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Reducing climate risks with fast and complete energy transitions

Applying the precautionary principle to the Paris agreement

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16.3.2021
Frontiers in Energy Research, ETH Zürich

Background

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- Mechanical and environmental engineer
- my research focus:
  - how can society operate within Earth system boundaries
  - how to use this knowledge in product and service design


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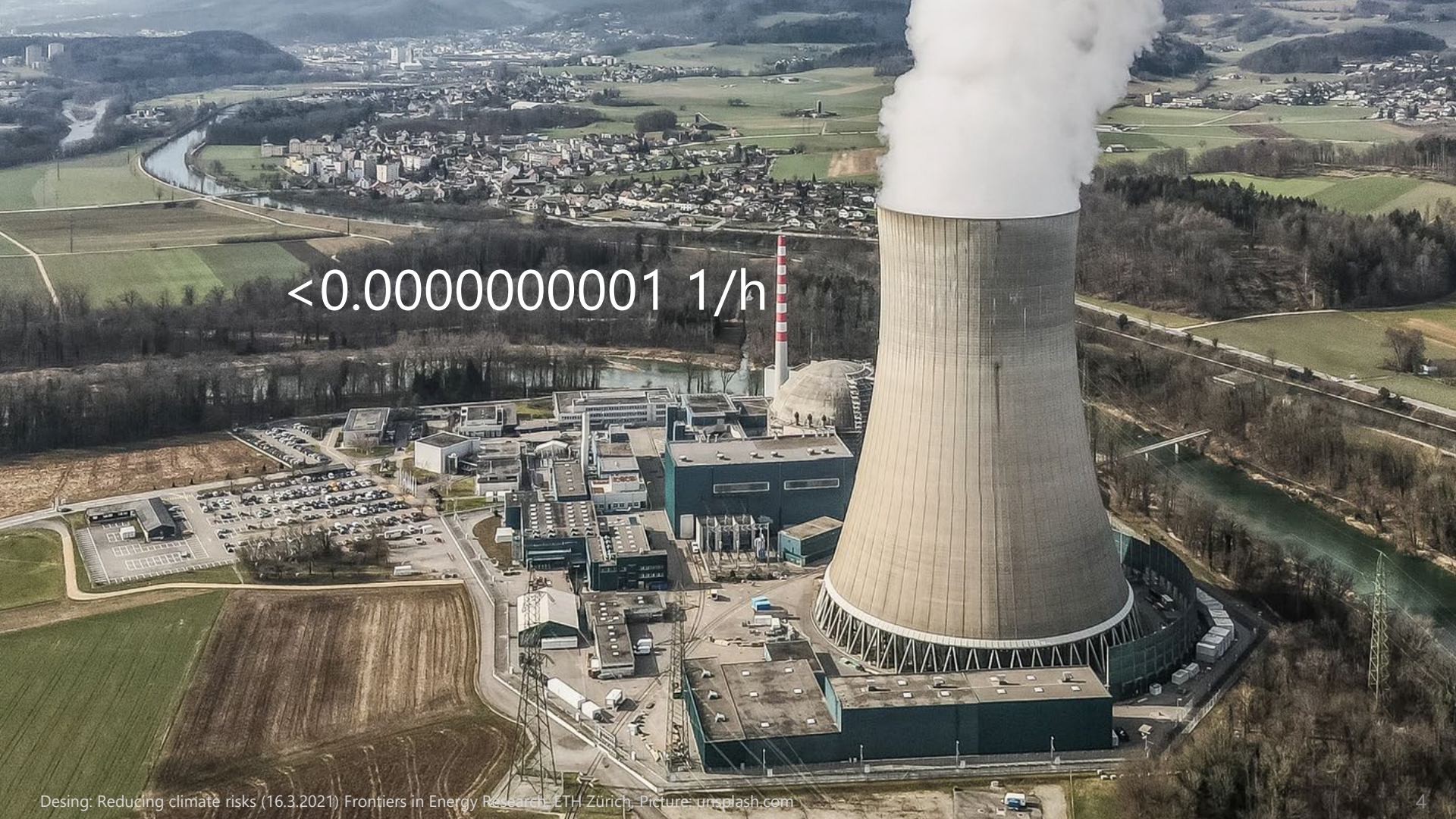

Desing: Reducing climate risks (16.3.2021) Frontiers in Energy Research: ETH Zürich. Picture: unsplash.com

Public health: probability of severe adverse effects from vaccinations

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Vaccine	severe adverse effect	P
Hep A	none	0
Hep B	anaphylactic reactions	1.10E-06
HPV	anaphylactic reactions	1.70E-06
MMR	allergic reactions	3.50E-06
MMR	thrombocytopenia	2.50E-05
Polio	vaccine-associated paralytic poliomyelitis	1.45E-07

https://www.who.int/initiatives/the-global-vaccine-safety-initiative/tools-and-methods/reaction-rates-information-sheets

… and for climate?

Paris agreement

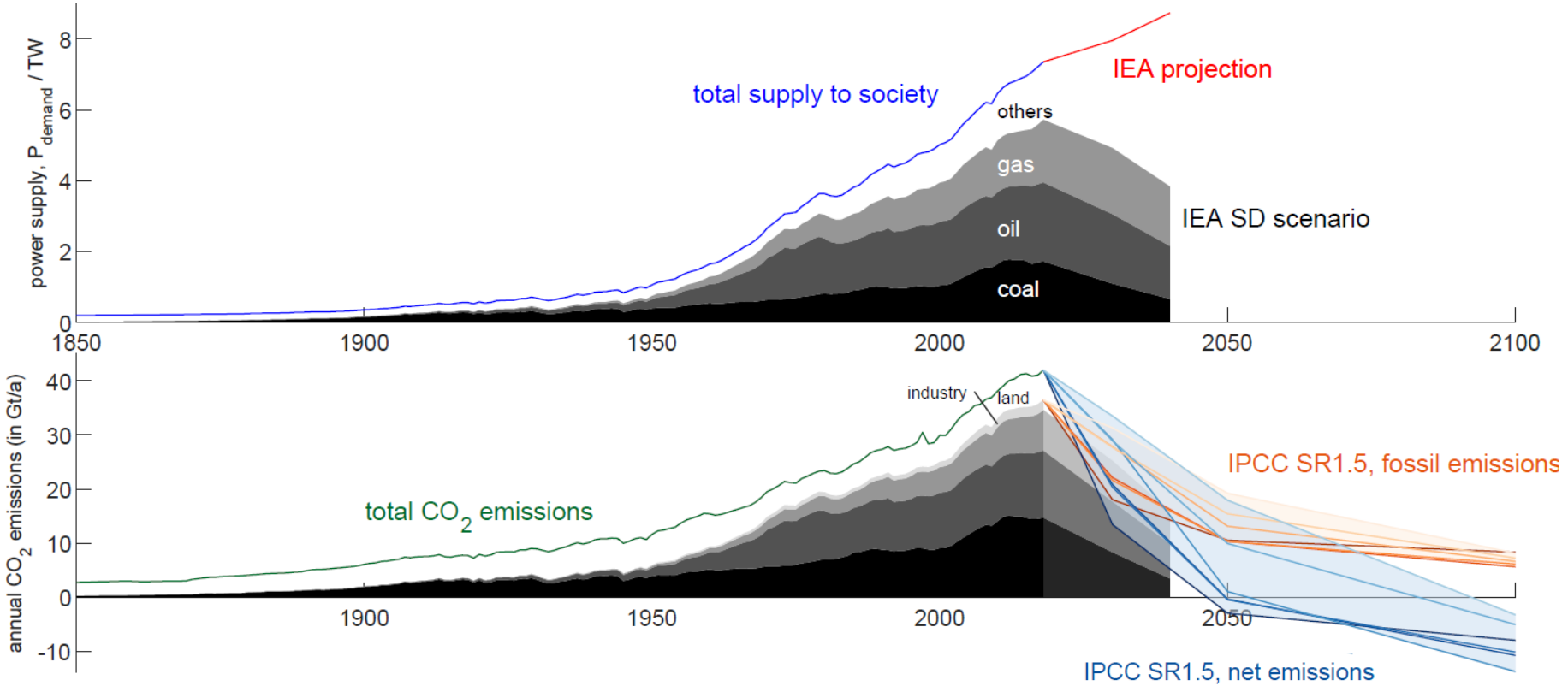
- "… holding the increase in the global average temperature to well below 2°C, **preferably to 1.5°C,** above pre-industrial levels."

- Translates into temperature targets for transition pathways (e.g. IPCC SR1.5), either aiming at limiting peak heating to 1.5°C or 2°C

- Growing evidence suggests, that even crossing 1.5°C peak heating can be existential to the biosphere and humanity.

https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
IPCC SR1.5 2018
Hough-Guldberg et al. 2019; Lenton et al. 2019

Historic and projected energy demand and carbon emissions



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Historic and projected cumulative carbon emissions

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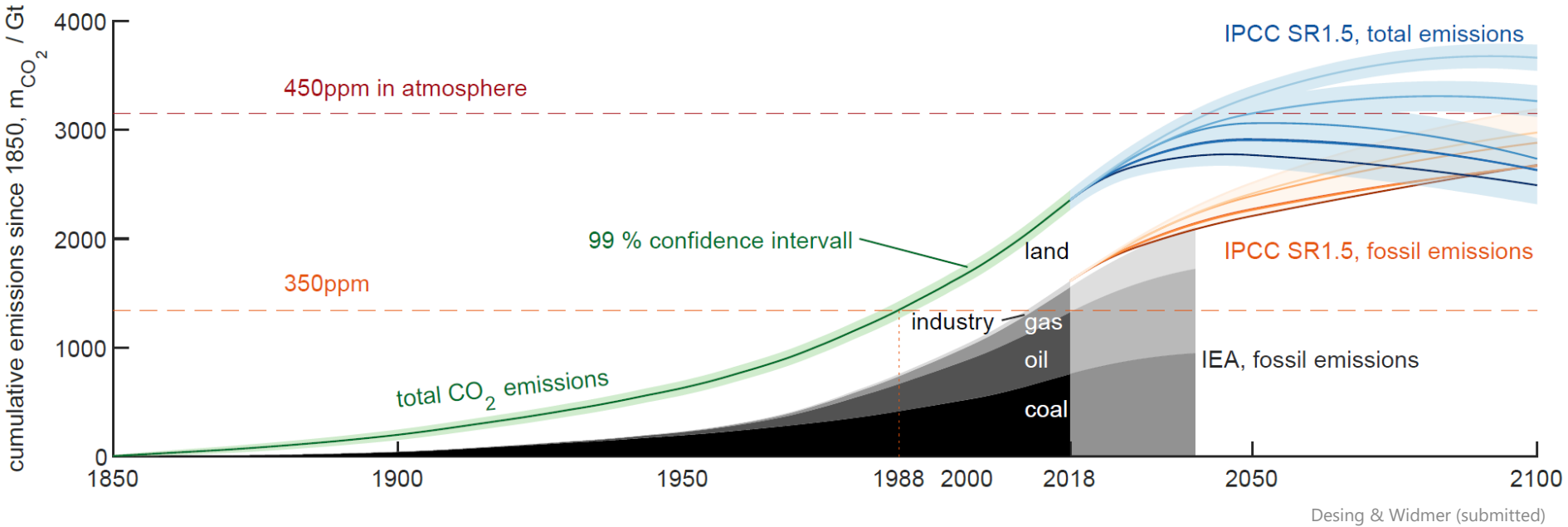

CO_2 emissions vs. temperature change

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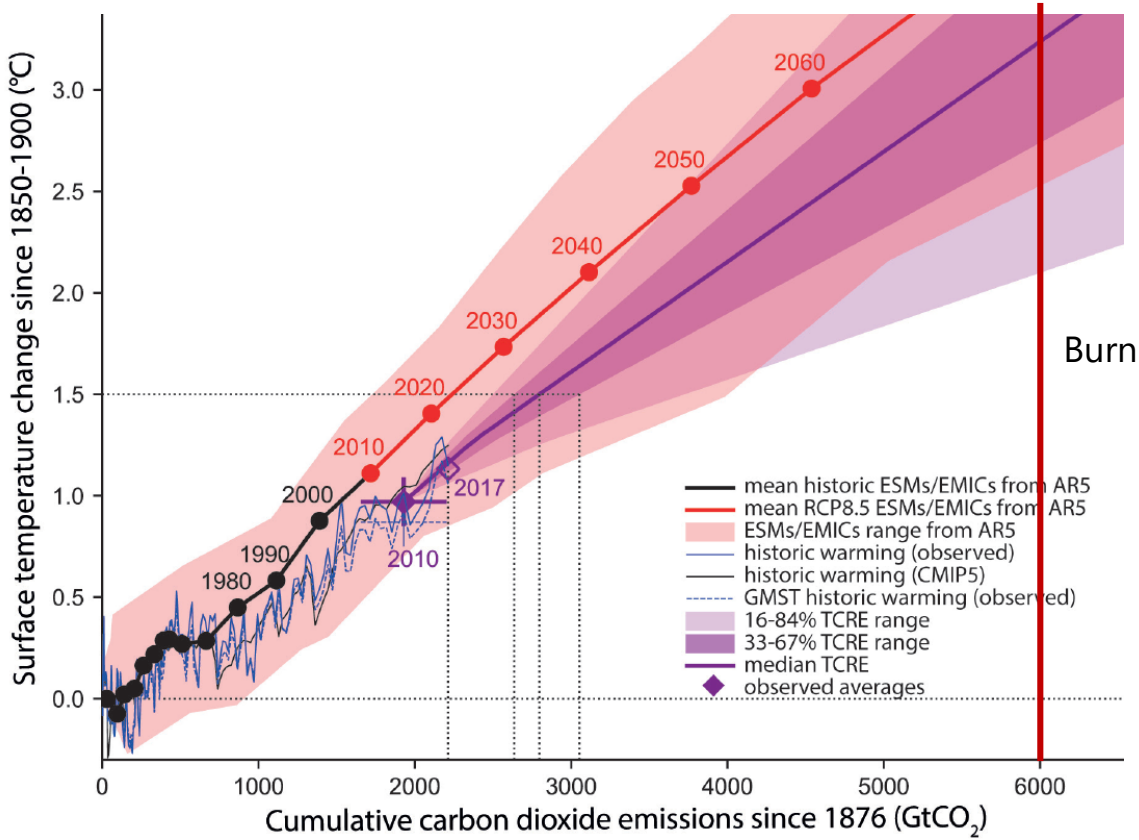

Burning all reserves

Burning all fossil resources

~60 000 (!)

IPCC 2018 (SR1.5, figure 2.3)

Uncertainty of remaining CO_2 budget

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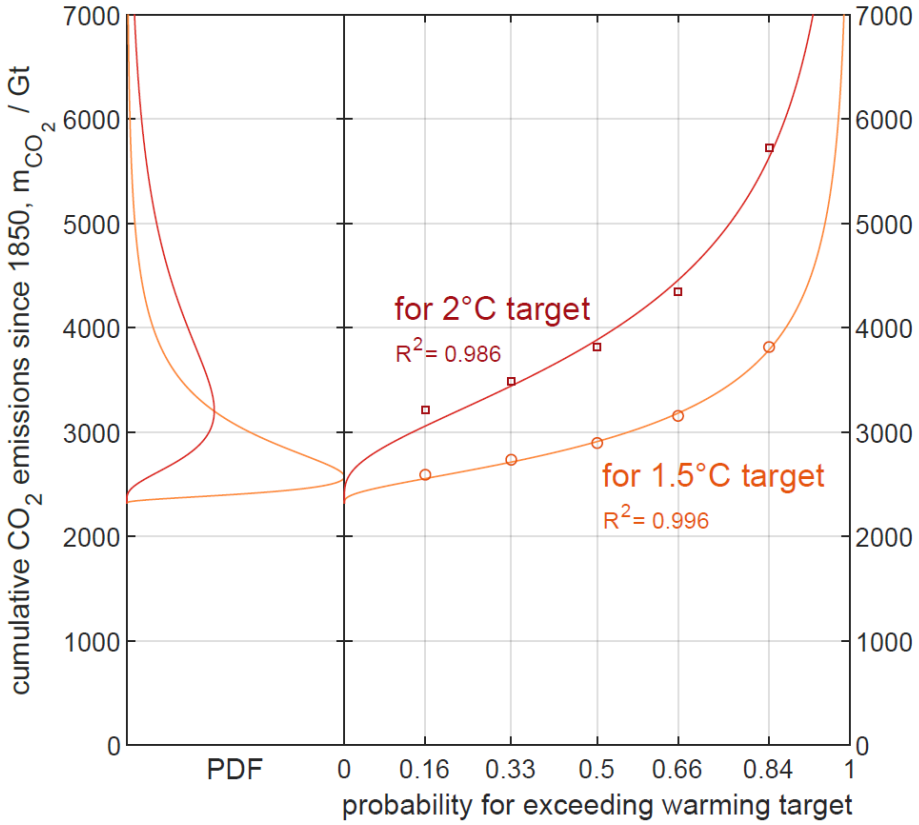
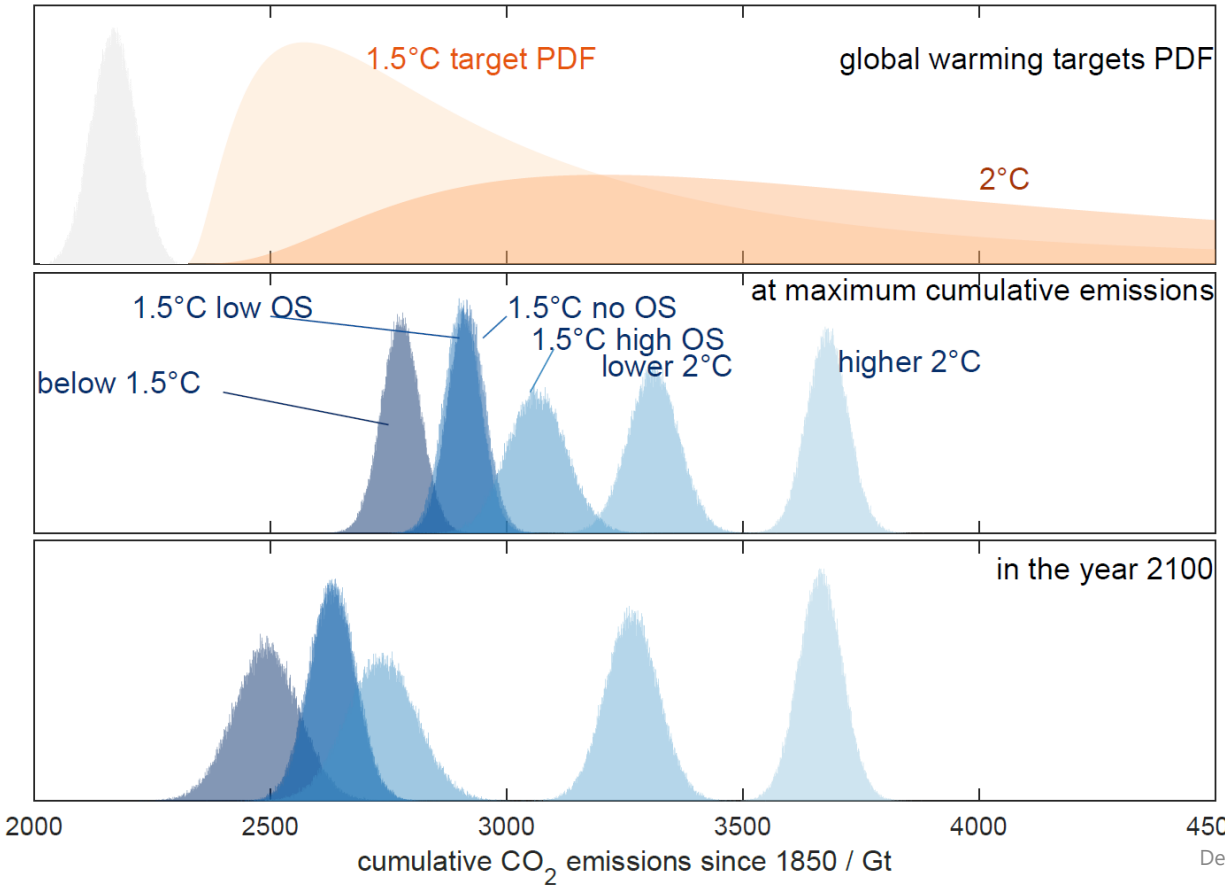


Based on IPCC 2018

Desing & Widmer (submitted)

Probability to exceed 1.5°C and 2°C with IPCC pathways



Desing & Widmer (submitted)

Probability to exceed 1.5°C and 2°C with IPCC pathways

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Scenario	maximum m_{CO_2} at t_{max}			in 2100	
	t_{max}	$P_{v,1.5\,°C}$	$P_{v,2\,°C}$	$P_{v,1.5\,°C}$	$P_{v,2\,°C}$
below 1.5 °C	2046	0.39	0.05	0.1	0.004
1.5 °C with low overshoot (OS)	2049	0.51	0.1	0.24	0.018
1.5 °C with no or limited OS	2049	0.5	0.1	0.25	0.019
1.5 °C with high OS	2053	0.6	0.16	0.35	0.043
lower 2 °C	2082	0.71	0.27	0.7	0.25
higher 2 °C	2092	0.82	0.42	0.81	0.42

Desing & Widmer (submitted)

How much can the probability to exceed 1.5°C peak heating still be reduced?

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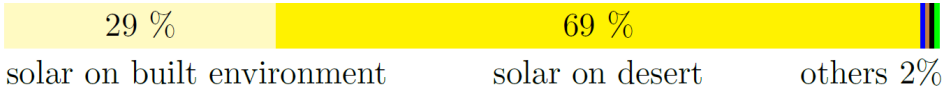
Current non-renewable energy system = fossil engine

Renewable energy system = solar engine

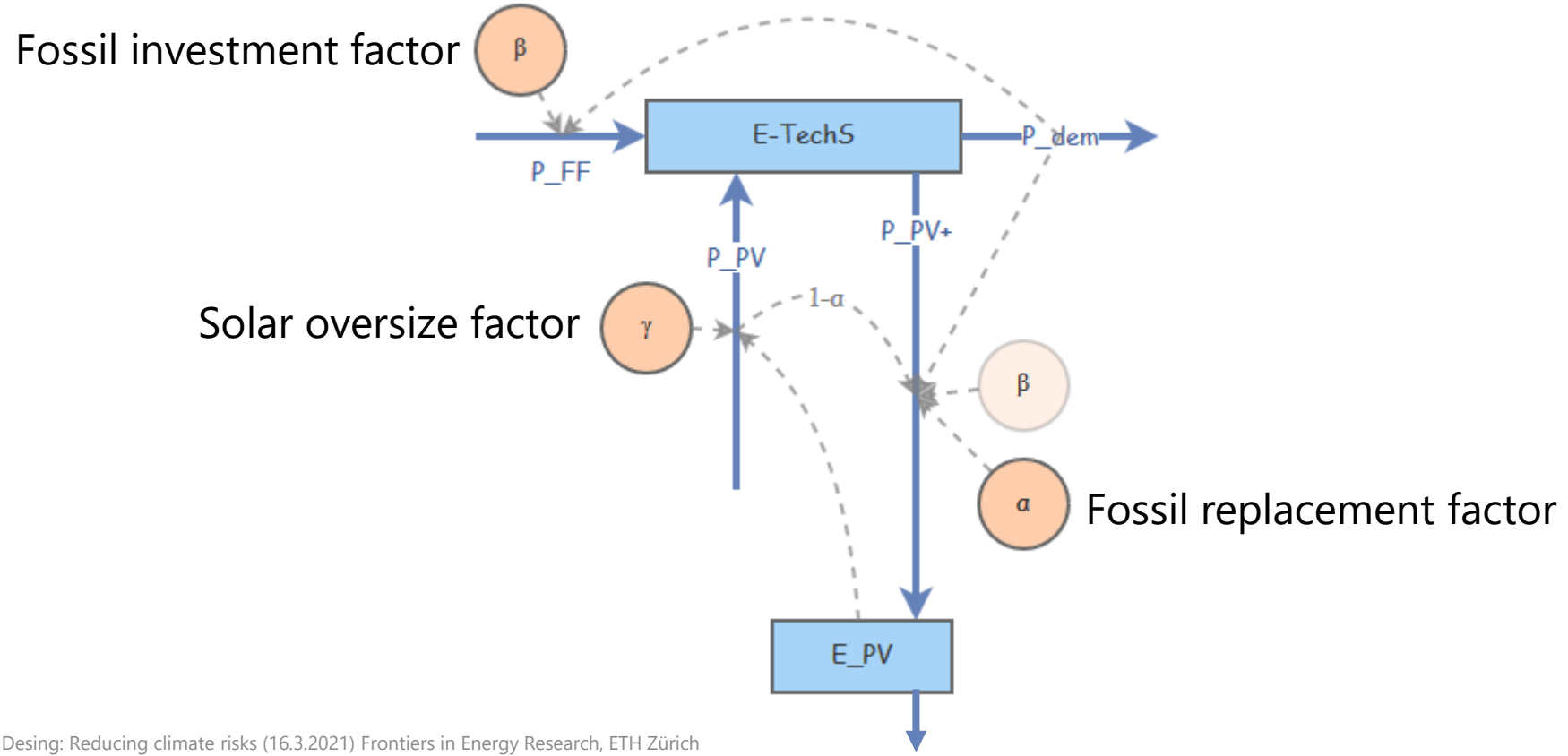
Why solar?

appropriable technical potential (ATP) to power a sustainable circular economy: 71 TW

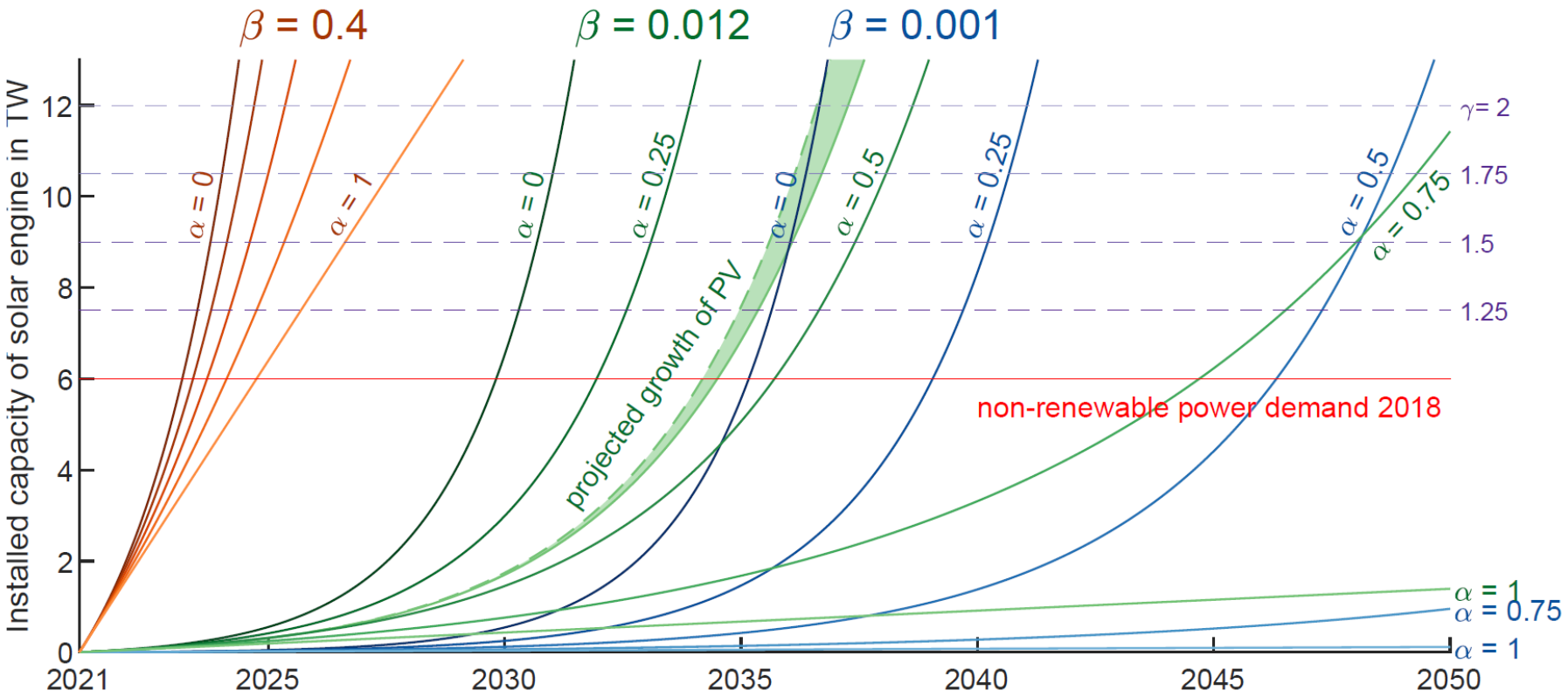


Desing et al. 2019

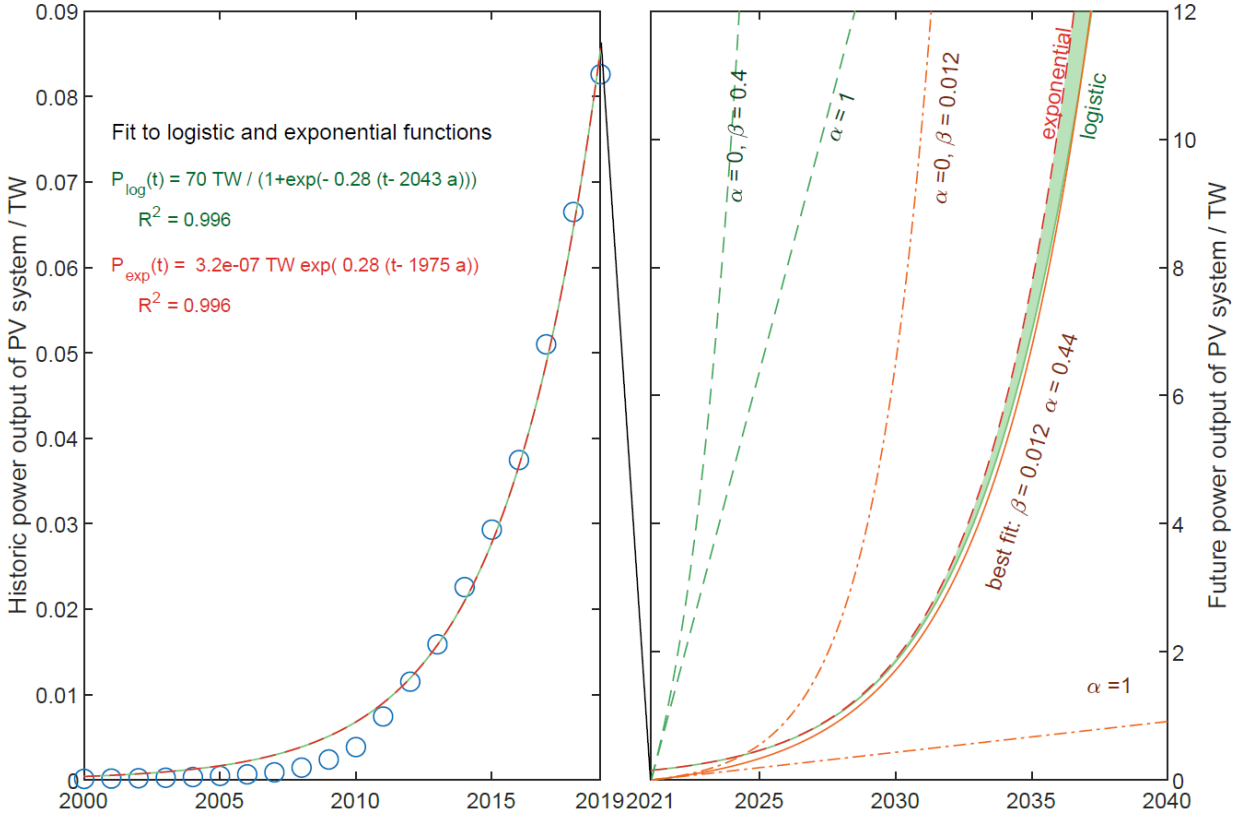
2 machines model: fossil → solar



Growth of the solar engine

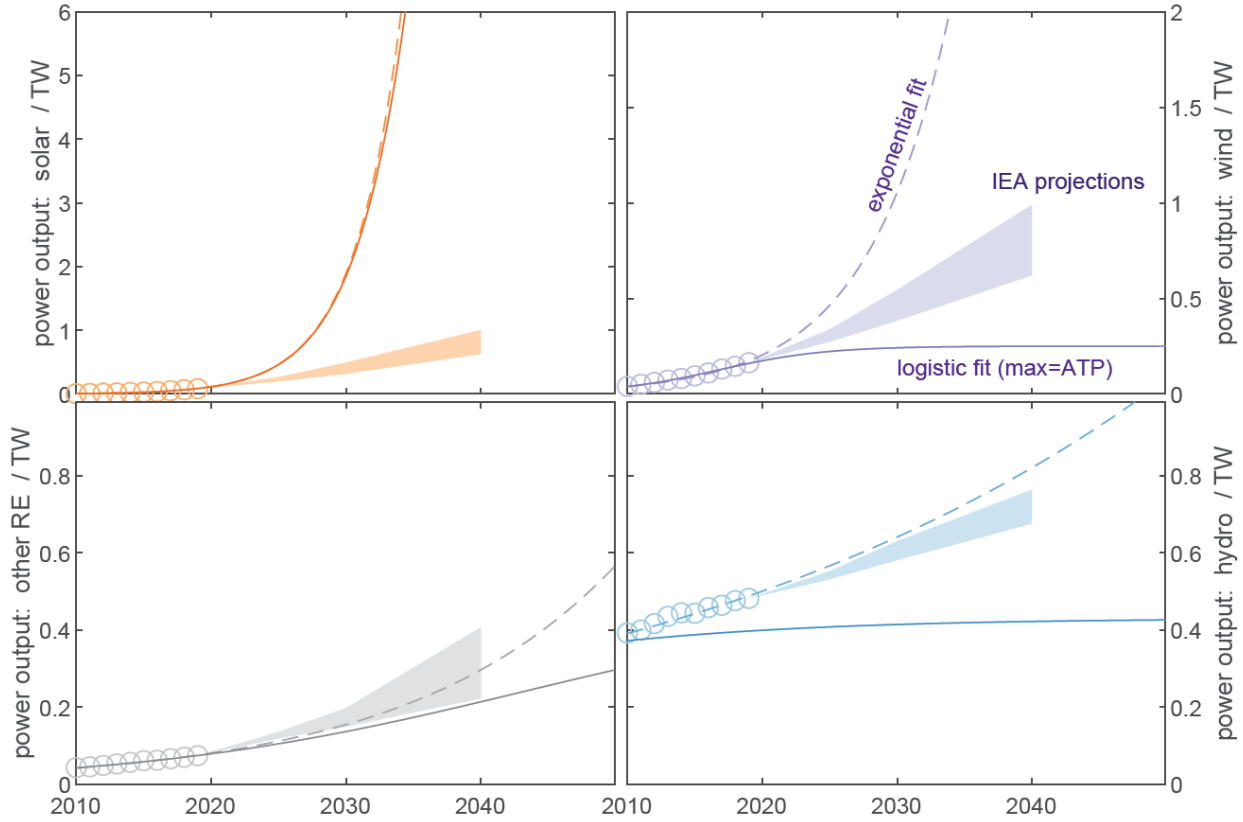


Is such fast growth of solar feasible?



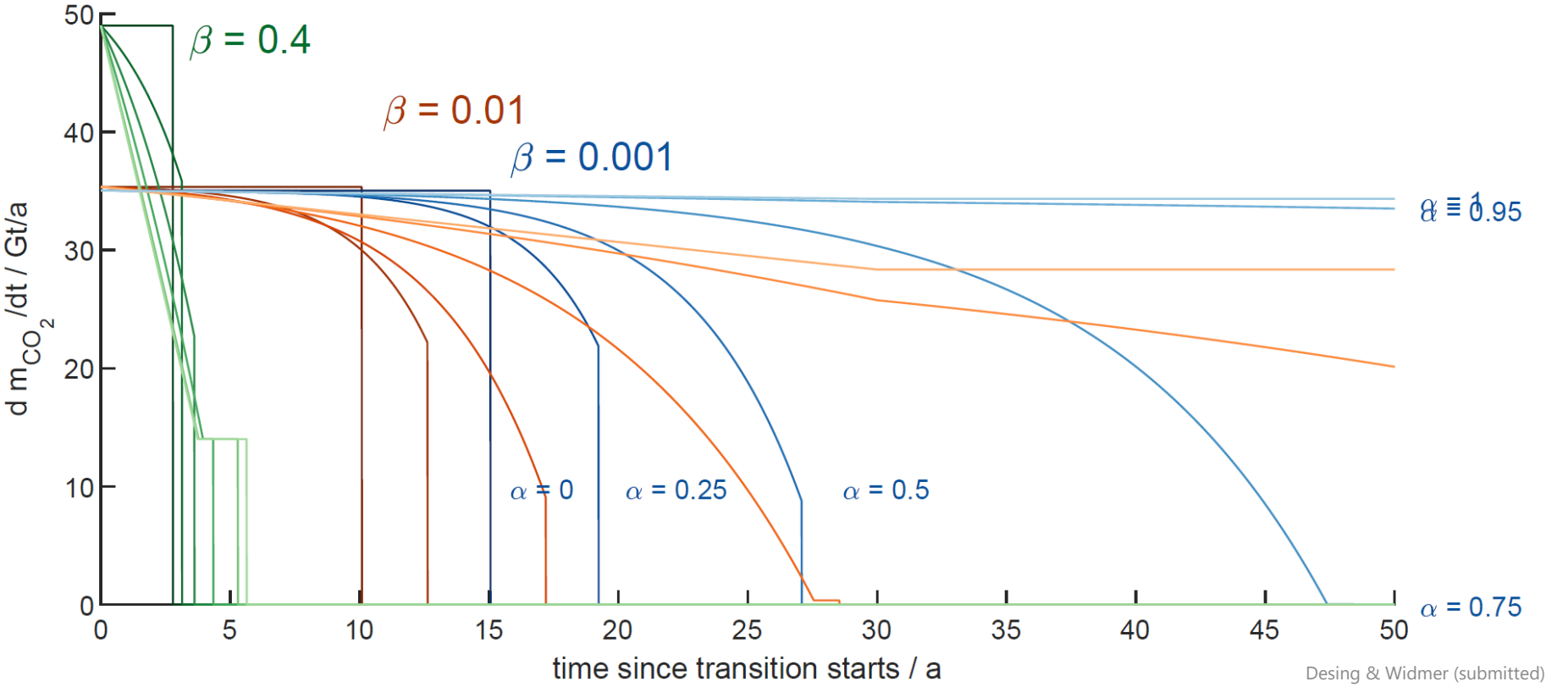
Desing & Widmer (submitted)
With data from BP (2020)

Comparison to IEA projections of RE growth



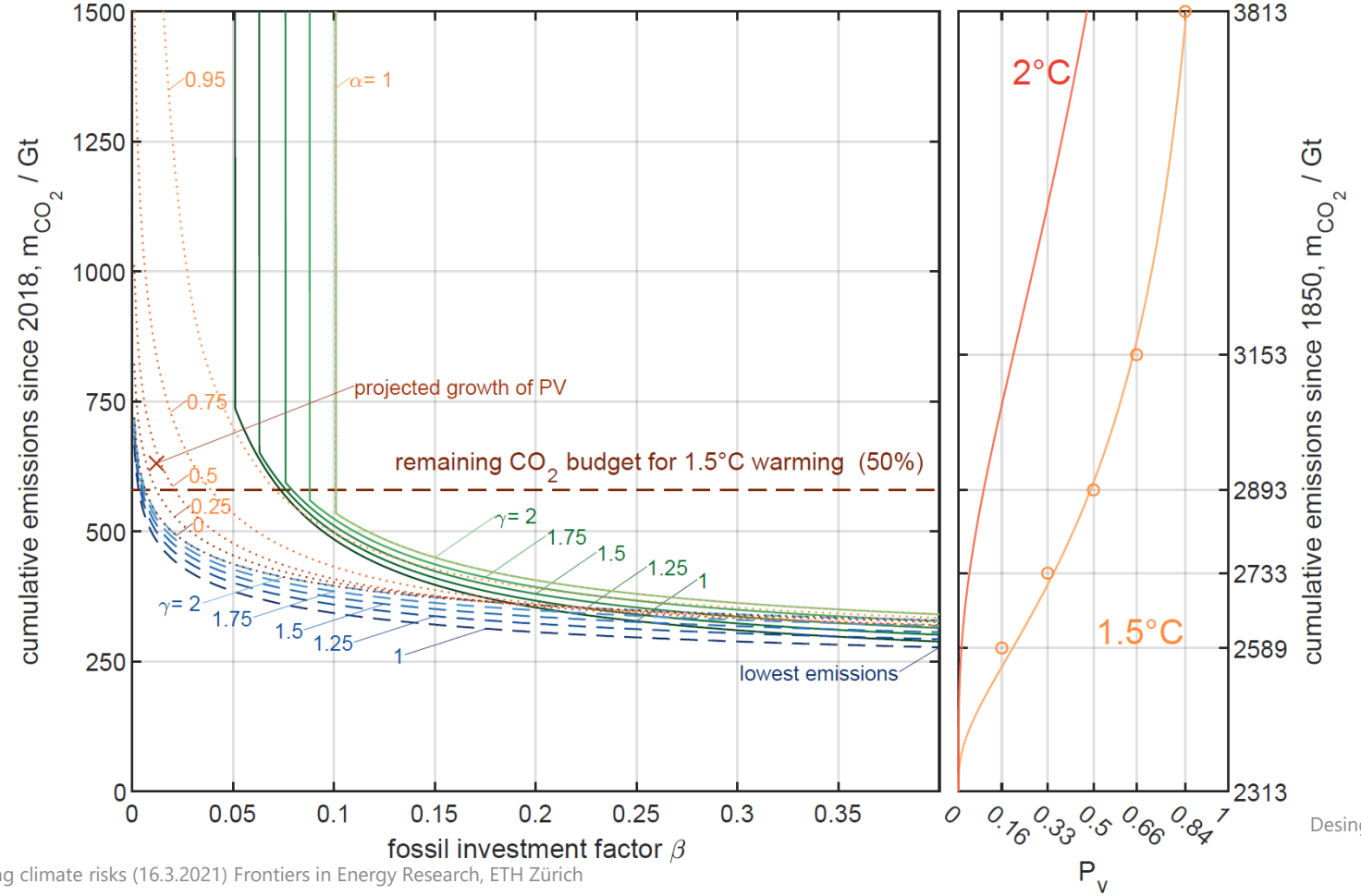
Desing & Widmer (submitted)
With data from BP (2020) and IEA (2020)

Carbon emissions



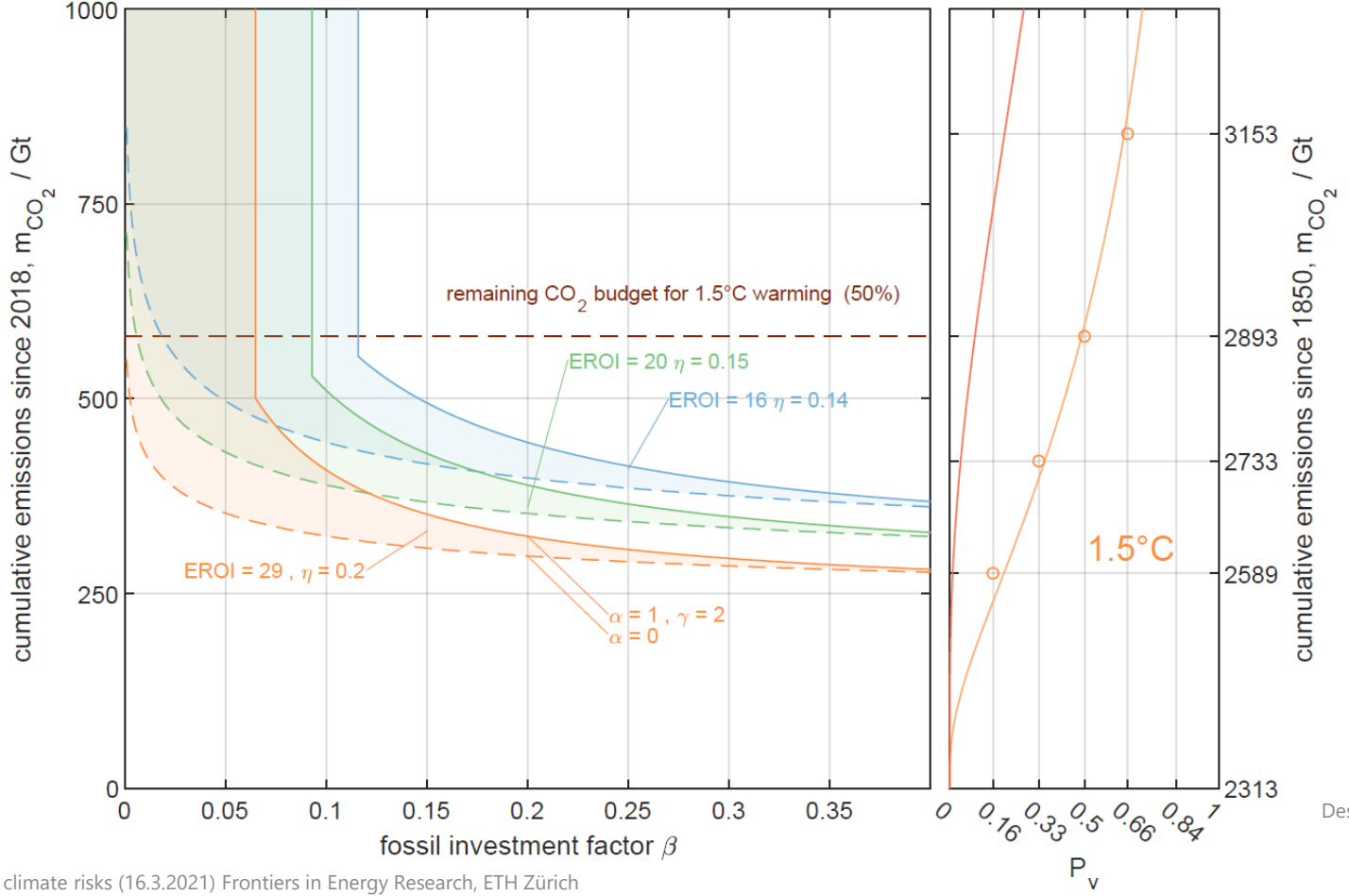
Desing & Widmer (submitted)

Results



Desing & Widmer (submitted)

Sensitivity



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Conclusion

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- Fast and complete energy transitions require temporarily increased fossil CO2 emissions above current levels
- Fast transitions can reduce the probability to violate 1.5°C peak heating significantly below 50%, however not below 20%.
- To reduce atmospheric CO2 concentration and stabilize the climate in the long run, CCS (not CCU!) is necessary
- How to use CCS together with fast and complete energy transitions?
  - 3-machines transition model

References

- Desing, H. and R. Widmer (submitted). "Reducing climate risks with fast and complete energy transitions: applying the precautionary principle to the Paris agreement." Environmental Research Letters. www.doi.org/10.31219/osf.io/5wf64

- Harald Desing, Rolf Widmer, Didier Beloin-Saint-Pierre, Roland Hischier, and Patrick Wäger. Powering a sustainable and circular economy—an engineering approach to estimating renewable energy potentials within earth system boundaries. Energies, 12(24):1–18, 2019. www.doi.org/10.3390/en12244723
- British Petroleum (BP). Statistical review of world energy, 2020.
- IPCC. Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Report, Intergovernmental Panel for Climate Change, 2018.
- International Energy Agency. World energy outlook. Report ISBN 9789264449237, International energy agency, 2020
- Lenton, T. M., J. Rockstrom, O. Gaffney, S. Rahmstorf, K. Richardson, W. Steffen and H. J. Schellnhuber (2019). "Climate tipping points - too risky to bet against." Nature 575(7784): 592-595.
- Hoegh-Guldberg, O., D. Jacob, M. Taylor, T. Guillen Bolanos, M. Bindi, S. Brown, I. A. Camilloni, A. Diedhiou, R. Djalante, K. Ebi, F. Engelbrecht, J. Guiot, Y. Hijioka, S. Mehrotra, C. W. Hope, A. J. Payne, H. O. Portner, S. I. Seneviratne, A. Thomas, R. Warren and G. Zhou (2019). "The human imperative of stabilizing global climate change at 1.5 degrees C." Science 365(6459): 1-11.

Questions?

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Thank you for your attention!

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