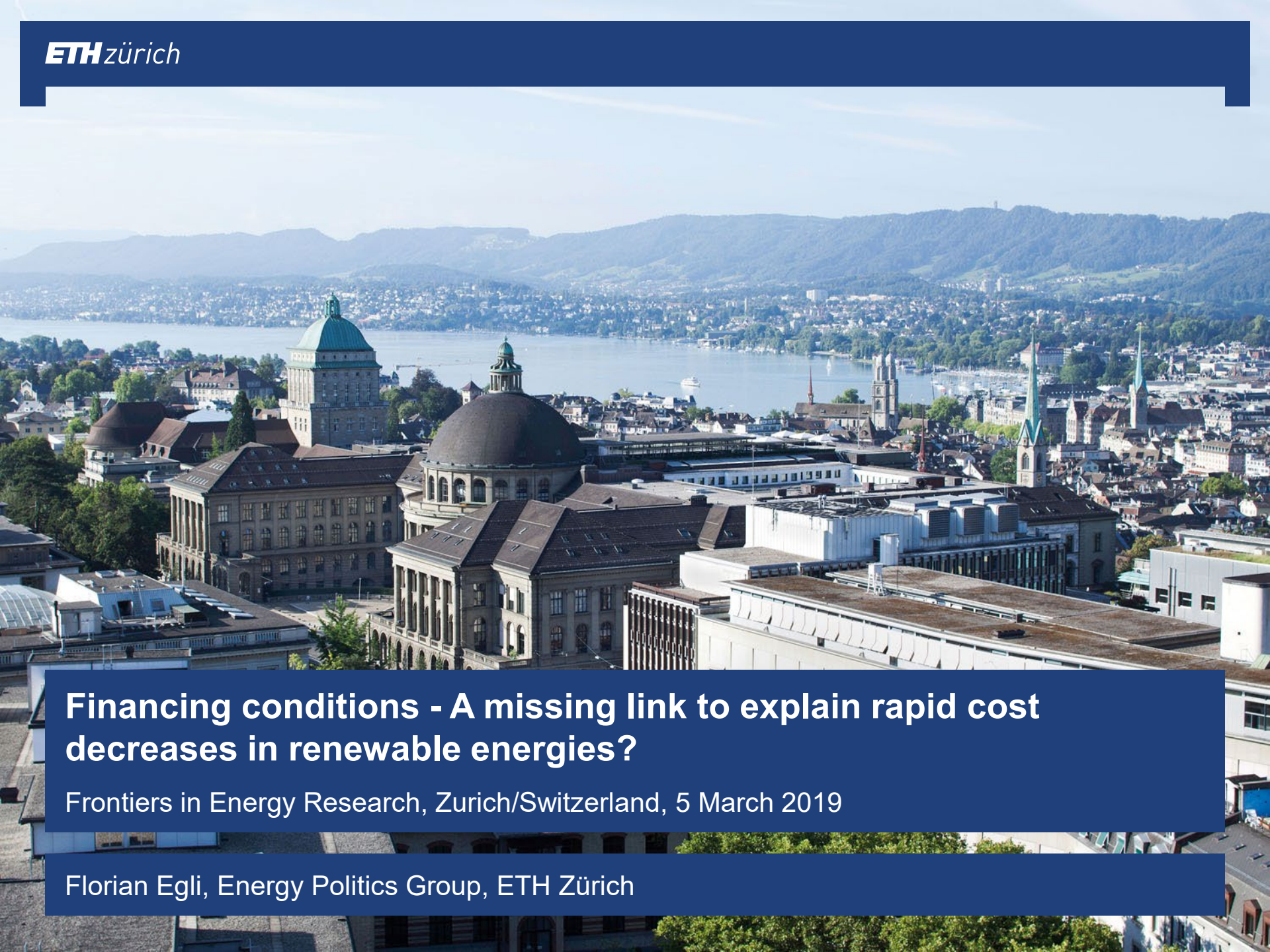


Financing conditions - A missing link to explain rapid cost decreases in renewable energies?

Frontiers in Energy Research, Zurich/Switzerland, 5 March 2019

Florian Egli, Energy Politics Group, ETH Zürich

Background

The INNOPATHS research project

- EU Horizon 2020 Project

  "generate new, state-of-the-art low-carbon pathways for the European Union"
- Cross-cutting finance work-stream
- Project partners

This talk

nature energy
ARTICLES
https://doi.org/10.1038/s41560-018-0277-y

A dynamic analysis of financing conditions for renewable energy technologies

Florian Egli*, Bjarne Steffen* and Tobias S. Schmidt*

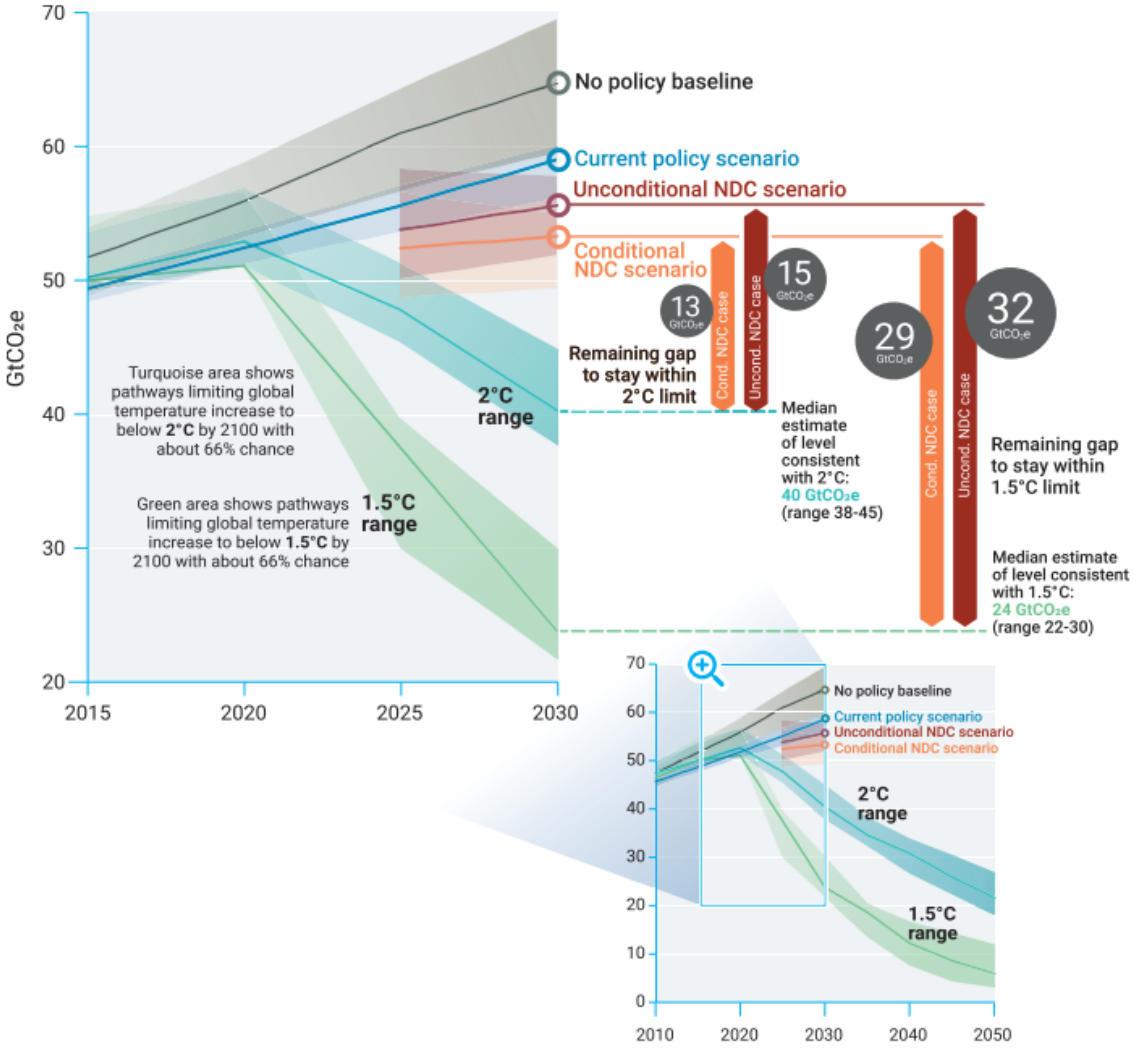
This work contributes to the European Union's Horizon 2020 research and innovation programme project INNOPATHS. It has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730403 as well as from the Swiss State Secretariat for Education, Research and Innovation (SERI) [contract number 16.0222]. The opinions expressed & arguments employed herein do not necessarily reflect the official views of the Swiss Government.

Agenda

Agenda

A milestone: the 2015 Paris Agreement

We are not on track…



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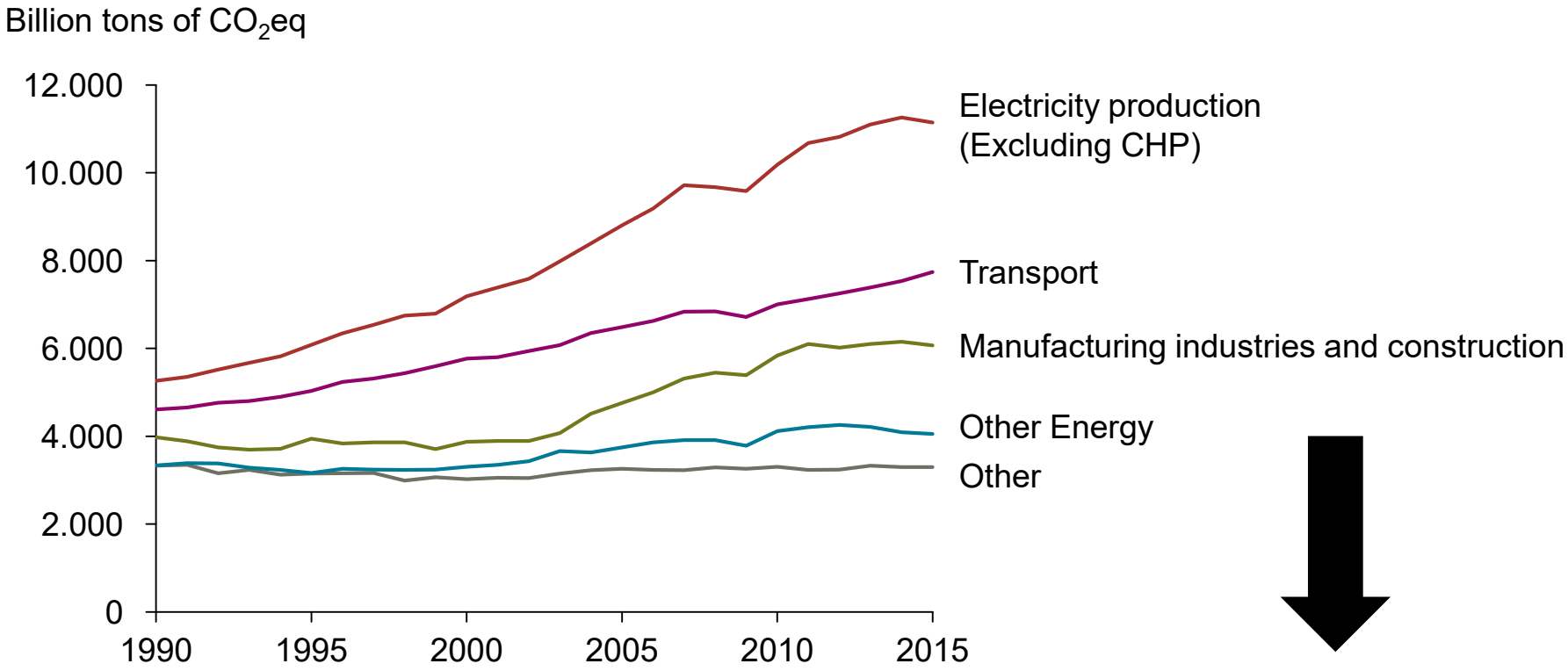
Low-carbon electricity is key to reach Paris Agreement targets



Source:
IEA, own calculations
Note:
Other Energy includes CHP plants, hearing plants and other energy industry own use.

Go to www.menti.com
Enter: 64 20 95

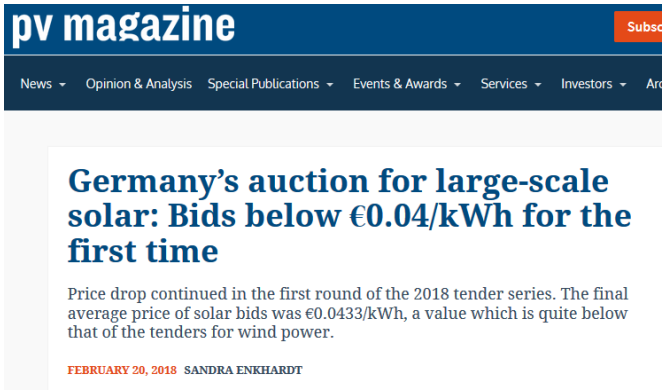
Renewable energy competitive in many places

Climate-changed

Saudi Arabia Gets Cheapest Bids for Solar Power in Auction

By Anthony Dipaola
October 3, 2017, 3:19 PM GMT+2 *Updated on October 3, 2017, 11:00 PM GMT+2*

- Masdar, EDF offer to supply power for 1.7 cents/Kilowatt hour
- Plant to be first in $50 billion plan to expand renewables



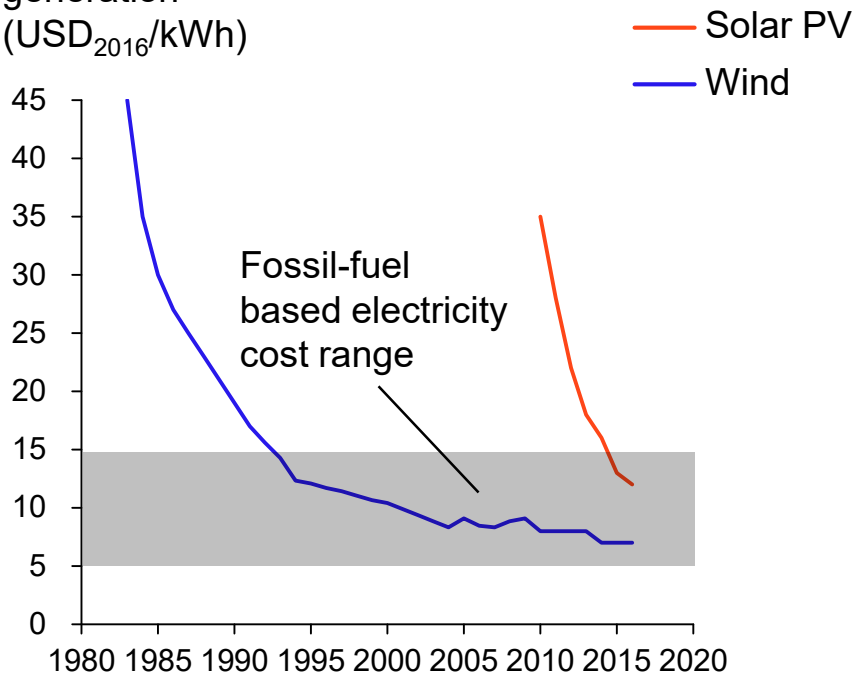
Mexican Solar Sets a Record Low Price for Latin America

Mexico's latest energy auction didn't set a world record, but confirms a trend toward ultra low-cost PV worldwide.

JASON DEIGN | NOVEMBER 29, 2017

Sources:
https://www.bloomberg.com/news/articles/2017-10-03/saudi-arabia-gets-cheapest-ever-bids-for-solar-power-in-auction
https://www.pv-magazine.com/2018/02/20/germanys-auction-for-large-scale-solar-bids-below-e0-04-kwh-for-the-first-time/
https://www.greentechmedia.com/articles/read/mexican-solar-record-low-price-latin-america#gs.FVwCkgI

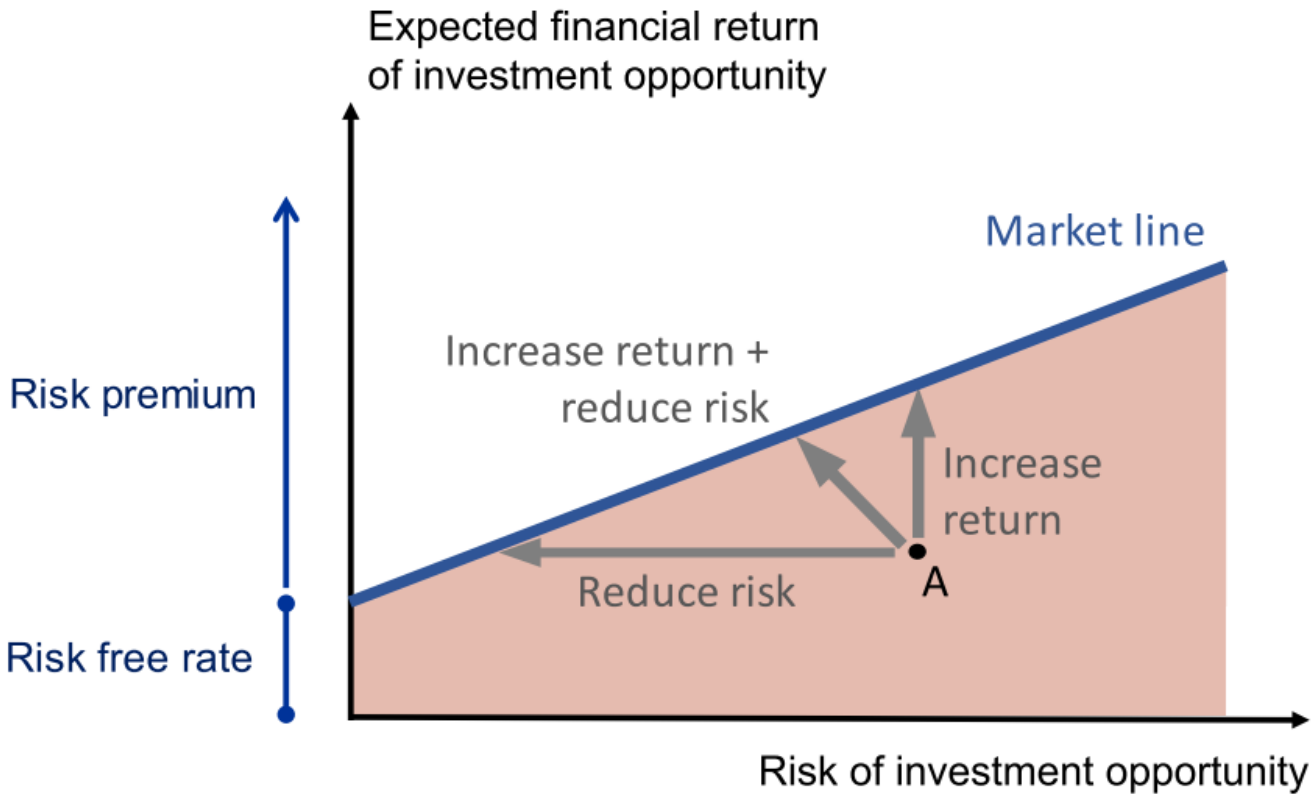
Global average levelized cost of electricity generation (USD_{2016}/kWh)



Note:
For 2010 – 2017 based on IRENA data; wind data for earlier years based on information from BNEF and Lawrence Berkeley National Laboratory. Biomass data from earlier years referring to wooden biomass from Sweden, as provided by Junginger et al. 2006, Energy Policy 34, 4024-4041. Fossil-fuel based range from Irena (2018), "Renewable Power Generation Costs in 2017"

Agenda

Investment decision

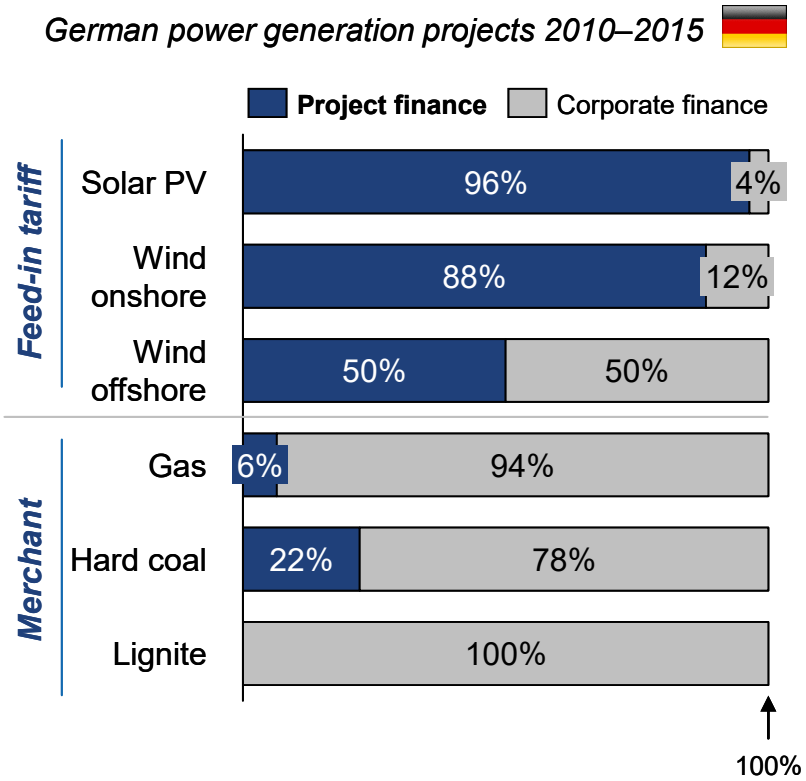


Source: Polzin, F., Egli F., Steffen B., and Schmidt T.S. (2019).
How Do Policies Mobilize Private Finance for Renewable Energy?—A Systematic Review with an Investor Perspective. *Applied Energy* (236), 1249–68.

Project finance

Project finance in practice

German power generation projects 2010–2015



Source: Steffen, B. (2018), The importance of project finance for renewable energy projects, *Energy Economics* (69), 280–294.

Project finance definition

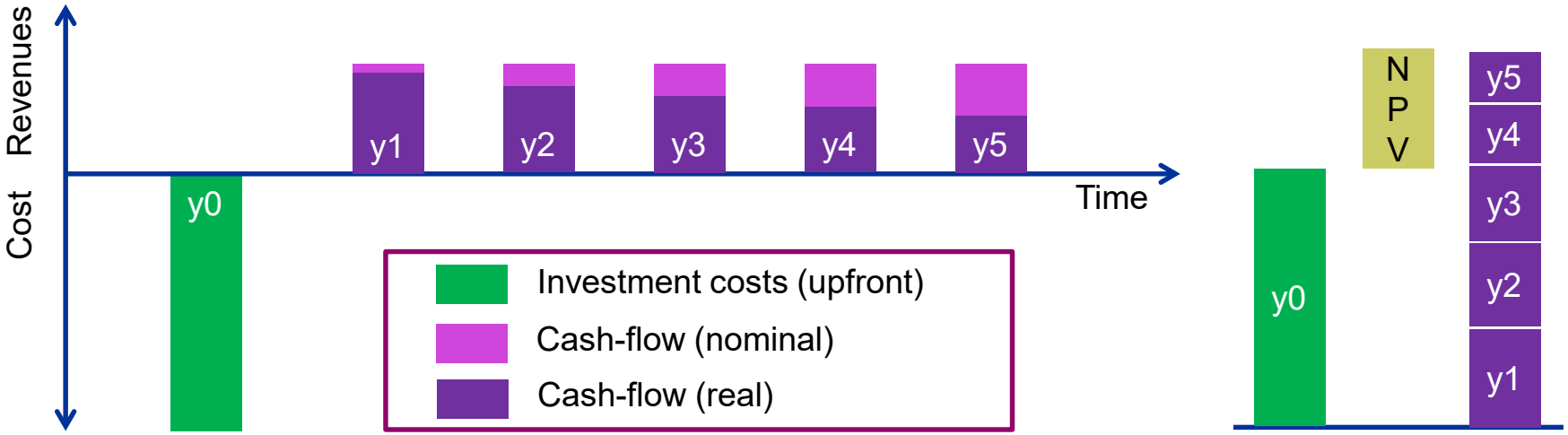
- Jargon: Sponsor realises project, lender provides financing
- Project = separate legal and commercial entity (SPV)
- Off-balance sheet
- Non-recourse; i.e., lender can only access project asset and cash flows

- *The financing conditions are project-specific*

NPV and the role of risk

$$NPV = investment_0 + \sum_{t=1}^{n} \frac{cashflow_t}{(1+r)^t}$$

r = cost of capital
t = year of cash-flow
n = expected lifetime of investment



Components of the cost of capital

$$r = K_E \frac{E}{V} + K_D \frac{D}{V}(1-T)$$

K_E = cost of equity
K_D = cost of equity
T = tax rate

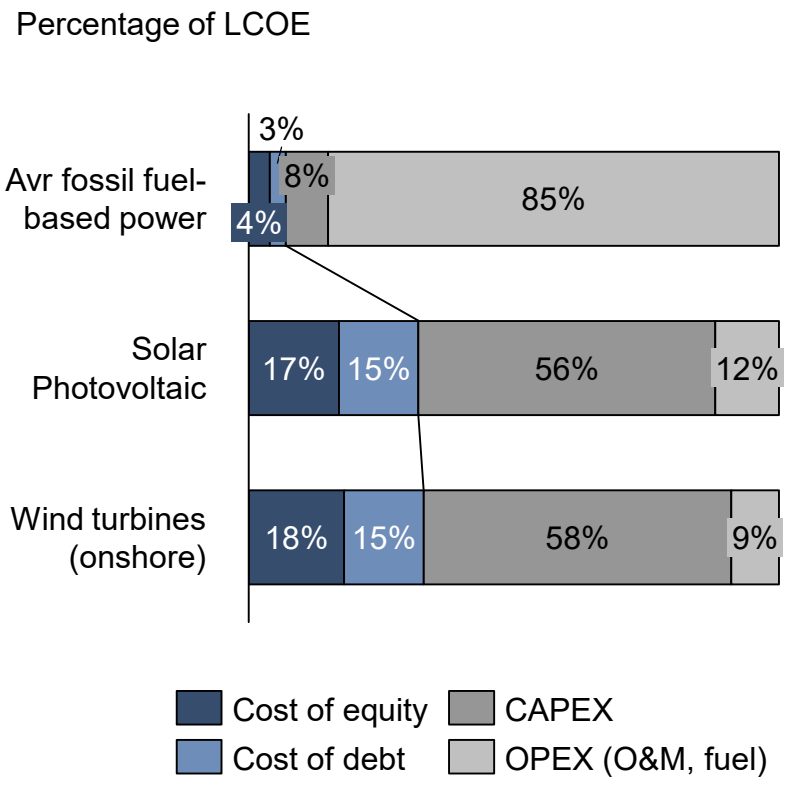
E = equity
D = debt
V = project volume

→ Higher risks increase the cost of capital in several ways

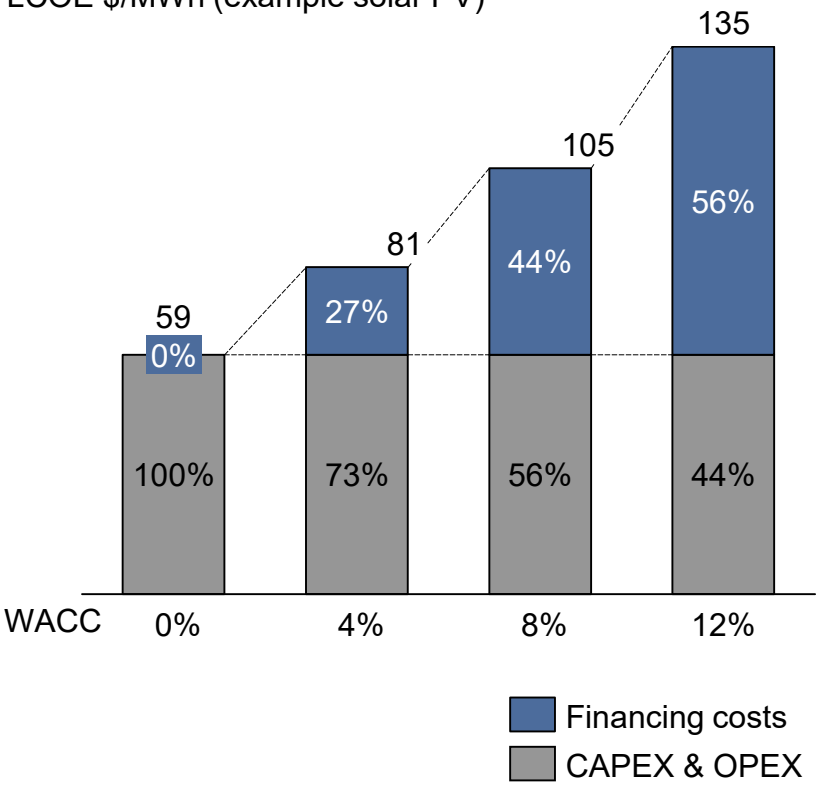
- *Increasing cost of debt and equity*
- *Decreasing leverage (i.e., capital structure)*
- *Other financial indicators (e.g., loan tenor)*

For renewables, cost of capital particularly important

Renewables w/ high upfront investment…



…hence LCOE are sensitive to WACC



Note: Assumes 5% cost of debt, 10% cost of equity, European fuel costs. Fossil fuel based is the average of hard coal, natural gas and diesel.

Agenda

Research adds to experience curve & RE financing literatures

Previous literature

Renewable energy (RE) cost dynamics

- Detailed understanding on renewable energy **technology cost reductions,** large 'experience curve' literature (e.g., Nemet 2006; Ferioli et al. 2009)

Role of financing dynamics of RE cost

- Conceptual studies on **drivers impacting RE investment decisions** (e.g., Wüstenhagen & Menichetti 2012)
- Model-based studies on **impact of financing conditions** on technology costs (e.g., Schmidt 2014; Hirth & Steckel, 2016)

Our research questions

1. How and why did solar PV and wind onshore financing conditions in DE change over time?
2. What is the effect of these changes on technology costs?

Challenges:

- *Scarce data, as financial details of project finance deals not disclosed*
- *For "why" part: Interest rate levels affected by multitude of drivers*

We follow a mixed-method approach in four steps

1. **Descriptive: Elicitation and mapping of project finance data**
   - Cost of equity, cost of debt/debt margin
   - Leverage, loan tenor, debt service coverage ratio

2. **Qualitative: Investor interviews to identify drivers for changes**
   - Semi-structured interviews, grounded theory-type coding of arguments

3. **Quantitative: Regression analysis for experience curves**
   - Various specifications of dependent and independent variables

4. **Model-based: Split-up of LCOE into technology cost effects**
   - Calibration of levelized cost of electricity (LCOE) in different settings

Case selection – why Germany?

Best suited to study financing dynamics

- Deployment history (2000 – 2016)
  - Most solar deployed in 13 of 17 years
  - Most wind deployed in 8 of 17 years
- Policy regime
  - Electricity market liberalized since 1998 and investments largely private
  - Landmark feed-in tariff in since 2000
- Project finance
  - Project-specific financing structures predominant for solar and wind

Data: Interview sample

ID	Interview type	Current organisation	Current position	RET investment experience since
1	Structured	Debt provider	Head of Division Energy & Utilities	2006
2	Structured	Debt provider	Vice President	1990
3	Structured	Debt provider	Associate Director Project Finance & Capital Advisory	2011
4	Structured	Debt provider	Associate Director Infrastructure & Power Project Finance	2009
5	Structured	Debt provider	Executive Director Project Finance Renewable Energies	1997
6	Structured	Debt provider	Associate Director Global Infrastructure Debt	2013
7	Structured	Debt provider	Head Renewable Energies	1991
8	Structured	Debt provider	Project Finance Analyst	2007
9	Structured	Debt provider	Vice President Corporates & Small Business Project Finance	2007
10	Structured	Debt provider	Director Structured Finance Power & Renewables	2007
11	Structured	Debt provider	Director Structured Finance Utilities, Power & Renewables	2007
12	Structured	Debt provider	Senior Manager Structured Finance Renewable Energy	1999
13	Structured	Debt provider	Director Project & Structured Finance Utilities, Power, Ren.	2007
14	Structured	Debt provider	Director Corporate Strategy	1999
15	Structured	Debt provider	Head of Renewable Energies	1995
16	Structured	Debt provider	Head of Project Finance Origination Renewable Energies	2010
17	Structured	Debt provider	Managing Director Project & Acquisition Finance	2006
18	Structured	Equity provider	Head Risk Advisory	2005
19	Structured	Equity provider	CEO	2008
20	Structured	Equity provider	Founder and CEO	2013
21	Structured	Equity provider	Principal	2013
22	Structured	Equity provider	Partner	2009
23	Structured	Equity provider	Director Infrastructure Equity Investment Team	2006
24	Structured	Equity provider	Vice President Renewables	2015
25	Structured	Equity provider	CIO	2016
26	Structured	Equity provider	CEO	2016
27	Structured	Equity provider	Associate Director Energy & Cleantech	2006
28	Structured	Equity provider	Associate	2000
29	Structured	Public actor	Head Energy Services	2006
30	Structured	Public actor	Deputy Head Energy Management	2015
31	Structured	Public actor	CEO	2011
32	Structured	Public actor	Head Portfolio and Asset Management Renewable Energies	2010
33	Structured	Public actor	Vice President Origination and Structuring	2012
34	Exploratory	Equity provider	Founding Partner	2000
35	Exploratory	Equity provider	Investments Director	2006
36	Exploratory	Equity provider	Head Risk Advisory	2005
37	Exploratory	Equity provider	Partner	2009
38	Exploratory	Equity provider	Principal	2013
39	Exploratory	Other	Head Hybrid Power Solutions (former researcher)	2006
40	Exploratory	Public actor	Senior Investment Manager	2007
41	Exploratory	Public actor	Economist	2003

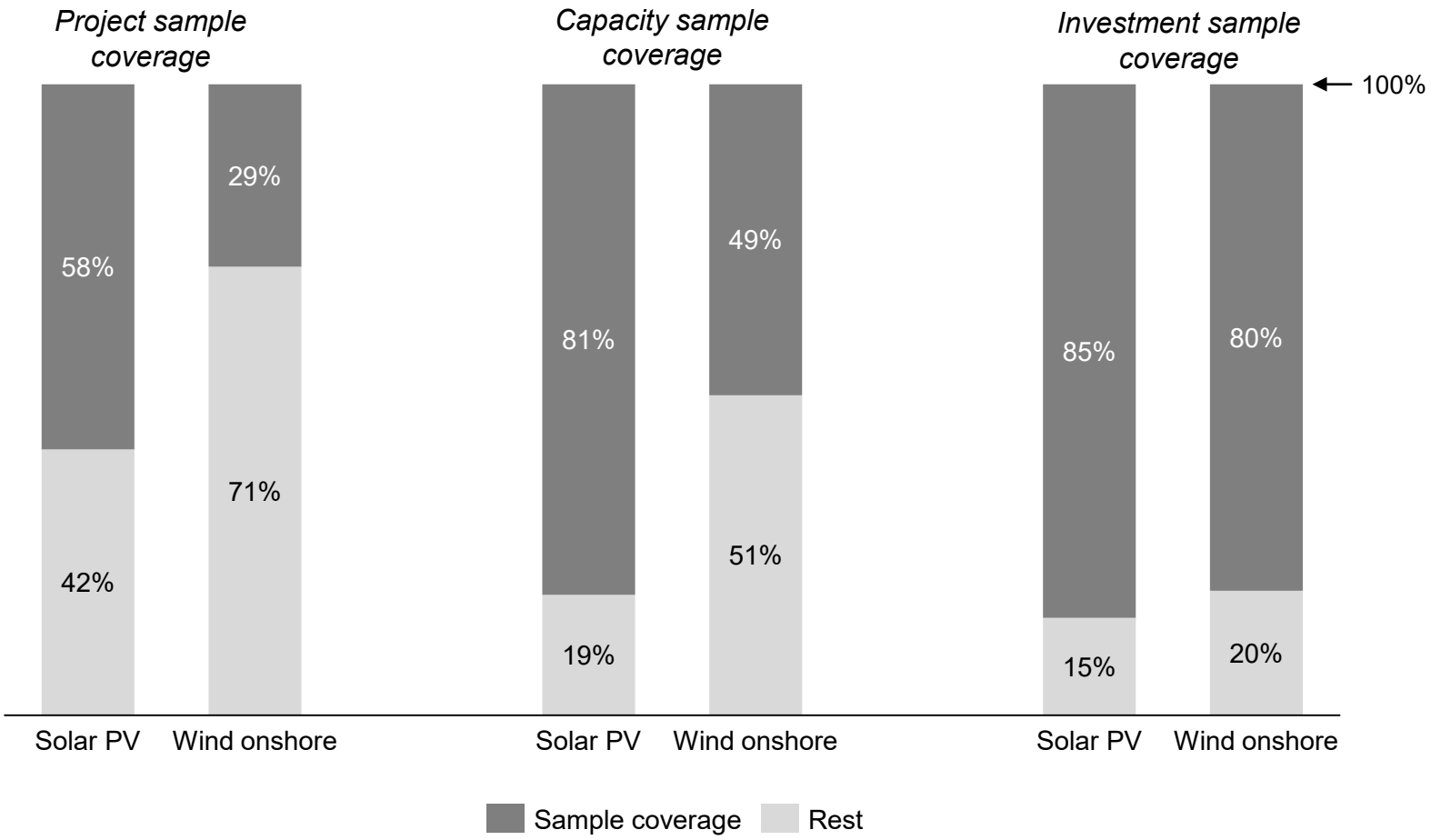
Sampling

- Exploratory interviews based on existing contacts
- Theoretical interview sampling
  1. Publicly available addresses of senior investment managers (BNEF)
  2. Professional network (esp. via Allianz Climate Solutions)
  3. Snowball sampling

Sample

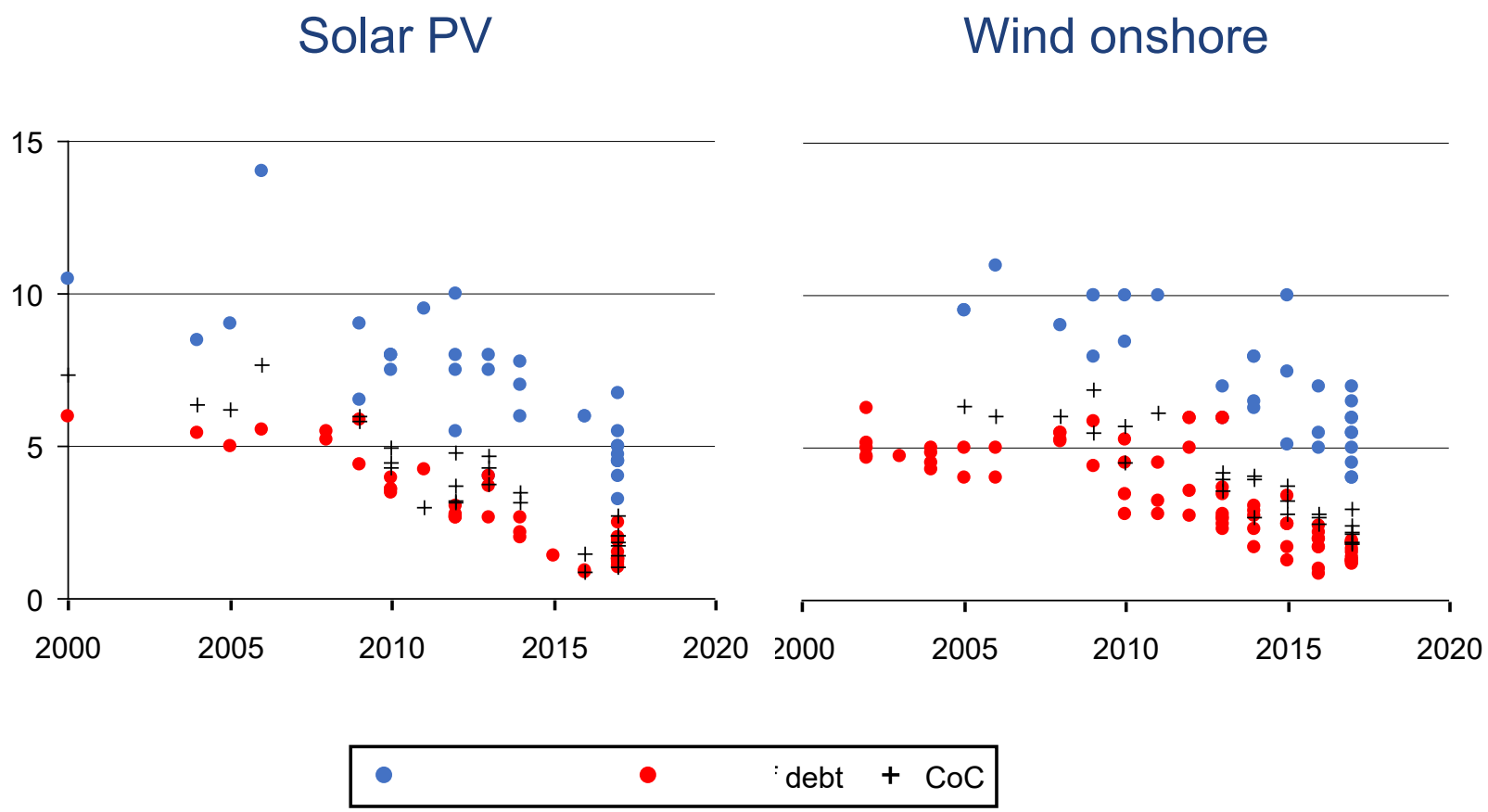
- 17 private debt providers (13 commercial banks, 4 private investment banks)
- 16 private equity providers
- 7 public actors (4 utilities that invested in RE, 3 public investment banks)
- 1 former researcher

Data: Sample coverage



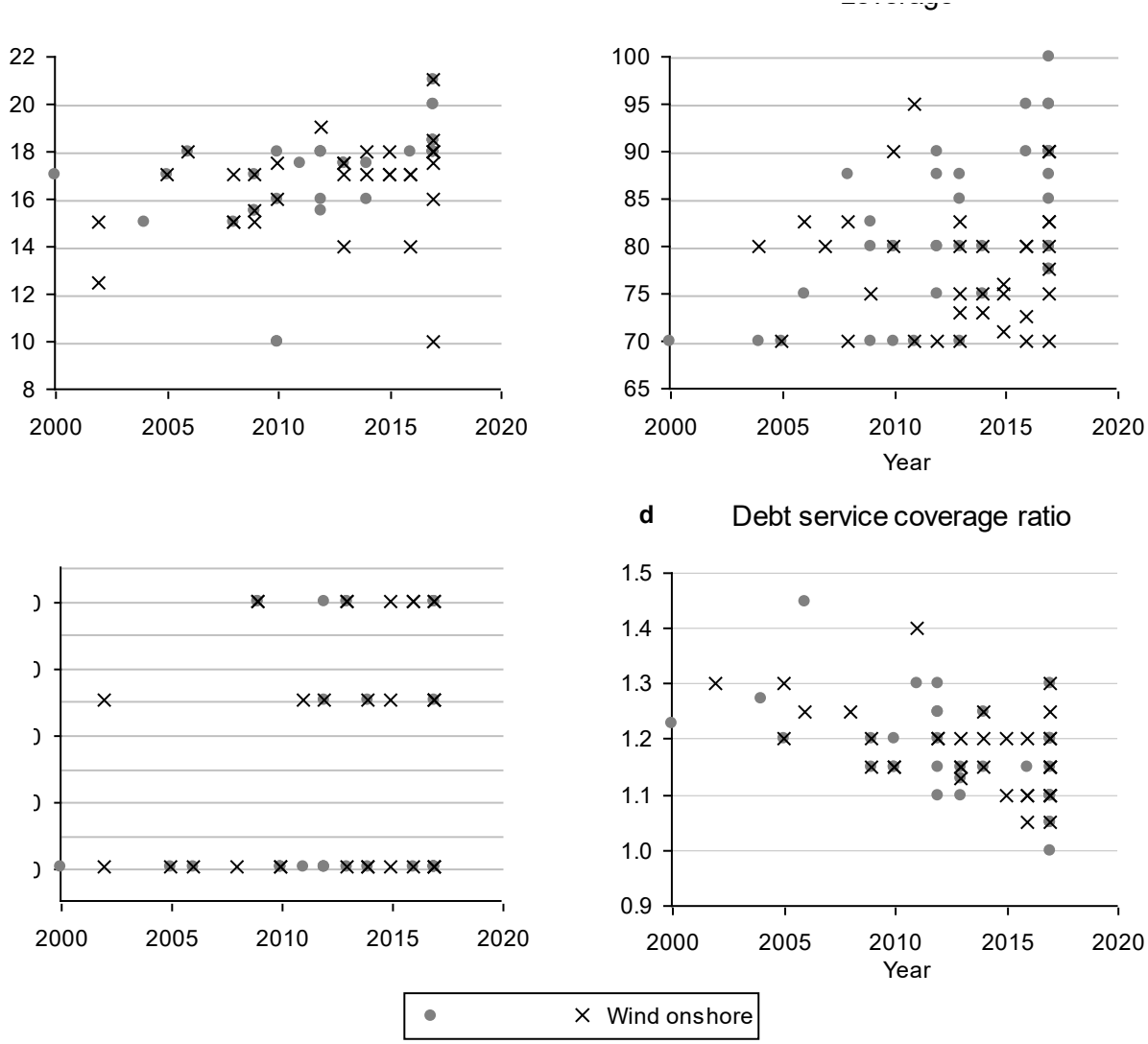
Source: Egli et al. (2018), cf. p.1.

Step 1: The data



Source: Egli et al. (2018), cf. p.1.

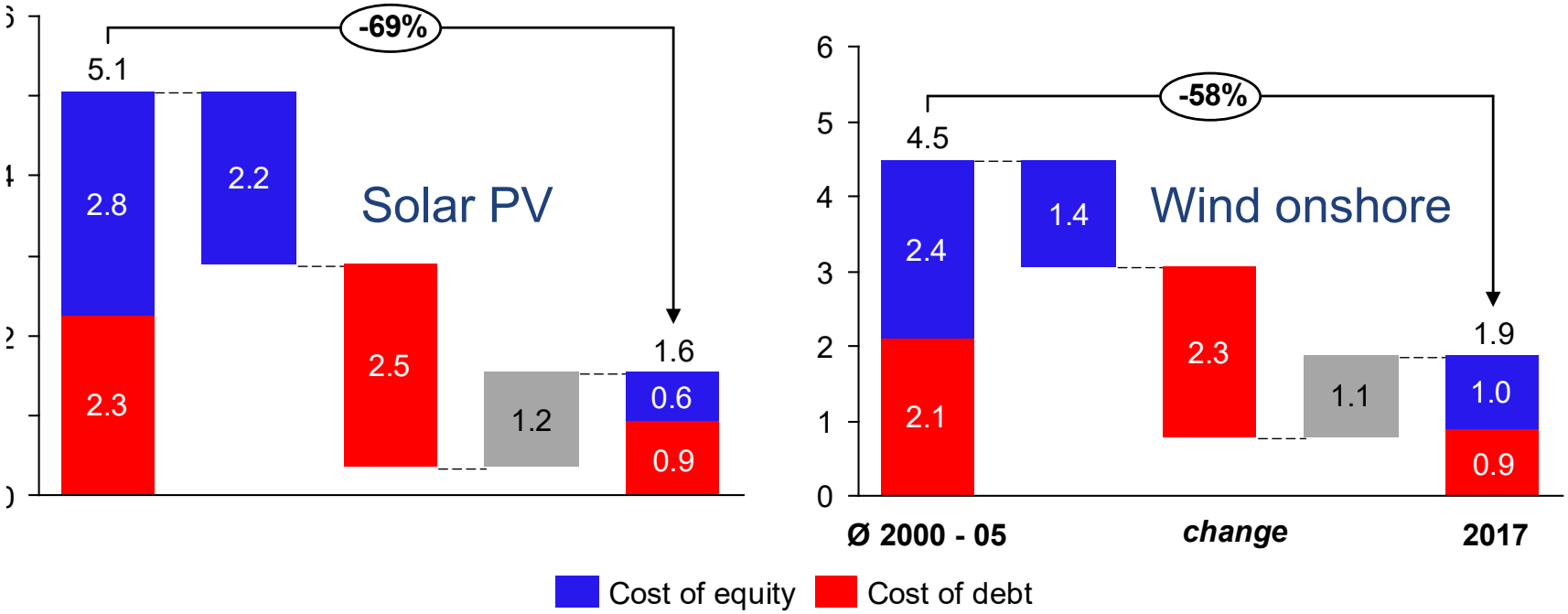
Step 1: The data (other financial indicators)



Source: Egli et al. (2018), cf. p.1.

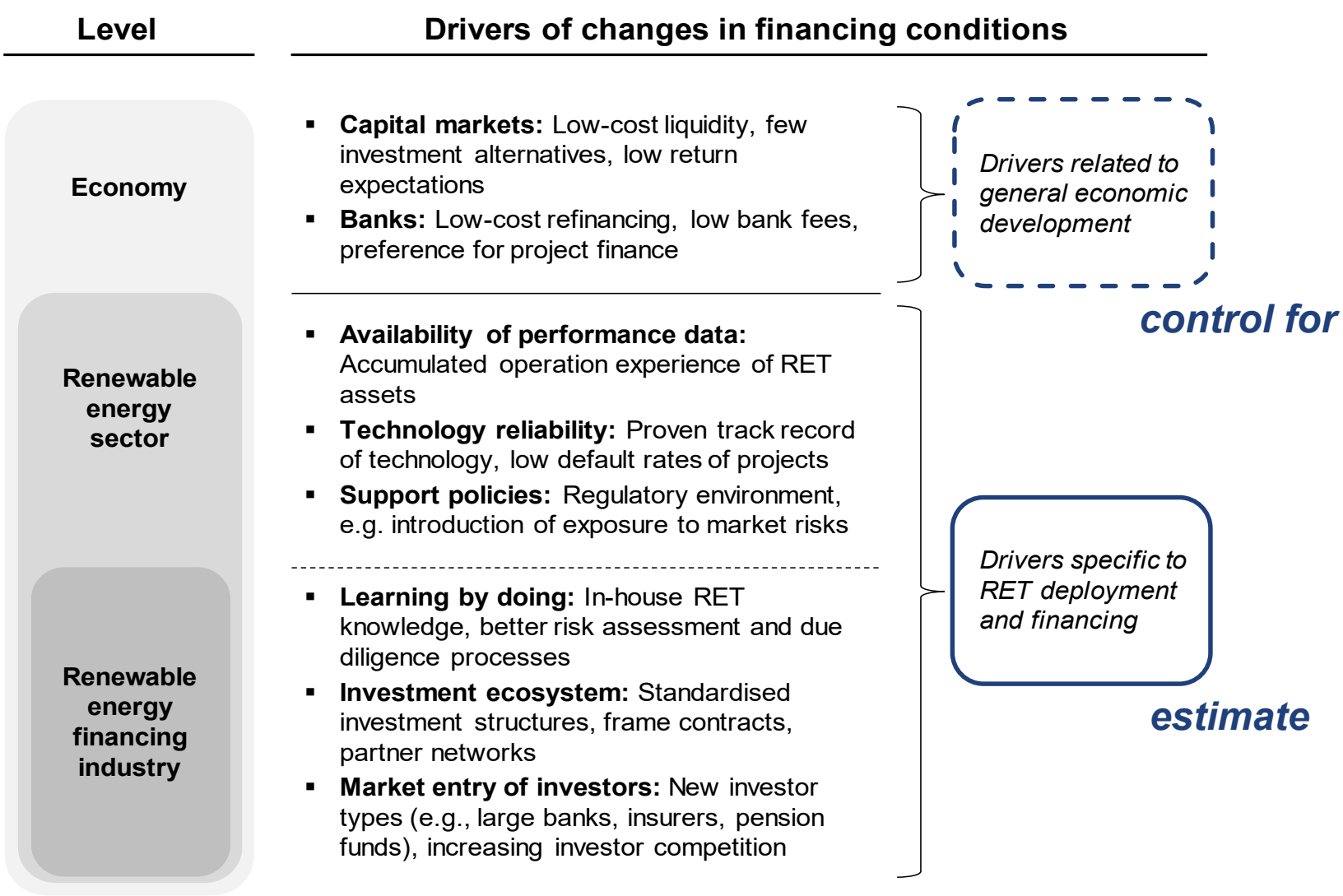
Step 1: The dynamics

$$\text{After-tax CoC} = K_E \frac{E}{V} + K_D \frac{D}{V}(1-T)$$



Source: Egli et al. (2018), cf. p.1.

Step 2: The drivers

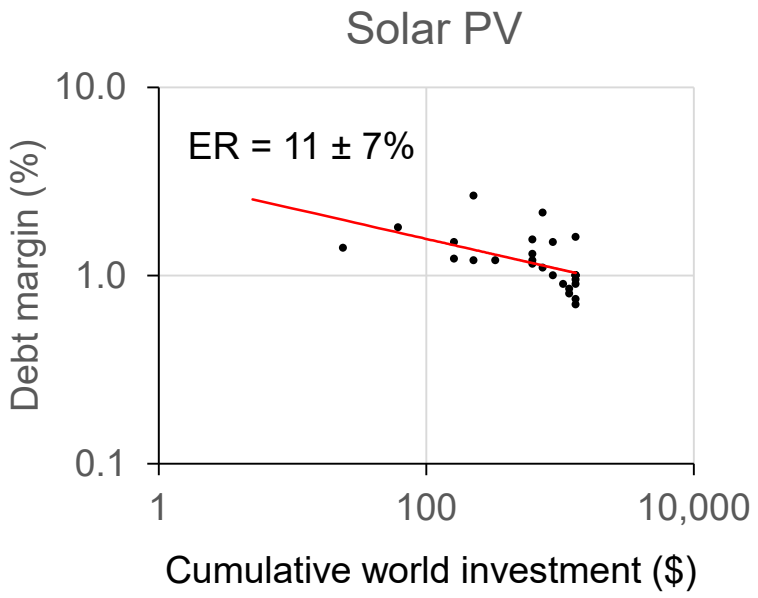


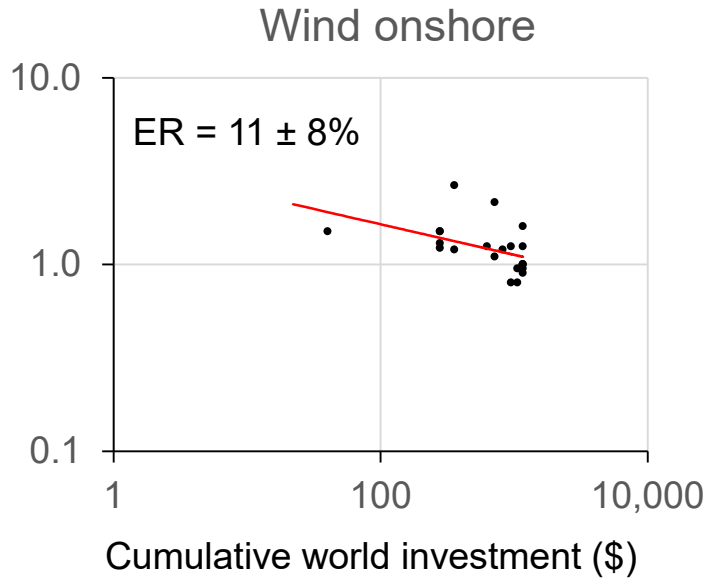
Source: Egli et al. (2018), cf. p.1.

Step 3: Identifying an experience effect

- Identification:

$$DebtMARGIN(I_t) = DebtMARGIN(I_0)\left(\frac{I_t}{I_0}\right)^{-b_1}$$

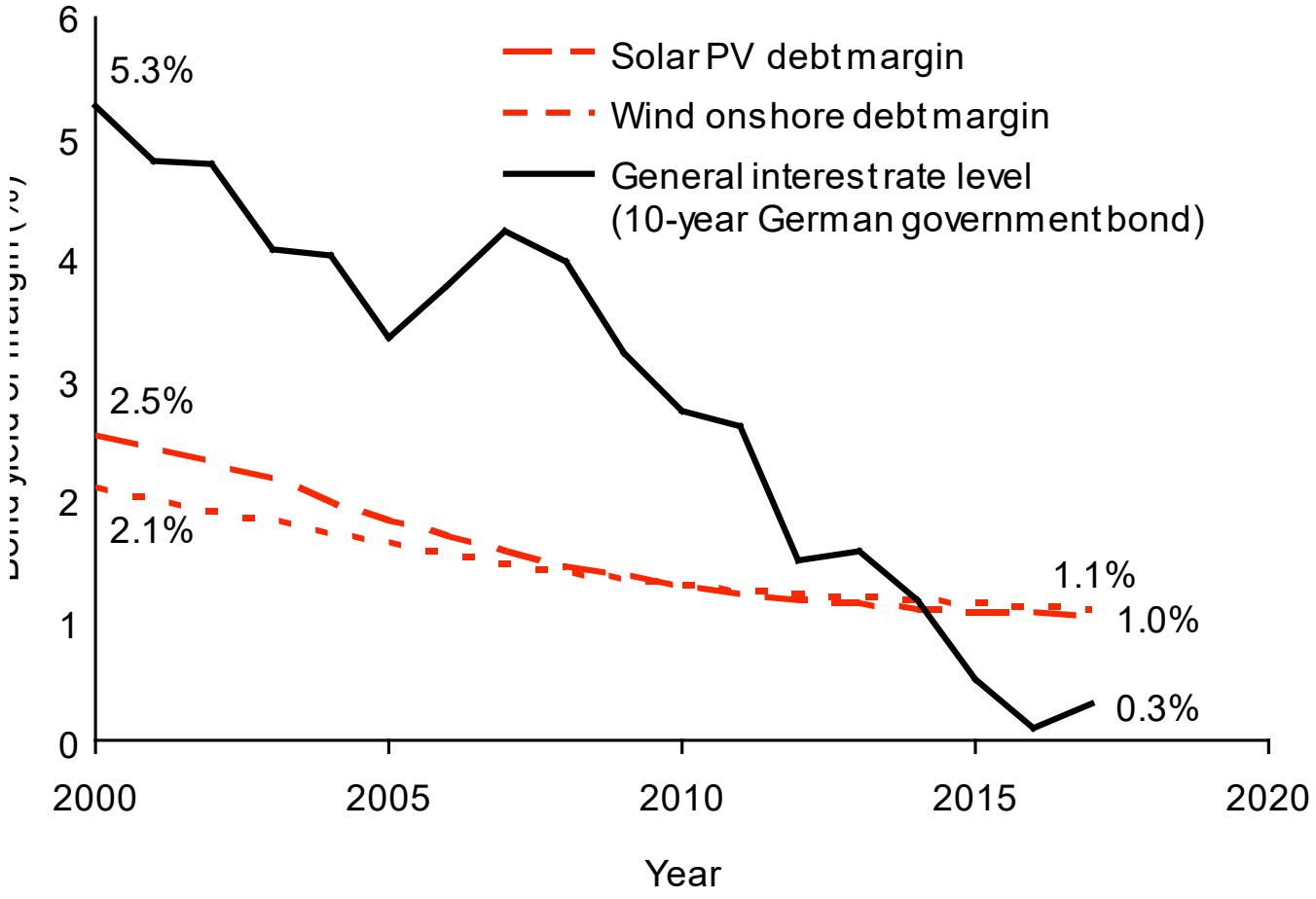




Source: Egli et al. (2018), cf. p.1.

But…

Step 3: Experience and financial crisis



Source: Egli et al. (2018), cf. p.1.

Step 4: Quantifying the effect on LCOE

- **Financing expenditure** of total LCOE

$$\delta_{it} = LCOE_{it,CoC_i=r_i} - LCOE_{it,CoC=0}$$

- The change in financing expenditure

$$\Delta_i = \delta_{i,t=1} - \delta_{i,t=2}$$

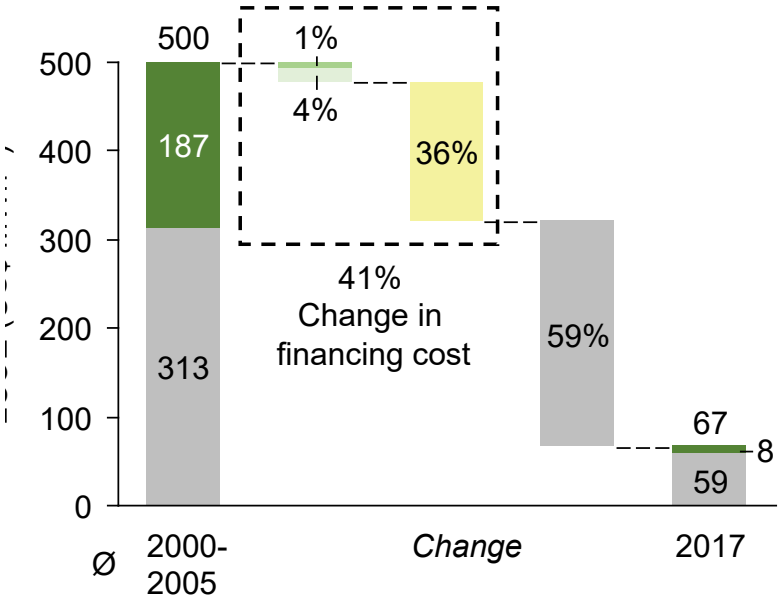
- The **channels** contributing to the change

$$\Delta_i = \Delta_i^{EXP} + \Delta_i^{INT} + \Delta_i^{CAPEX}$$

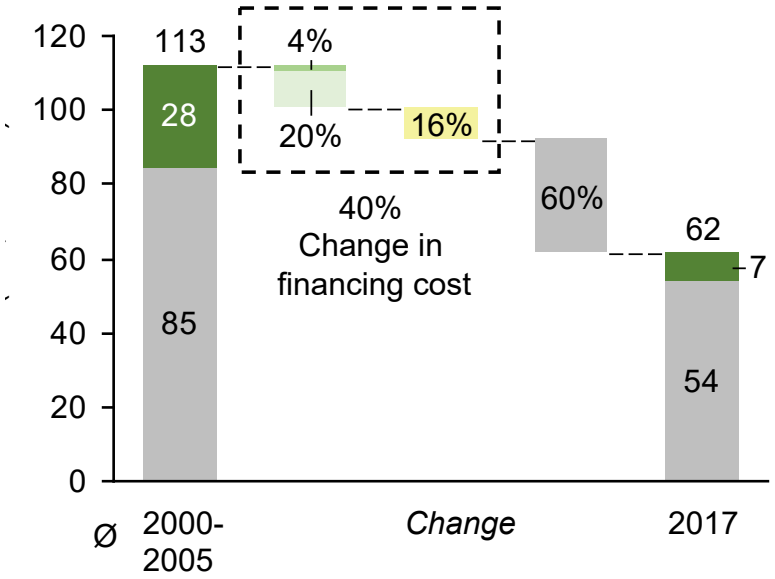
Source: Egli et al. (2018), cf. p.1.

Step 4: Channels of improved financing costs

Solar PV



Wind onshore



Change in financing cost from

- Experience effect
- General interest rate effect
- Lower capital expenditures

Source: Egli et al. (2018), cf. p.1.

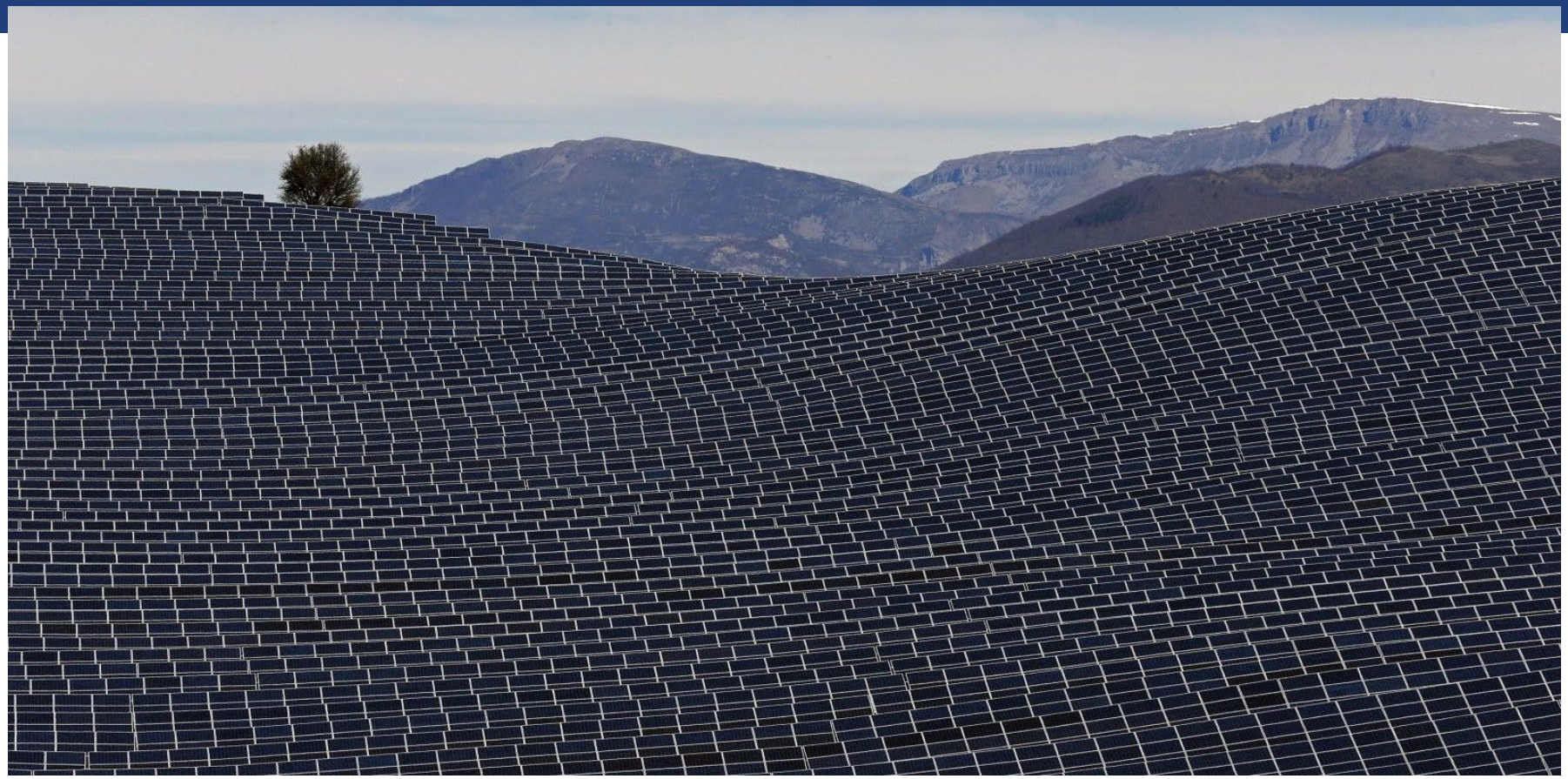
Conclusion

Large effect of financing conditions on renewable energy cost empirically established – to be considered in **changing interest rate environment**: Future work on this under way

Experience effect qualitatively and quantitatively established – "co-benefit" of deployment policies for immature technologies

More work needed to

- investigate **other countries and technologies (differences)**
- reduce uncertainty on **size of experience effect**
- understand **learning mechanisms**
- understand **risk perceptions** in renewable asset financing



Thank you very much!

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Florian Egli | Energy Politics Group | ETH Zürich