

The role of solar PV in global decarbonisation scenarios

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on behalf of
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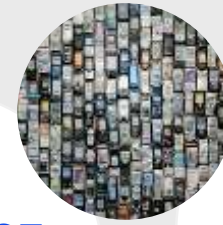
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Asia-Pacific Solar Research Conference
6 Dec 2018

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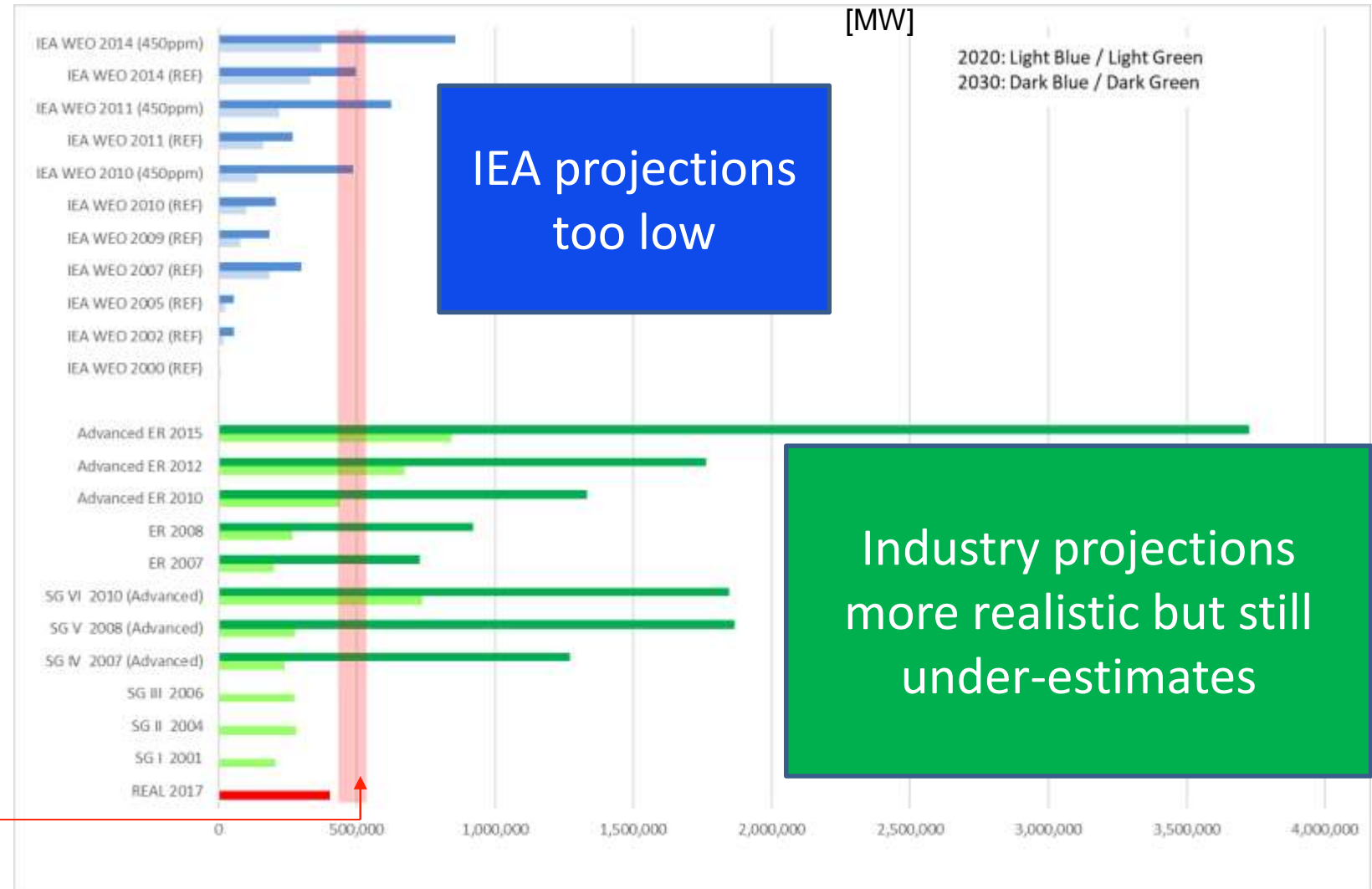
**FOOD
SYSTEMS**



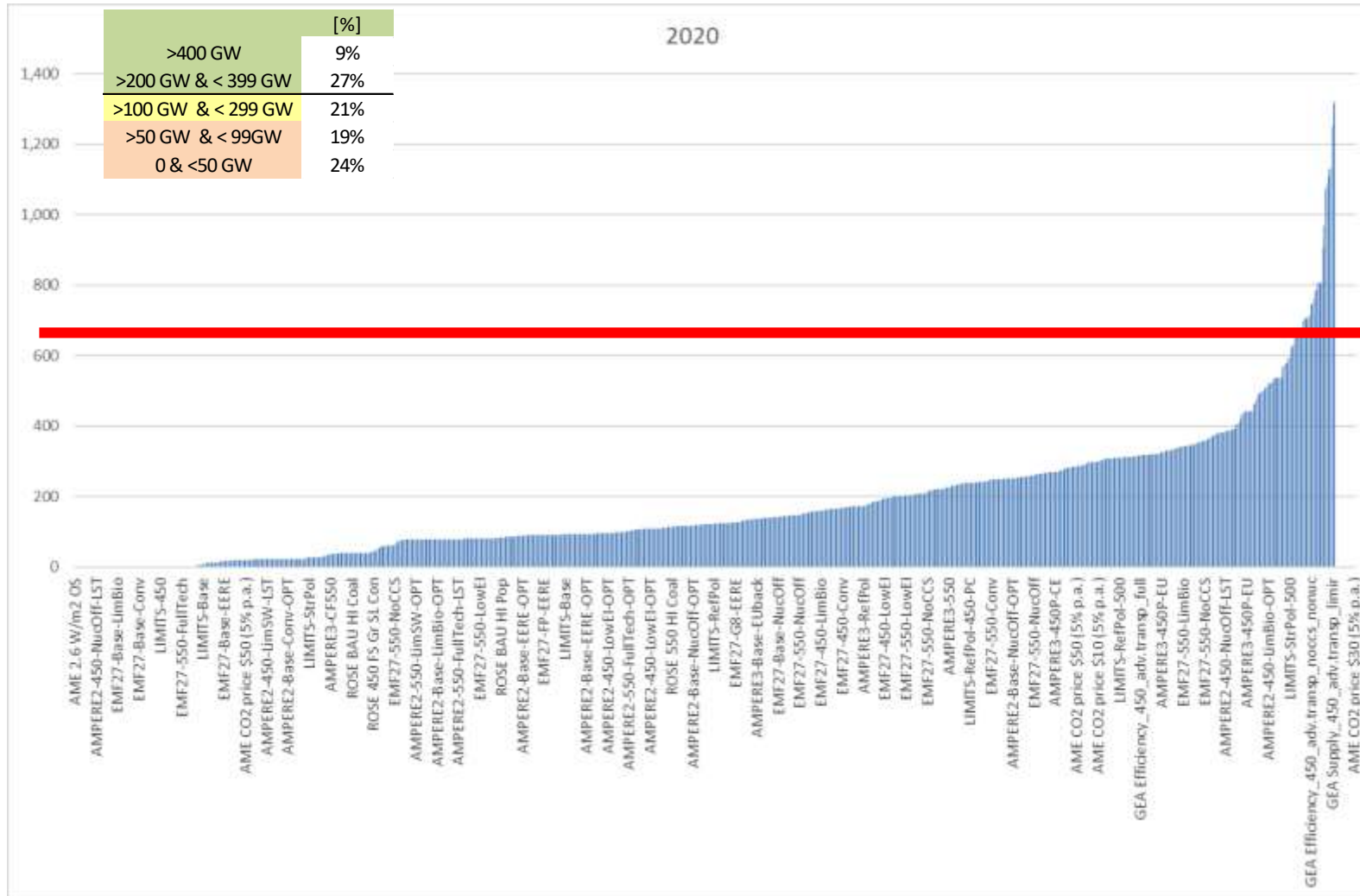
PV growth exceeds expectations

Projections for global cumulative PV capacities published from Industry (EPIA), NGO (Greenpeace) and IEA between 2000 and 2015 for the years 2020 and 2030

500 GW PV, by end 2018



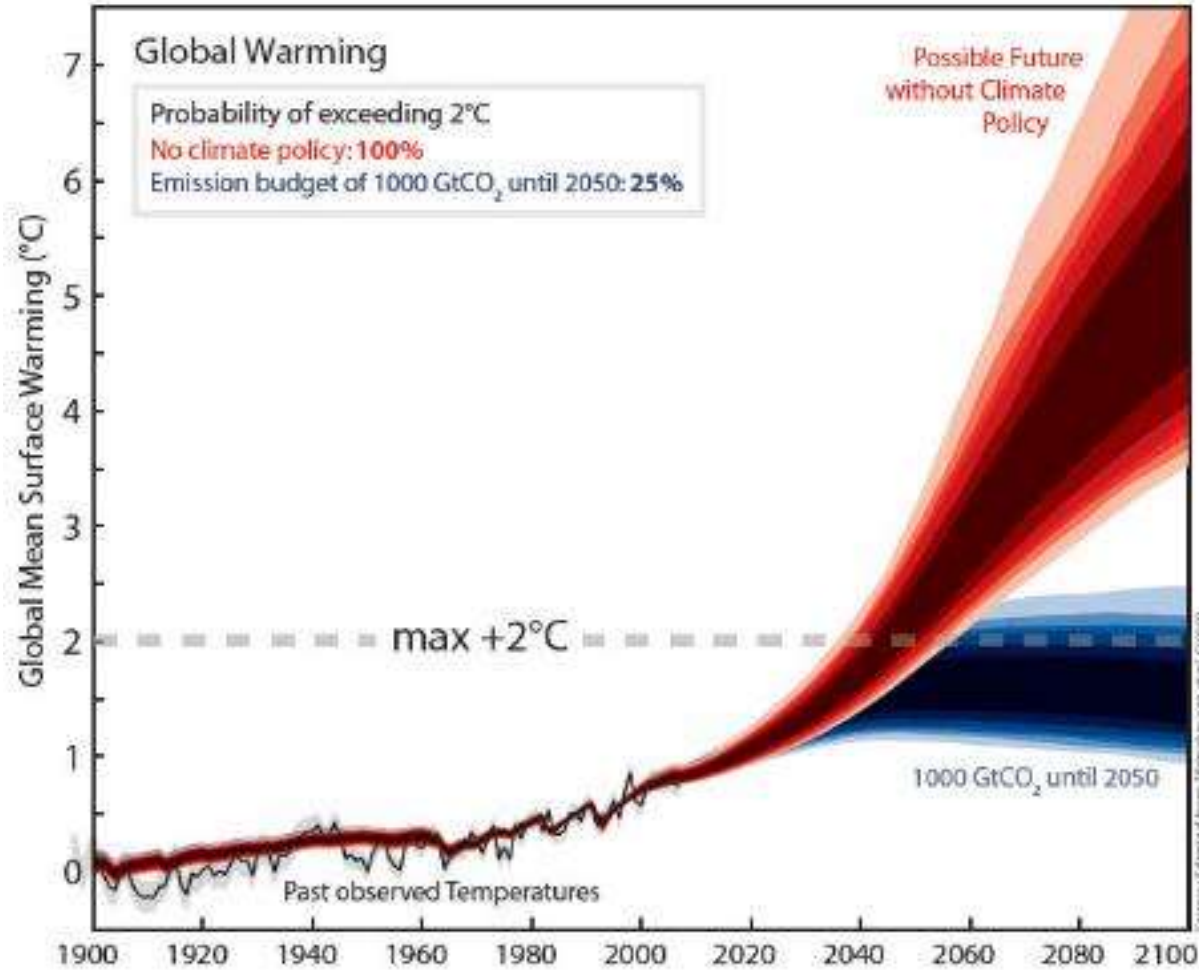
IPCC database of 950 scenarios: 91% underestimated the role of PV



Projections for 2020: IPCC AR 5 scenario data base – approx. 950 scenarios published before 2015 -

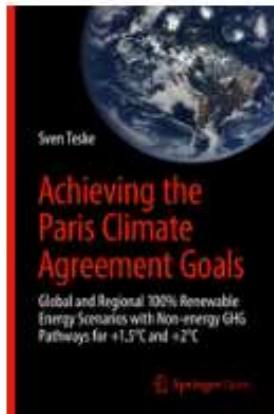
Category “Secondary Solar (Electricity)” - includes PV and CSP; converted from EJ/a to GW
 - Assumption: Capacity factor 17% (1500 h/a) -

Rapid energy transition needed



The Paris Agreement sets a long-term goal of holding the global average temperature increase to well below +2C and pursuing efforts to limit this to +1.5C above pre-industrial levels.

Leonardo DiCaprio Foundation (LDF) Project – Background: One Generation Decarbonisation
A global 1.5C mitigation pathway without negative emissions



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Achieving the Paris Climate Agreement Goals

Global and Regional 100% Renewable Energy Scenarios with Non-energy GHG Pathways for +1.5°C and +2°C

Authors: Teske, Sven

Presents robustly modeled scenarios to achieve 100% renewable energy by 2050

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The Concept

Leonardo DiCaprio Foundation (LDF) Project – Background: One Generation Decarbonisation

A global 1.5C mitigation pathway without negative emissions

A. University of Technology Sydney is a dynamic and innovative university in central Sydney and one of Australia's leading universities of technology. Our vision for sustainable Energy Futures is one in which energy is clean, affordable and accessible to all, where energy systems and services support a high quality of life and in which people and communities are empowered. We recognize that radical transformation is needed to replace old, outdated and polluting energy systems and to tackle one of the major causes of climate change. We view the energy system holistically and work on improving every part of it, from financing and business models, to policy and regulation, to technology analysis.

B. The German Aerospace Center (DLR) is one of Germany's largest federal research centers with a staff of 8.000. Amongst others, it does research in the fields of energy and transport, specifically for efficient energy systems that conserve natural resources. Special focusses are on technological, environmental, and economic potentials of Renewable Energy in the context of energy economy, advanced energy system modeling & development of energy scenarios and the analysis of future vehicle concepts for road and rail traffic as well as the analysis of future vehicle concepts for road and rail traffic from the perspective of engineering, commerce, society, and environment. (<http://www.dlr.de/tt/en/>)

C. The University of Melbourne (UM) co-leads a new bilateral research collaboration with top German institutions including Germany's Potsdam Institute for Climate Impact Research (PIK) to perform research into the economic opportunities of a zero carbon future. Also, the University of Melbourne houses the Australian-German Climate & Energy College where the MAGICC climate model is maintained that is used throughout various IPCC Assessment reports, including the forthcoming Special Report on 1.5C.

The Concept

Leonardo DiCaprio Foundation (LDF) Project – Background: One Generation Decarbonisation

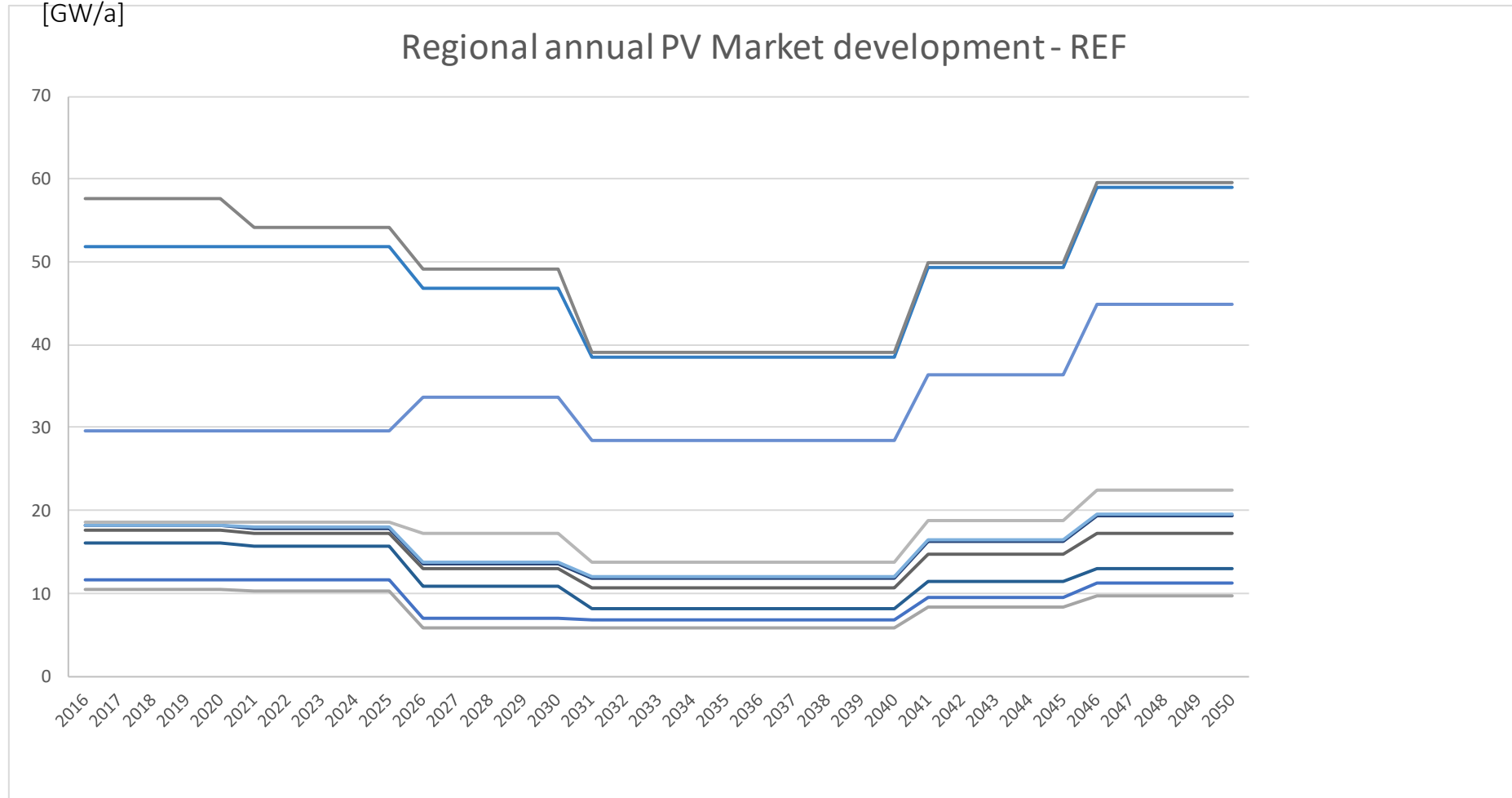
A global 1.5C mitigation pathway without negative emissions

- Development of a 100% renewable energy scenario
- De-carbonization of the entire global energy sector within one generation (until 2050).
- Based only on technologies currently available or under development, excluding BioEnergy-with-CCS and nuclear energy.
- The scenario was modelled for 10 world regions
- All sectors: power, buildings, industry and transport
- The power sector was modelled in hourly resolution order to assess storage demand and demand side management options for the integration of high shares of variable renewable energy, such as solar and wind for all regions.
- Non-energy related green-house-gas (GHG) emission scenarios were developed in order to define a sustainable pathway for land-use change and the agricultural sector.

All pathways are evaluated in regard to their implicit use of the carbon budget and their exceedance probabilities for 1.5°C and 2°C

Reference scenario - IEA

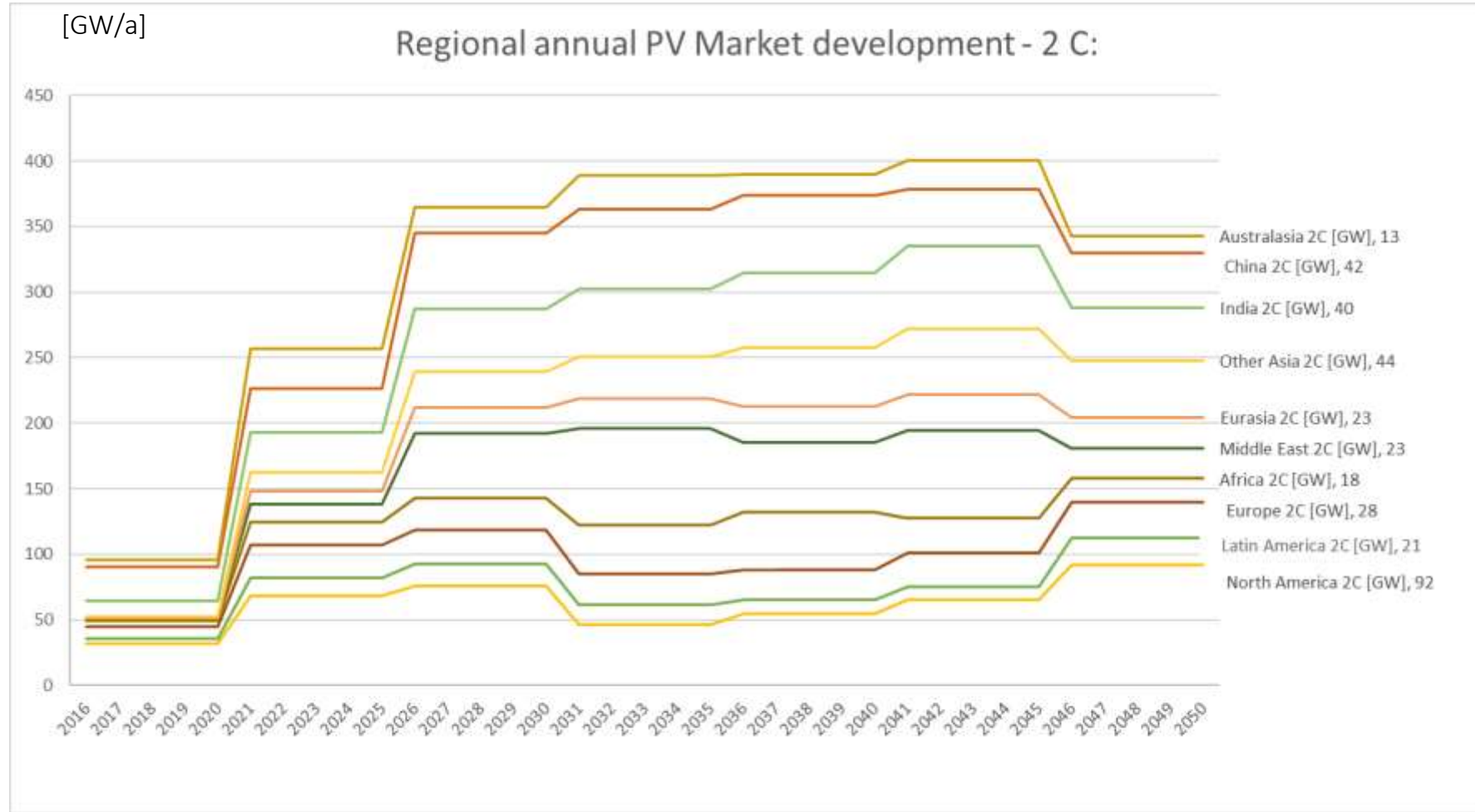
Possible Role of Solar PV by 2050: REFERENCE and LDF 2°C



The IEA World Energy Outlook 2016 predicts a flat – slowly declining - global PV market till 2035

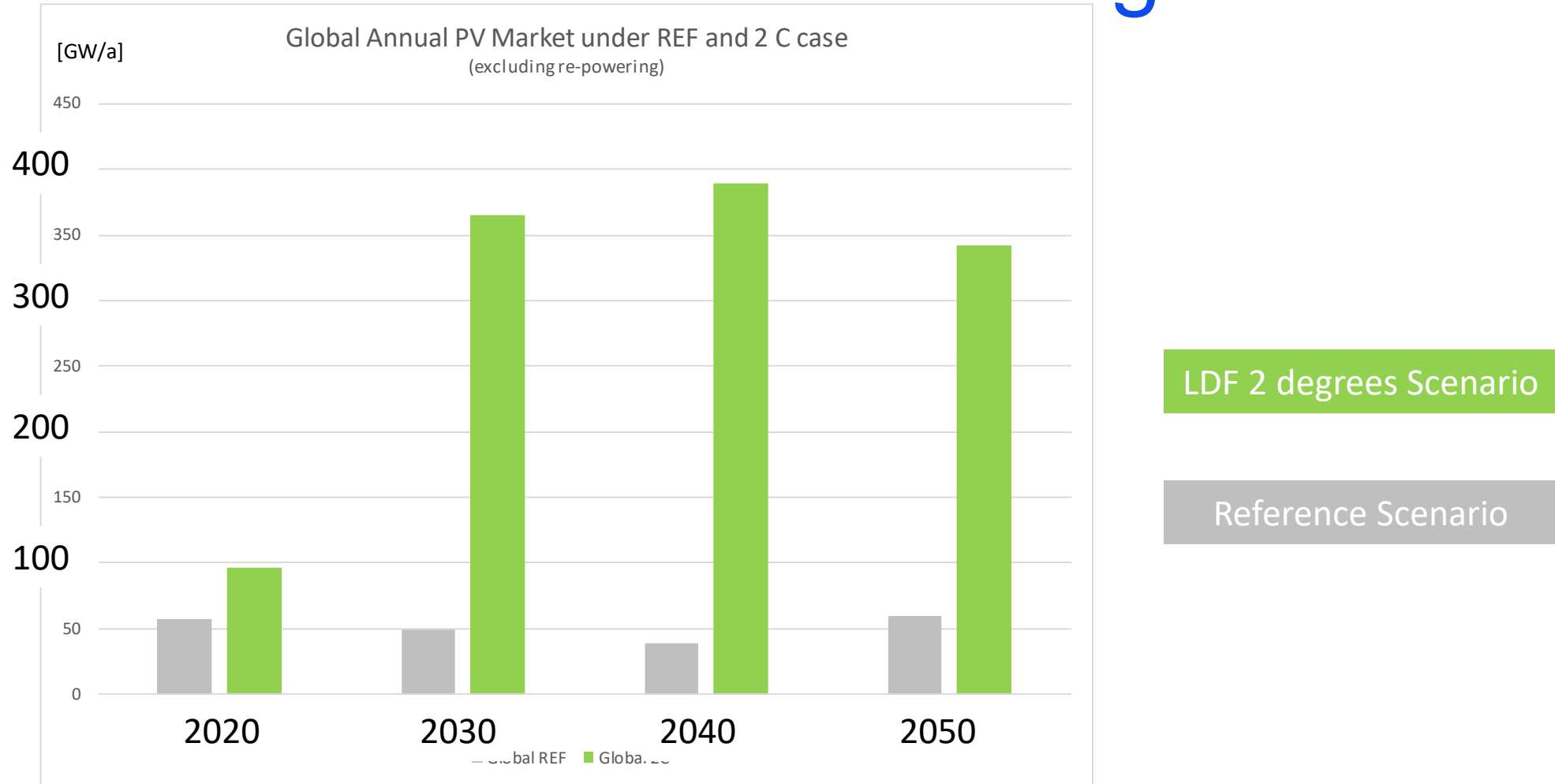
Global path to 2 degrees scenario

Possible Role of Solar PV by 2050: REFERENCE and **LDF 2°C**



The LDF 2 ° C - 2050: Largest market North America (92 GW/a), 3 regions with a market of around 40 GW/a and 5 regions 20+ GW/a.
 - No repowering included -

Reference and LDF 2 deg. C scenarios



The 2 °C Scenario expects doubling of the global PV market by 2021 to over 200GW/a and around 350 GW/a by 2030
 - No repowering included -

Cumulative PV Capacity by 2050: 2°C & 1.5 °C scenarios

Case	Unit	2015	2020	2025	2030	2035	2040	2045	2050	
- PV	World 5.0 C	[GW]	226	515	785	1,031	1,226	1,422	1,690	2,017
- PV	World 2.0 C	[GW]	225	712	2,194	4,158	6,196	8,343	10,532	12,306
- PV	World 1.5 C	[GW]	225	733	2,829	5,133	7,485	10,017	11,842	12,684
- PV	OECD North America 5.0 C	[GW]	29	81	133	162	191	220	280	358
- PV	OECD North America 2.0 C	[GW]	29	91	534	991	1,223	1,419	1,696	2,129
- PV	OECD North America 1.5 C	[GW]	29	91	659	1,007	1,388	1,783	2,083	2,269
- PV	Latin America 5.0 C	[GW]	2	8	14	19	24	29	35	42
- PV	Latin America 2.0 C	[GW]	2	43	108	175	260	295	329	409
- PV	Latin America 1.5 C	[GW]	2	49	133	237	401	529	557	537
- PV	OECD Europe 5.0 C	[GW]	95	117	137	157	164	172	182	191
- PV	OECD Europe 2.0 C	[GW]	95	140	264	422	585	745	911	996
- PV	OECD Europe 1.5 C	[GW]	95	140	364	598	814	1,028	1,110	1,151
- PV	Africa 5.0 C	[GW]	2	9	17	27	40	52	68	89
- PV	Africa 2.0 C	[GW]	2	20	38	134	345	611	846	983
- PV	Africa 1.5 C	[GW]	2	25	70	166	392	757	930	1,162
- PV	Middle East 5.0 C	[GW]	0	3	7	10	15	21	29	40
- PV	Middle East 2.0 C	[GW]	0	24	76	187	350	560	878	1,069
- PV	Middle East 1.5 C	[GW]	0	32	92	236	412	587	912	928
- PV	Eurasia 5.0 C	[GW]	4	4	5	6	7	8	9	10
- PV	Eurasia 2.0 C	[GW]	4	11	108	209	324	502	670	817
- PV	Eurasia 1.5 C	[GW]	4	25	132	294	475	678	788	821
- PV	Other Asia 5.0 C	[GW]	4	6	9	26	35	44	56	70
- PV	Other Asia 2.0 C	[GW]	3	15	107	287	526	806	1,062	1,282
- PV	Other Asia 1.5 C	[GW]	3	15	157	396	657	907	1,106	1,256
- PV	India 5.0 C	[GW]	5	60	115	198	271	345	433	545
- PV	India 2.0 C	[GW]	5	65	230	469	754	1,090	1,410	1,572
- PV	India 1.5 C	[GW]	5	65	365	648	927	1,185	1,346	1,412
- PV	China 5.0 C	[GW]	43	154	265	330	380	430	495	565
- PV	China 2.0 C	[GW]	43	211	504	889	1,257	1,614	1,935	2,218
- PV	China 1.5 C	[GW]	43	211	604	1,036	1,417	1,781	2,131	2,215
- PV	OECD Pacific 5.0 C	[GW]	43	73	84	96	99	102	105	107
- PV	OECD Pacific 2.0 C	[GW]	43	93	225	394	572	701	796	831
- PV	OECD Pacific 1.5 C	[GW]	43	80	253	427	602	782	879	932

4158 GW
by 2030
(2 deg case)

Global PV
Capacity in 2030
increases by
factor 10 (2.0 °C)
/ factor 12 (1.5°C)

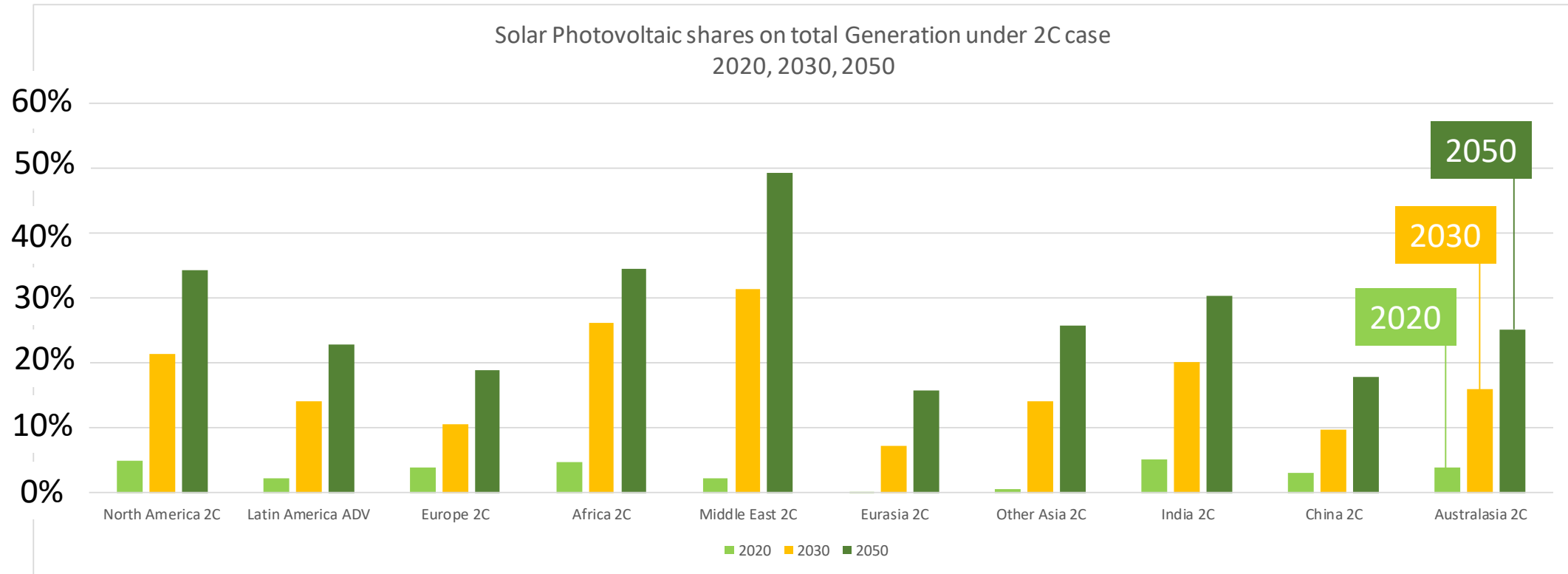
PV Capacity Shares: 2°C & 1.5 °C scenarios

Case	Unit	2015	2020	2025	2030	2035	2040	2045	2050
- PV World 5.0 C	[%]	4%	7%	9%	11%	12%	12%	14%	15%
- PV World 2.0 C	[%]	4%	10%	22%	31%	36%	38%	41%	43%
- PV World 1.5 C	[%]	4%	10%	27%	34%	38%	41%	43%	44%
- PV OECD North America 5.0 C	[%]	2%	6%	9%	10%	11%	12%	14%	17%
- PV OECD North America 2.0 C	[%]	2%	6%	27%	37%	39%	41%	43%	47%
- PV OECD North America 1.5 C	[%]	2%	6%	31%	37%	41%	44%	47%	49%
- PV Latin America 5.0 C	[%]	1%	2%	3%	4%	4%	5%	5%	6%
- PV Latin America 2.0 C	[%]	1%	10%	21%	27%	31%	31%	31%	35%
- PV Latin America 1.5 C	[%]	1%	12%	24%	31%	36%	39%	39%	38%
- PV OECD Europe 5.0 C	[%]	9%	10%	11%	12%	12%	12%	12%	13%
- PV OECD Europe 2.0 C	[%]	9%	12%	20%	27%	32%	35%	39%	40%
- PV OECD Europe 1.5 C	[%]	9%	12%	26%	34%	38%	41%	42%	43%
- PV Africa 5.0 C	[%]	1%	4%	5%	7%	9%	10%	11%	13%
- PV Africa 2.0 C	[%]	1%	8%	11%	23%	35%	39%	41%	41%
- PV Africa 1.5 C	[%]	1%	10%	18%	25%	34%	42%	41%	43%
- PV Middle East 5.0 C	[%]	0%	1%	2%	2%	3%	4%	5%	6%
- PV Middle East 2.0 C	[%]	0%	7%	16%	25%	31%	36%	46%	49%
- PV Middle East 1.5 C	[%]	0%	9%	19%	29%	32%	34%	46%	46%
- PV Eurasia 5.0 C	[%]	1%	1%	1%	1%	1%	1%	2%	2%
- PV Eurasia 2.0 C	[%]	1%	2%	17%	26%	30%	34%	36%	38%
- PV Eurasia 1.5 C	[%]	1%	5%	20%	32%	37%	39%	40%	39%
- PV Other Asia 5.0 C	[%]	1%	2%	2%	4%	5%	5%	6%	6%
- PV Other Asia 2.0 C	[%]	1%	4%	19%	32%	39%	42%	44%	45%
- PV Other Asia 1.5 C	[%]	1%	4%	19%	32%	39%	42%	44%	45%
- PV India 5.0 C	[%]	2%	12%	17%	21%	23%	25%	27%	30%
- PV India 2.0 C	[%]	2%	14%	26%	33%	36%	39%	41%	42%
- PV India 1.5 C	[%]	2%	15%	35%	39%	41%	43%	42%	41%
- PV China 5.0 C	[%]	3%	8%	11%	12%	13%	13%	15%	16%
- PV China 2.0 C	[%]	3%	11%	20%	29%	34%	36%	37%	39%
- PV China 1.5 C	[%]	3%	11%	24%	30%	35%	37%	38%	38%
- PV OECD Pacific 5.0 C	[%]	8%	13%	15%	16%	16%	16%	16%	16%
- PV OECD Pacific 2.0 C	[%]	9%	16%	30%	41%	48%	52%	53%	53%
- PV OECD Pacific 1.5 C	[%]	9%	14%	33%	42%	47%	51%	52%	53%

Global PV Capacity Shares over 25% in most world regions

2°C: High PV penetration in power grids world wide

The 2 °C Scenario leads to a PV generation share **by 2030 of around 10-20%** in the power grid in all 10 world regions.
By 2050 PV supplies around 20-30+% across regions.



China: Storage Demand

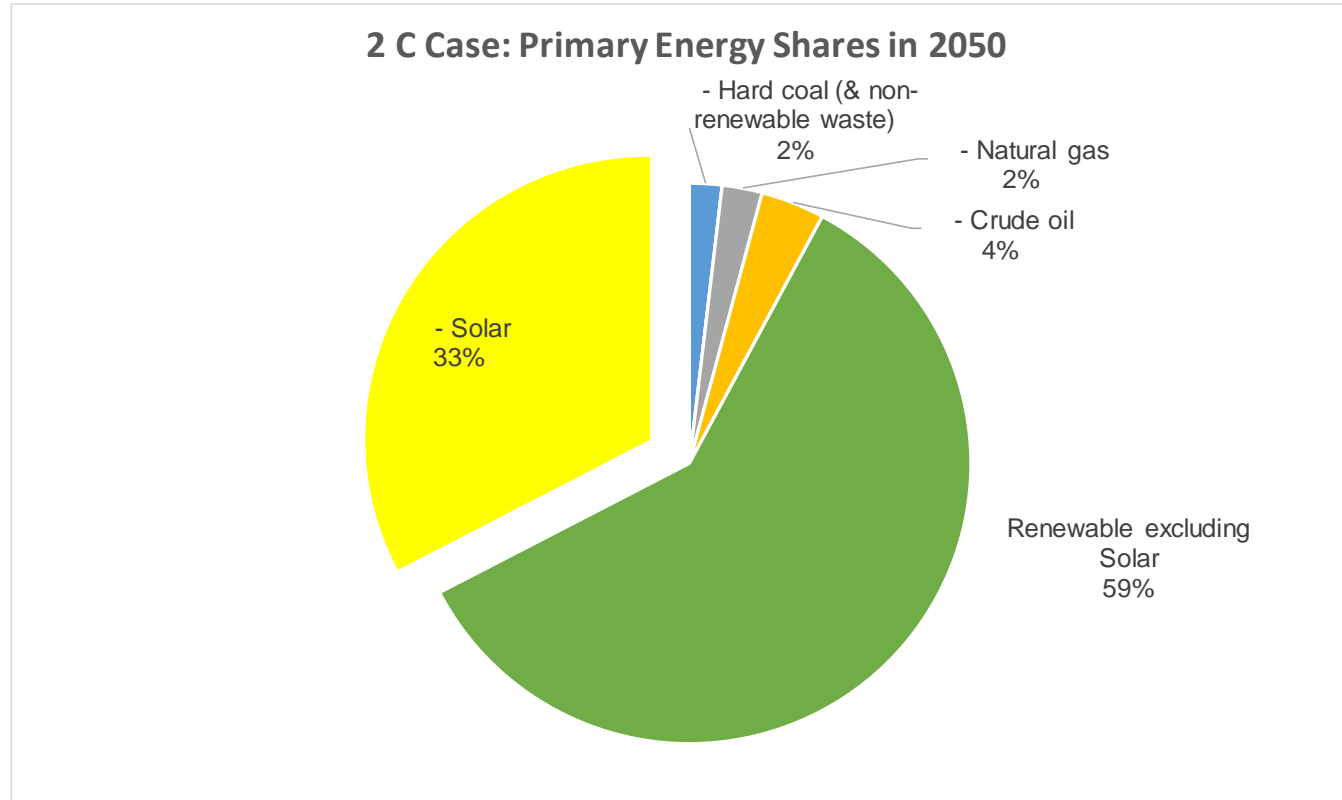
– including generation used for fuel production

Storage and Dispatch Requirements		2.0° C		1.5° C	
		Required storage to avoid curtailment [GWh/yr]	Required storage capacity to avoid curtailment [GW/yr]	Required storage to avoid curtailment [GWh/yr]	Required storage capacity to avoid curtailment [GW/yr]
China					
China-North	2020	0	0	0	0
Central	2030	45	17	6,734	90
	2050	14,152	153	39,562	233
China-Northwest	2020	158	6	326	8
UK & Islands	2030	7	4	3,401	36
	2050	12,360	76	31,642	114
China-Northeast	2020	0	0	0	0
Iberian Peninsula	2030	912	17	11,430	48
	2050	24,955	93	49,329	127
China-Tibet	2020	0	0	0	0
Balkans + Greece	2030	0	0	43	0
	2050	0	0	3	0
China-Central	2020	0	0	0	0
Baltic	2030	6	3	6,013	87
	2050	4,763	113	23,175	212
China-East	2020	0	0	0	0
Nordic	2030	59	18	8,720	111
	2050	17,604	201	50,402	303
China-South	2020	0	0	0	0
Turkey	2030	74	17	8,676	95
	2050	21,703	183	56,742	272
Taiwan	2020	0	0	0	0
	2030	0	0	202	9
	2050	6,506	38	13,873	44
China	2020	158	6	326	8
	2030	1,102	75	45,217	476
	2050	102,042	849	264,729	1,305

Little storage demand before 2025

Storage requirement for variable Generation (PV and Wind) increases dramatically after 2030.

2°C Scenario : Solar grows to the single biggest PRIMARY ENERGY contributor globally



The 2°C increased electrification of the transport, heating and industry sector – with the assumed uptake of storage technologies – leads to 1/3 solar energy. This includes PV, CSP and Solar heating.

Findings

- The Solar PV Industry has a huge role to play in limiting dangerous climate change
- Global PV Market will continue to grow by double digits for at least one more decade
 - Work force will increase from currently around 3 million to 5 million+
 - Education and Training requirements continue to increase
 - Resources requirements – for example Silver – will in be high demand and need strategic resources planning including recycling infrastructure
- Generation Management, Storage and Solar-Generation Forecasting will play a significantly higher role in just 5 to 7 years
- “Base load” power plants will have to be replaced by “Flexible Power Plants” between 2020 and 2030 in all regions
 - (New) Business Concepts for utilities – and the required policy - needed



Design for renewable energy & resource cycles for a circular economy

New model: social access 'solar gardens'



Australian Government
Australian Renewable
Energy Agency

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Solar gardens to bring rooftop solar to all Australians

Allowing renters or those renting or without roof space to access solar

CATEGORY

 News

DATE

17 May 2018

PROJECT

N/A

Know-how to accelerate the transition



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Seeking partners ahead
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The proposed research themes of the RACE for 2030 CRC, subject to partner input, include:

- 1: RACE for Industry** - Boosting business energy productivity (via digitalisation, electrification and value chain optimisation)
- 2: RACE for Networks** - Optimising Australia's electricity grid through customer distributed energy resources and network integration
- 3: RACE for Consumers** - Developing and applying new energy technologies and solutions for consumers
- 4: RACE for the Future** - Foresighting, capacity building, training and education

Thank you

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