update – 1st Workshop – 3 February, Paris

www.iea.org

Why an update is needed: Various IEA scenarios for STE/CSP

Time	GW	TWh	*Scenario*	Source
2018	12.4 (14)	34		*Medium Term RE Market Report 2013*
2020	147	414		*IEA Technology Roadmap (2010)*
	17	56	*450*	*World Energy Outlook 2013*
2035	224	806		
2050	1 089	4 770		*IEA Technology Roadmap (2010)*
	859	3 333	*2DS*	*Energy Technology Perspectives 2012*
	1 108	4 125	*hi-Ren*	
>2060	6 000	25 000	*« Testing limits »*	*Solar Energy Perspectives (2011)*

The price of PV systems fell rapidly…

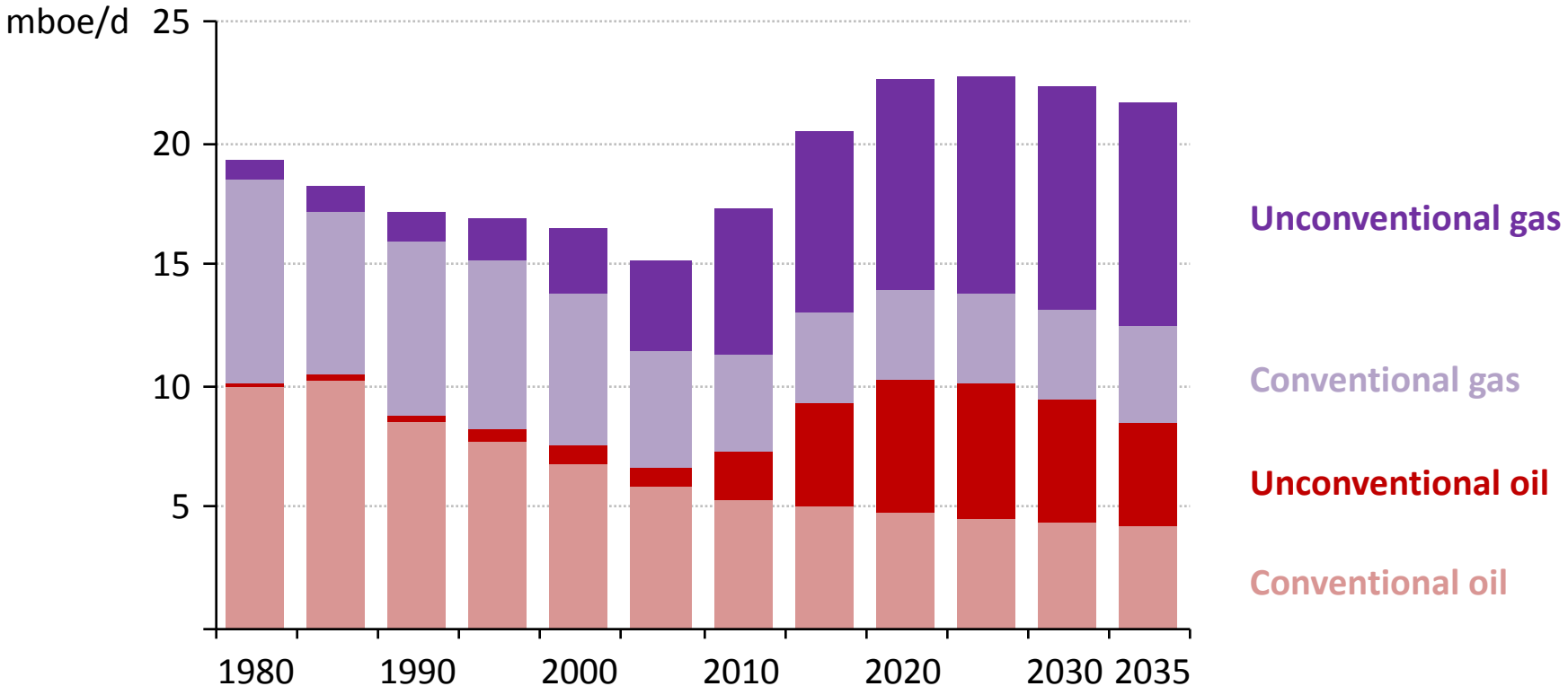


- **PV system prices in Italy: divided by 2 or more**

In the USA, another surprise…

WORLD ENERGY OUTLOOK

US oil and gas production



The surge in unconventional oil & gas production has implications well beyond the United States

STE lags behind PV

- 3 GW deployed (vs.130 GW PV)
- Troughs with oil as heat transfer fuel (HTF) the dominant technology
- Molten-salt heat storage
- Dishes almost wiped out
- First large linear Fresnel
- First large towers, direct steam generation or molten salt as HTF
- Molten salts as HTF for all?

Key findings

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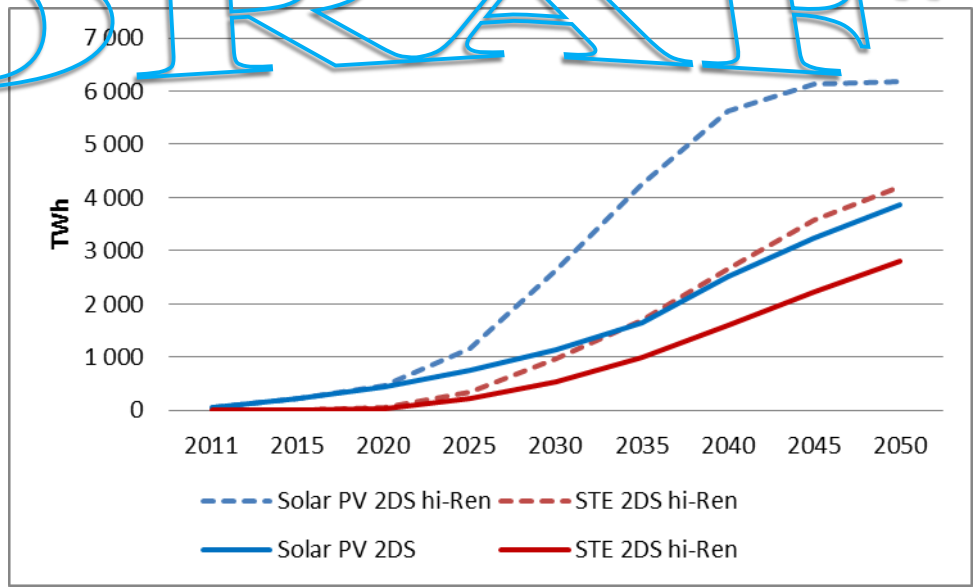
- Solar electricity comes close to wind power, hydropower and nuclear by 2050 in the 2°C scenario
- In the hi-Ren scenario, solar electricity becomes the first electricity source from 2040 on
  - It provides more a fourth of global electricity by 2050.



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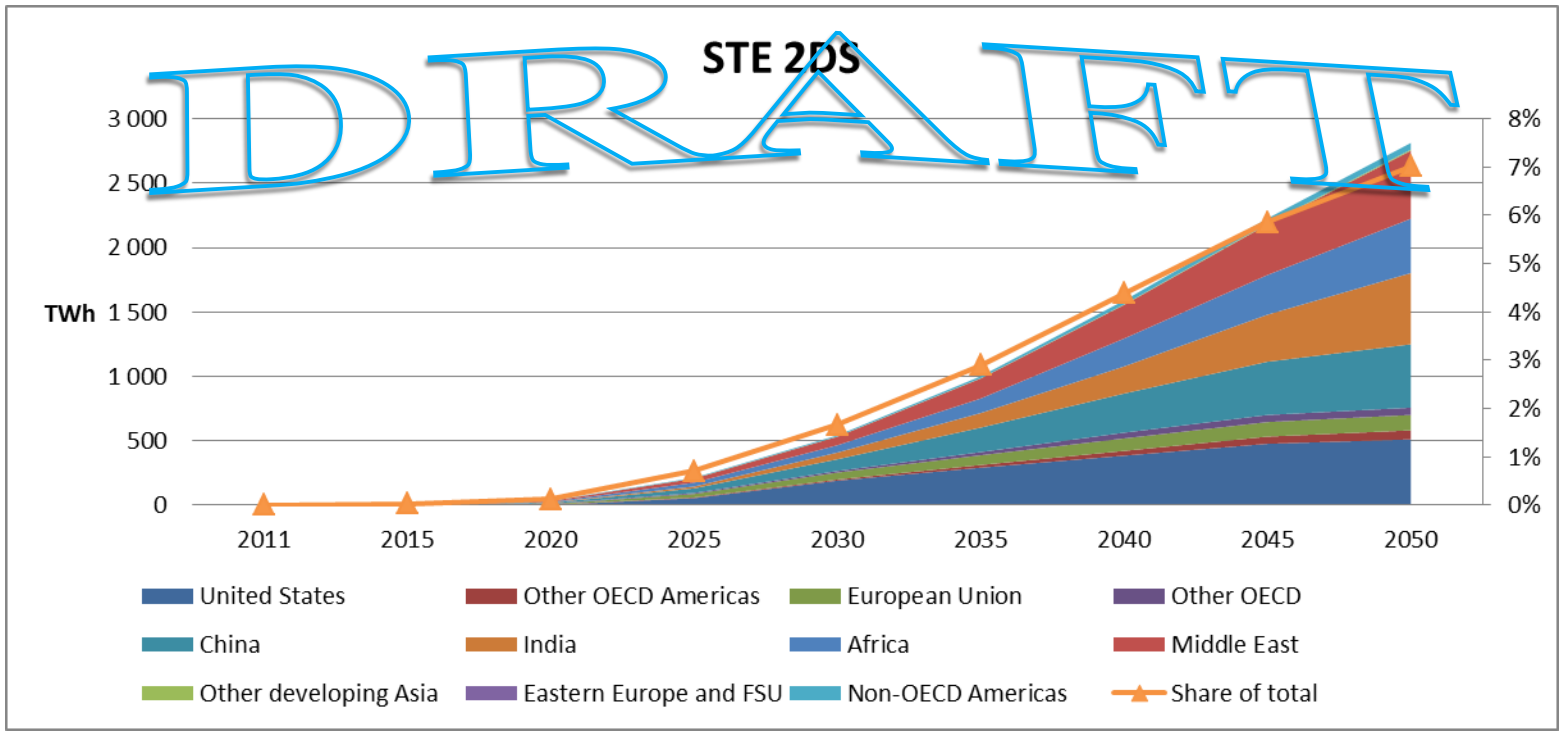
Solar electricity generation by 2050 by region in the 2DS

ETP 2014



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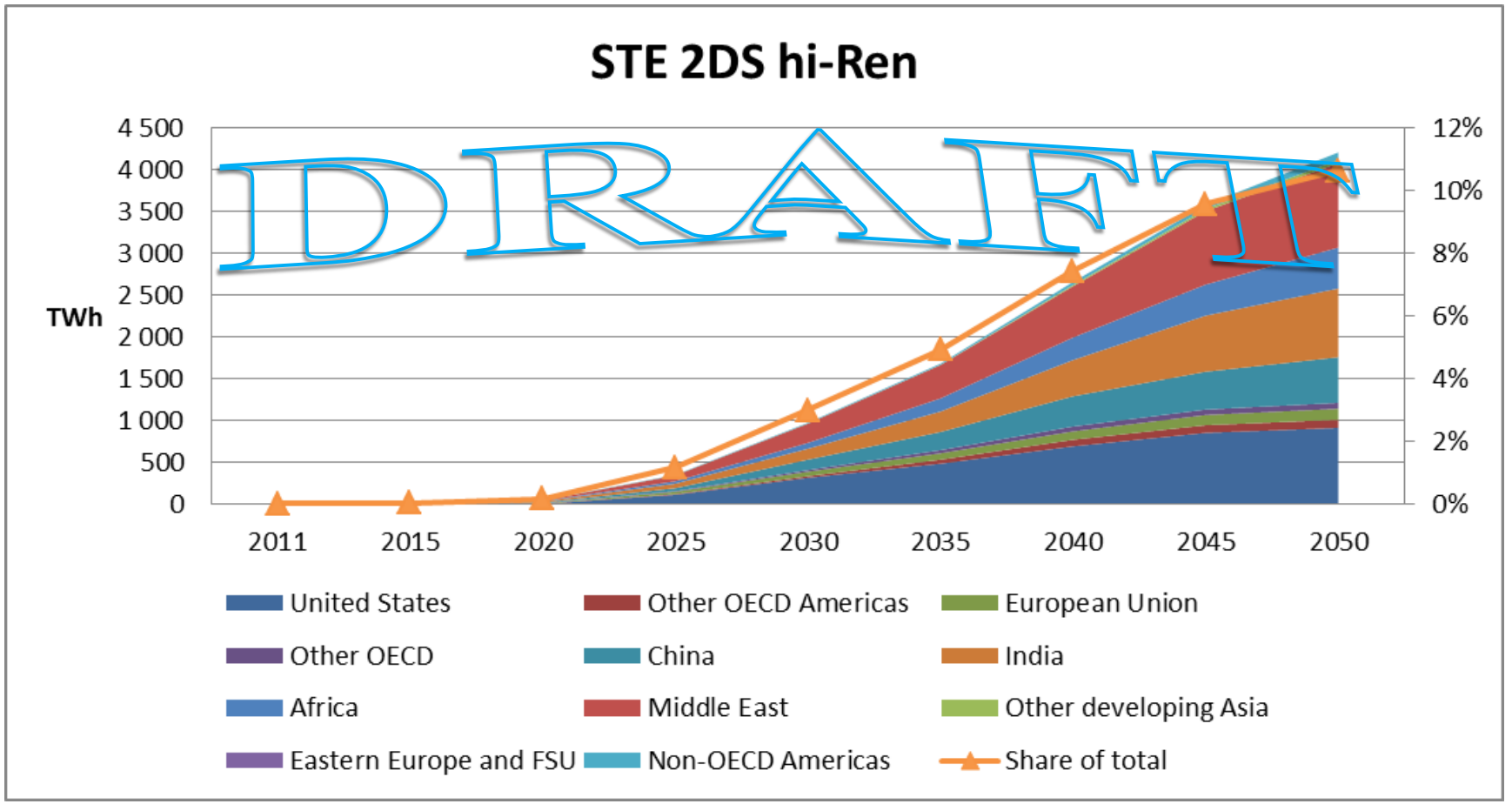
Solar electricity generation by 2050 by region in the 2DS hi-Ren

ETP 2014



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STE vs. PV by region

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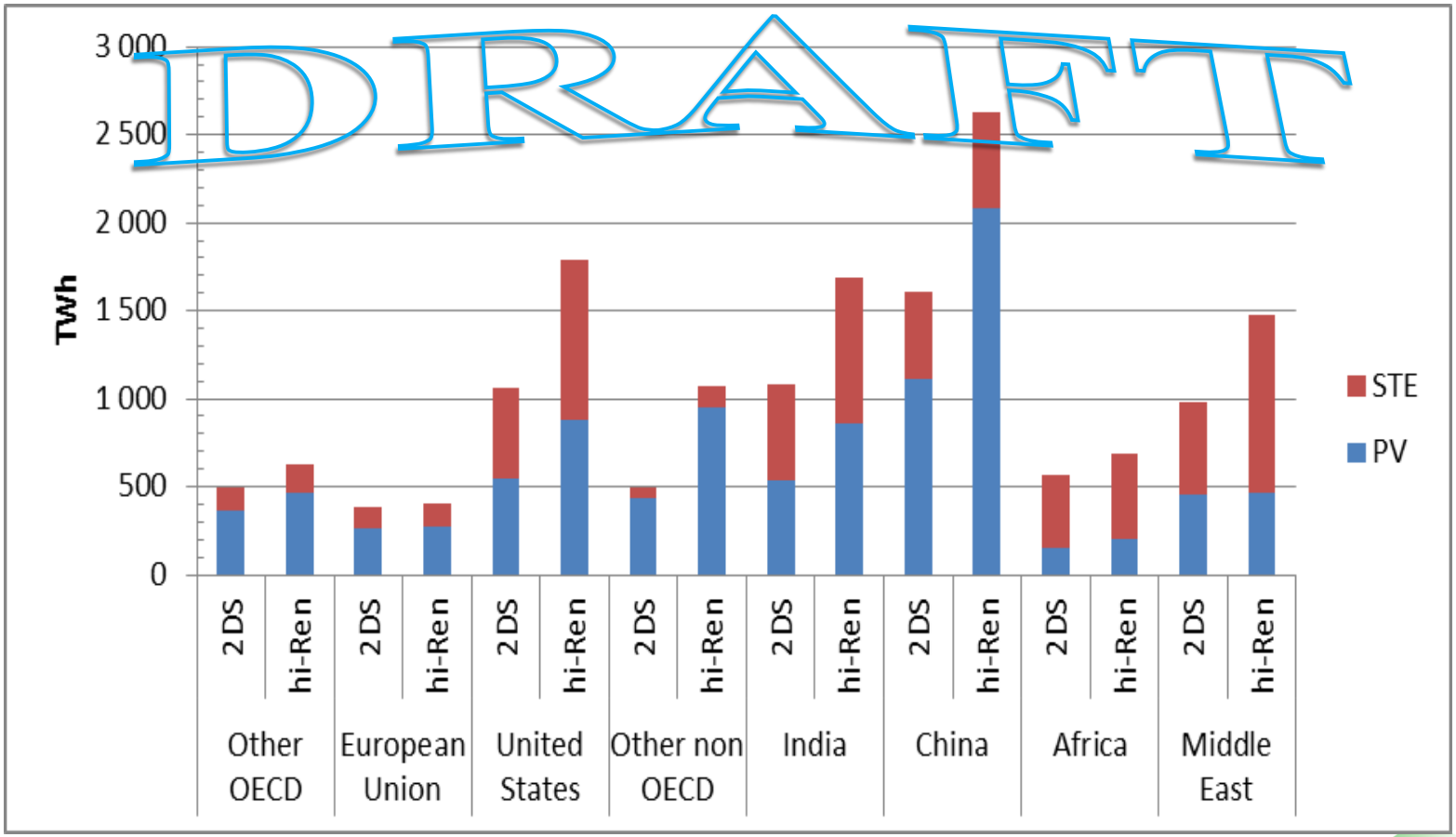

CSP costs

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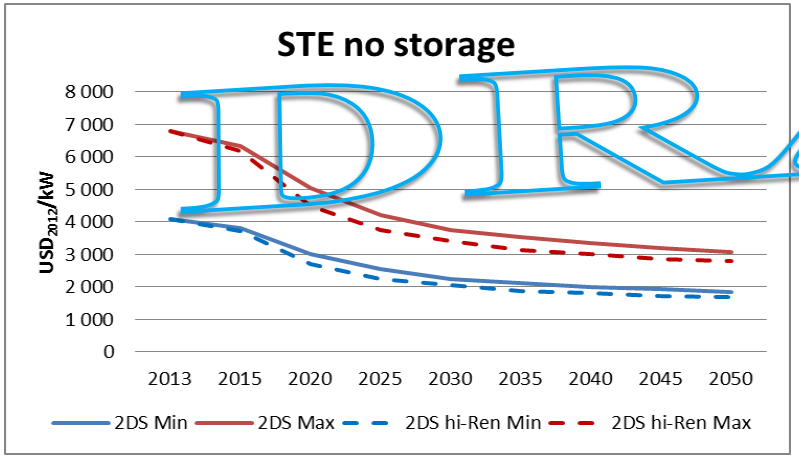
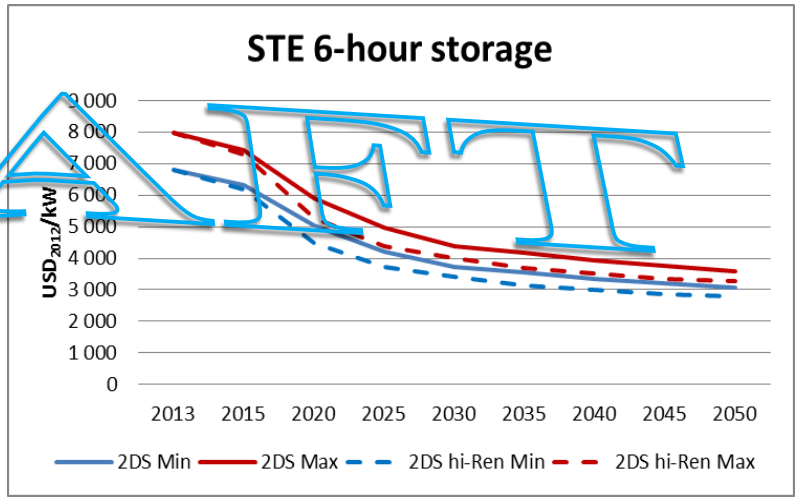
CSP investment costs





STE LCOE

USD/MWh		2015	2020	2025	2030	2035	2040	2045	2050
W/o storage	Min	158	126	105	93	88	83	80	76
	Max	263	209	175	156	147	139	133	127
W. 6-hour storage	Min	146	116	97	86	82	77	74	71
	Max	172	137	115	102	96	91	87	83

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Investment needs CSP in 2DS

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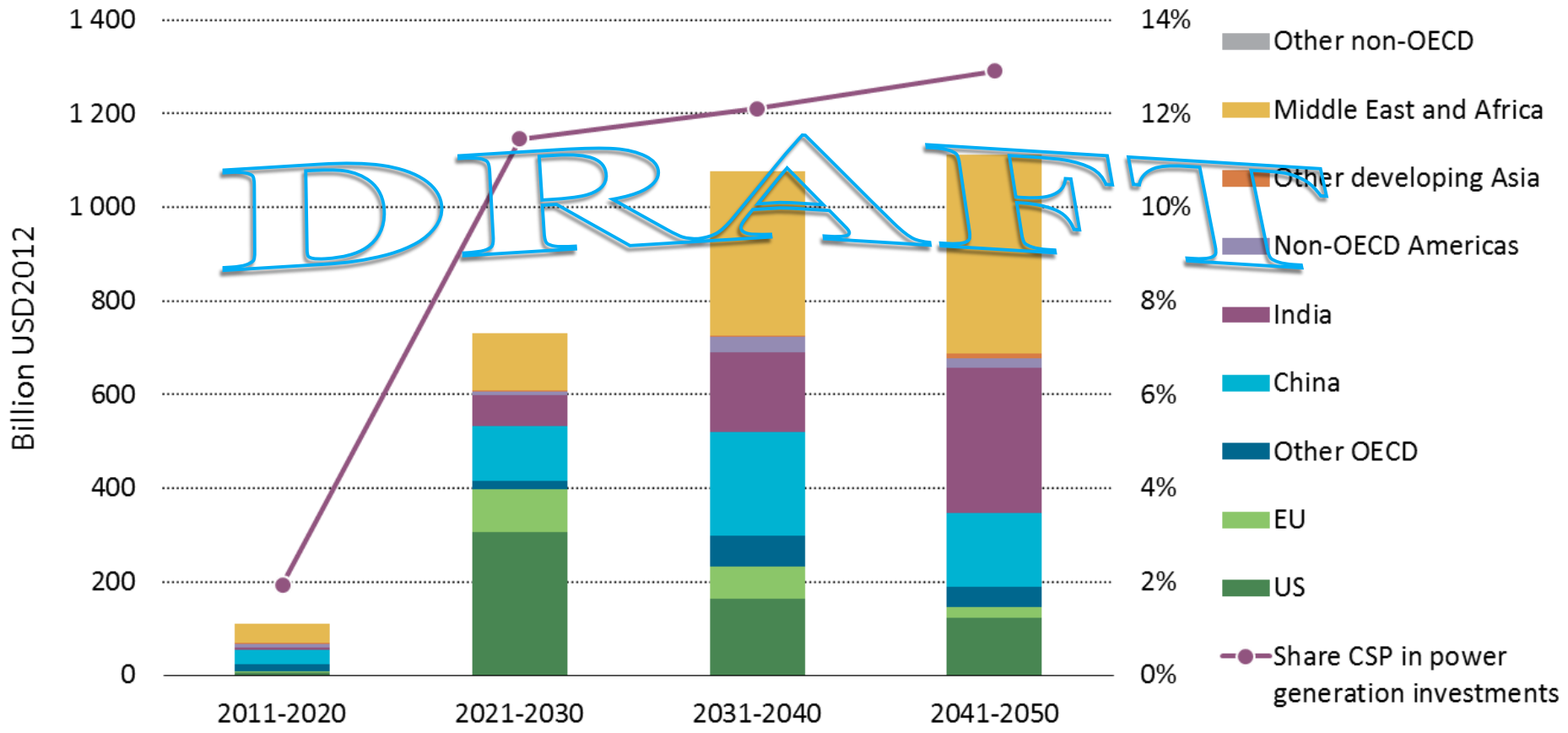

- **2DS: 10% of cumulative power generation investments**
- **Hi-Ren: 14% of cumulative generation investments**

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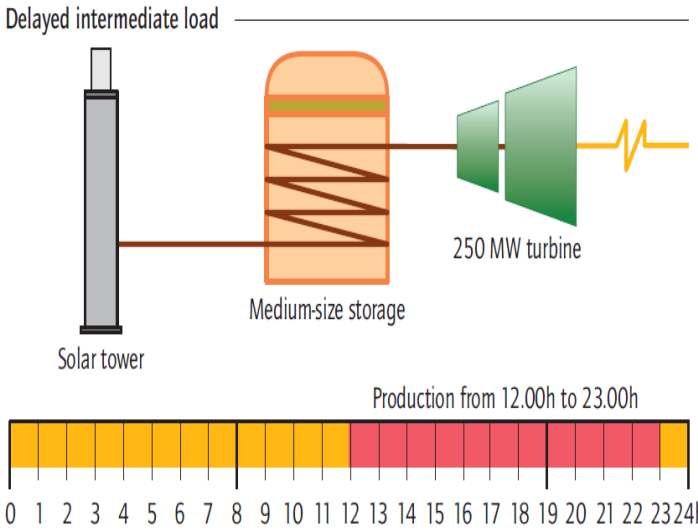
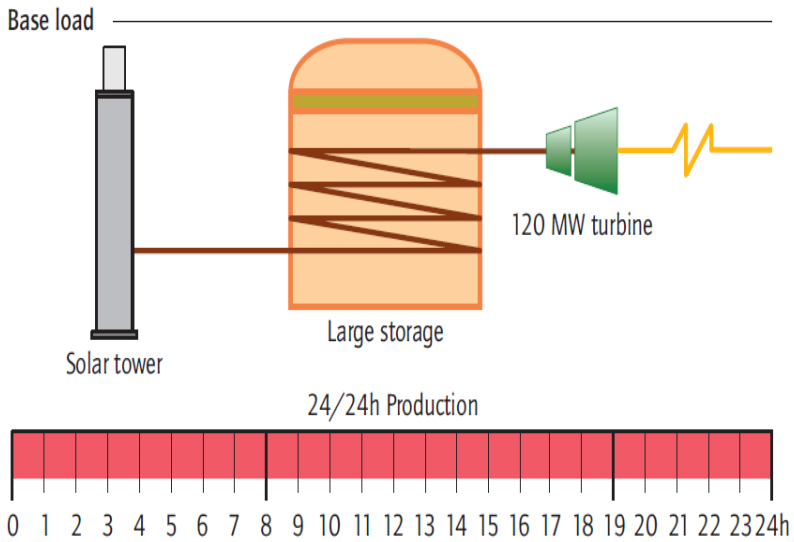
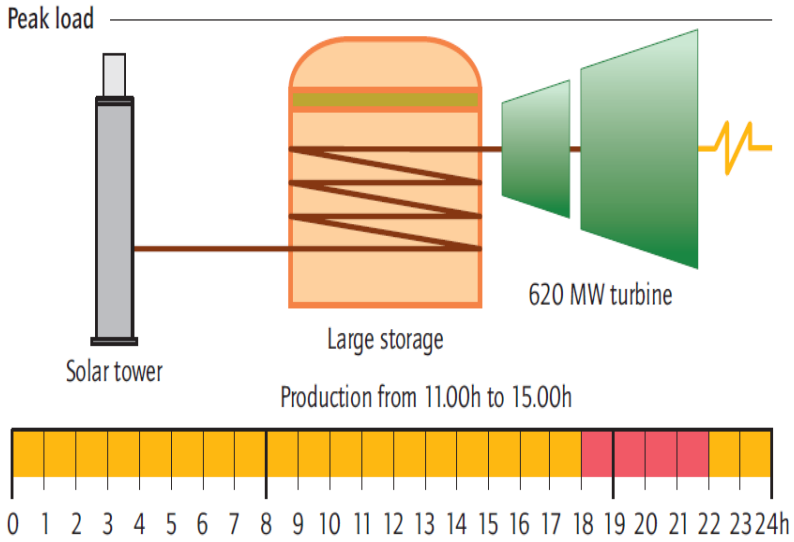
Why STE/CSP will survive the competition of PV

- Higher costs but built-in thermal storage
  - When demand peaks after sunset!
  - If PV (plus minimum load of back-up, if any) already saturates demand at noon
- Only competing option (for now): pump-hydro storage
  - Saudi Arabia plans for 2032: PV 16 GW and 25 GW STE/CSP; China's plans for 2030
  - STE very flexible, helps accommodating more PV (when replacing coal)
- But: limited to areas with good DNI
- Small-scale, decentralised possible but costly

Possible roles of storage

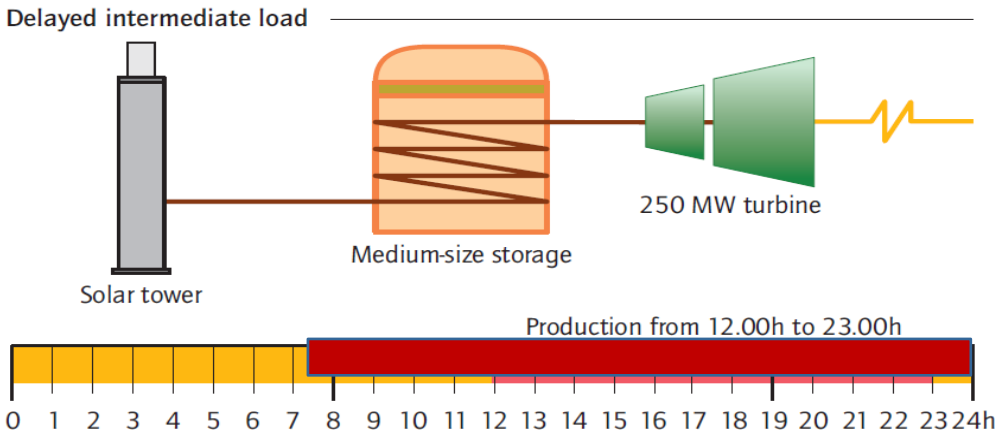






- **Thermal storage can be used to shift production, to extend it to base load or to concentrate it to super peak load**

Roles of storage: all of the above?



- Shift generation to peak loads in Winter
- Extend hours to cover peak and mid-peak loads in Summer
  - Reducing costs and increasing value
  - If solar field & storage covers evening peak, producing during the day as well only costs an extension of solar field
  - Other sources of value, e.g. reserves, etc…

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Load profile of South Africa

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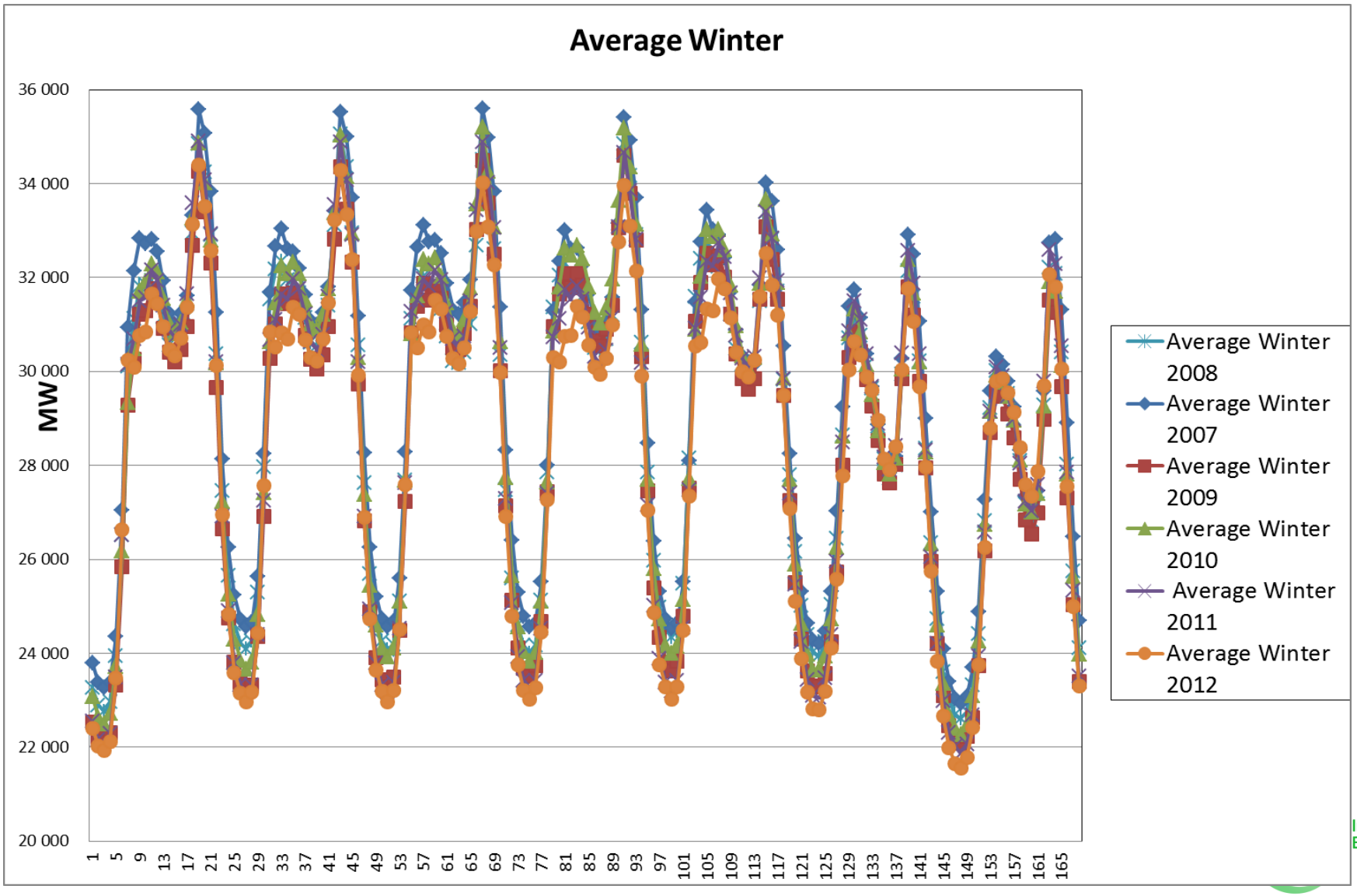

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TOD pricing for STE in RSA

ETP 2014

energy

Department:
Energy
REPUBLIC OF SOUTH AFRICA

Reissued for Third Bid
Submission Date: May 2013
TENDER NO: DOE/003/13/14

	Time of day for Delivery of Energy Output	Percentage of Base Price payable
Standard Time:	Every day 5:00am to 4:30pm 9:30pm to 10:00pm	100% of the Base Price
Peak Time:	Every day 4:30pm to 9:30pm	270% of the Base Price
Night Time:	Every day 10:00pm to 5:00am	0% of the Base Price

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PV at sunrise, CSP at sunset

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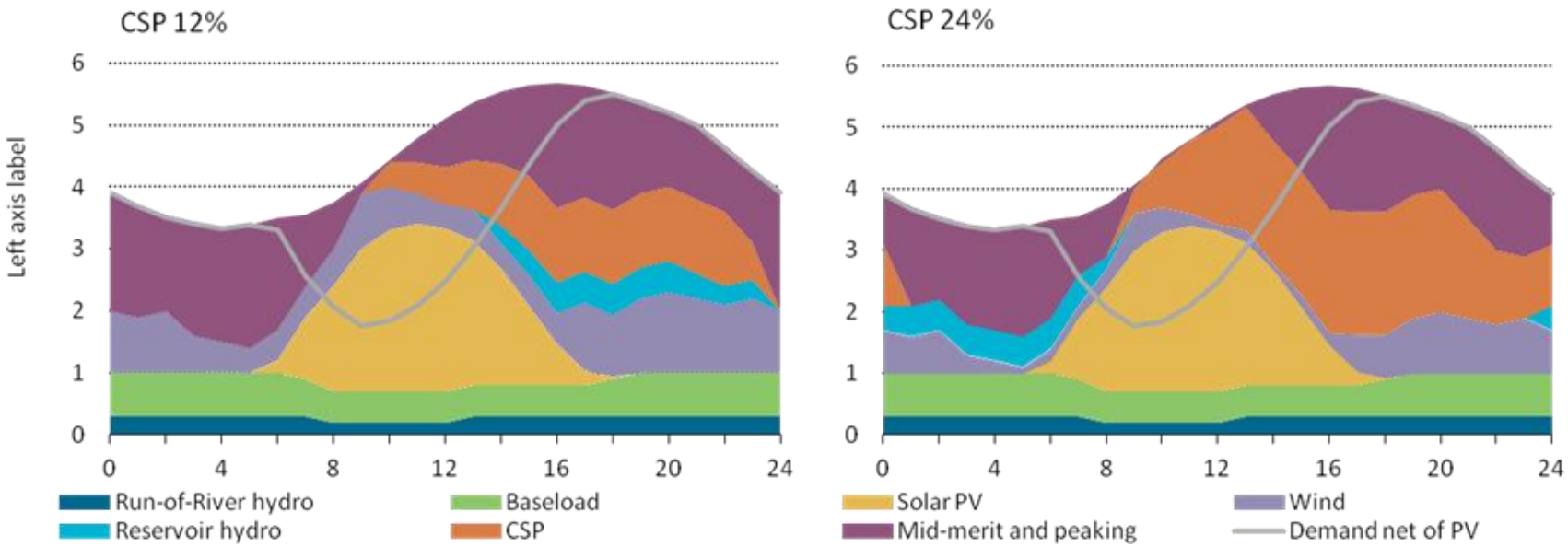
Daily dispatch for stylised system with annual PV electricity shares of 18%



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Directions for STE industry

- **Storage is the key asset**
- **Molten salts as both heat transfer fluid and storage medium offer advantages**
  - **Molten-salts solar tower the current standard**
    - **Gemasolar (Spain), Tonopah (Nevada), Agengoa (Chile)**
  - **Various options still to be considered**
    - **One tower one turbine *vs.* several towers per turbine**
    - **Surface receivers *vs.* cavity receiver**
    - **Small *vs.* large heliostats**
  - **Molten salts as HTF and storage in linear plants?**
    - **New HCEs by Schott for trough and Fresnel plants**
    - **Freeze risks and parasitic losses?**
    - **Higher temperature difference decreases storage costs**