Towards further solar PV cost reduction – Impact of research innovations

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Disclaimer

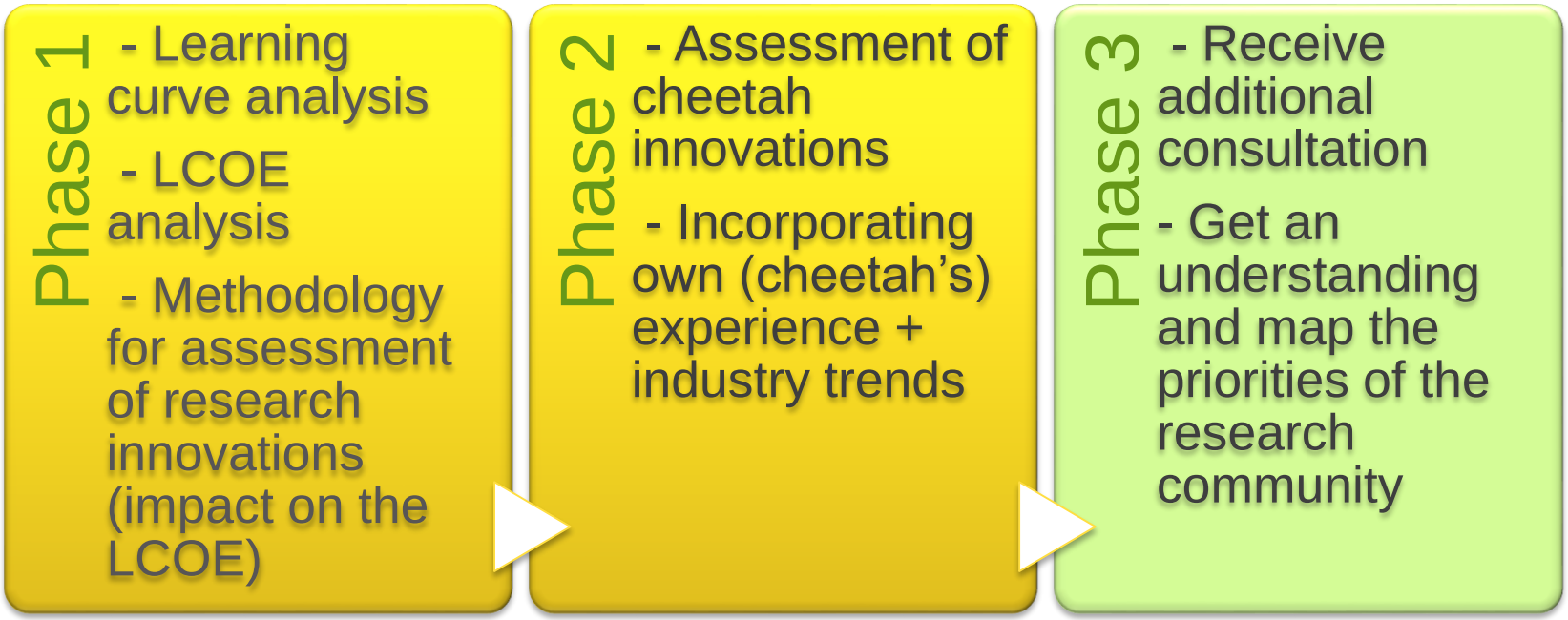
The results presented in this presentation are still considered draft and subject to comments. The assessment period will be completed in 1 to 2 months and the final results will be uploaded in cheetah's website.

www.cheetah-project.eu

Part of the overall objectives of cheetah

- Developing new concepts and technologies for wafer-based crystalline silicon PV (modules with ultrathin cells), thin-film PV (advanced light management) and organic PV (very low-cost barriers), resulting in (strongly) reduced cost of environmentally benign/abundant/non-toxic materials and increased module performance.
- Fostering long-term European cooperation in the PV R&D sector, by sharing knowledge, organizing workshops, exchange and training researchers inside and outside Europe, efficient use of infrastructures, promoting best practices and standards
- Accelerating the implementation of innovative technologies in the PV industry, by a strong involvement of SolarPower Europe and EIT-KIC InnoEnergy in this program

2 phases of the cost research



The question of the cost decrease of the PV system and especially of its components, is still at the core of the discussion on future system prices

1st phase build in 3 pillars

Learning Curve

- Examine different learning curves
- Challenge their hypothesis
- Introduce new ones
- Assess future module prices and system prices

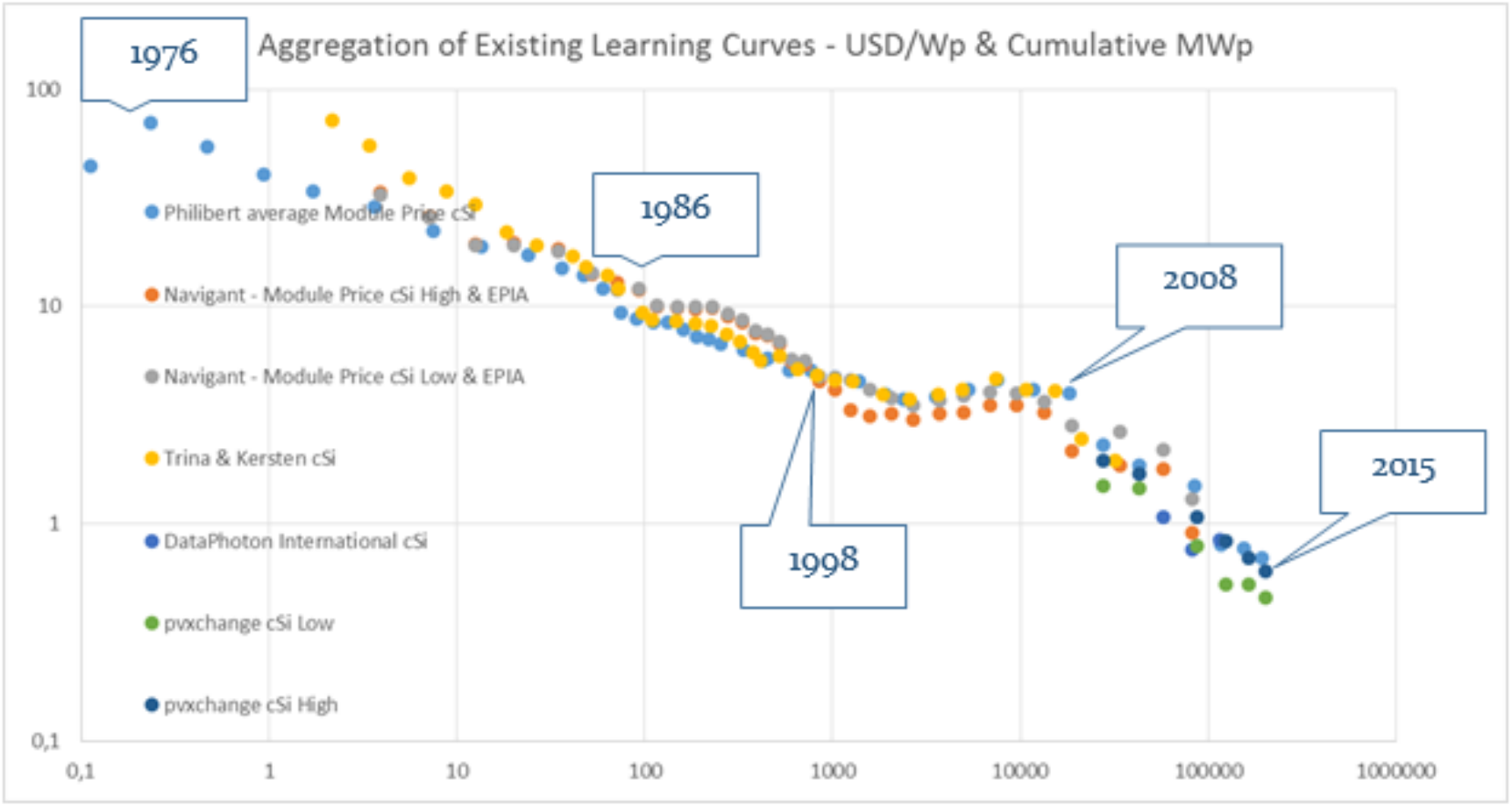
LCOE

- Use learning curve results to assess future LCOE
- Assess LCOE on main cases (segment and respective technology)

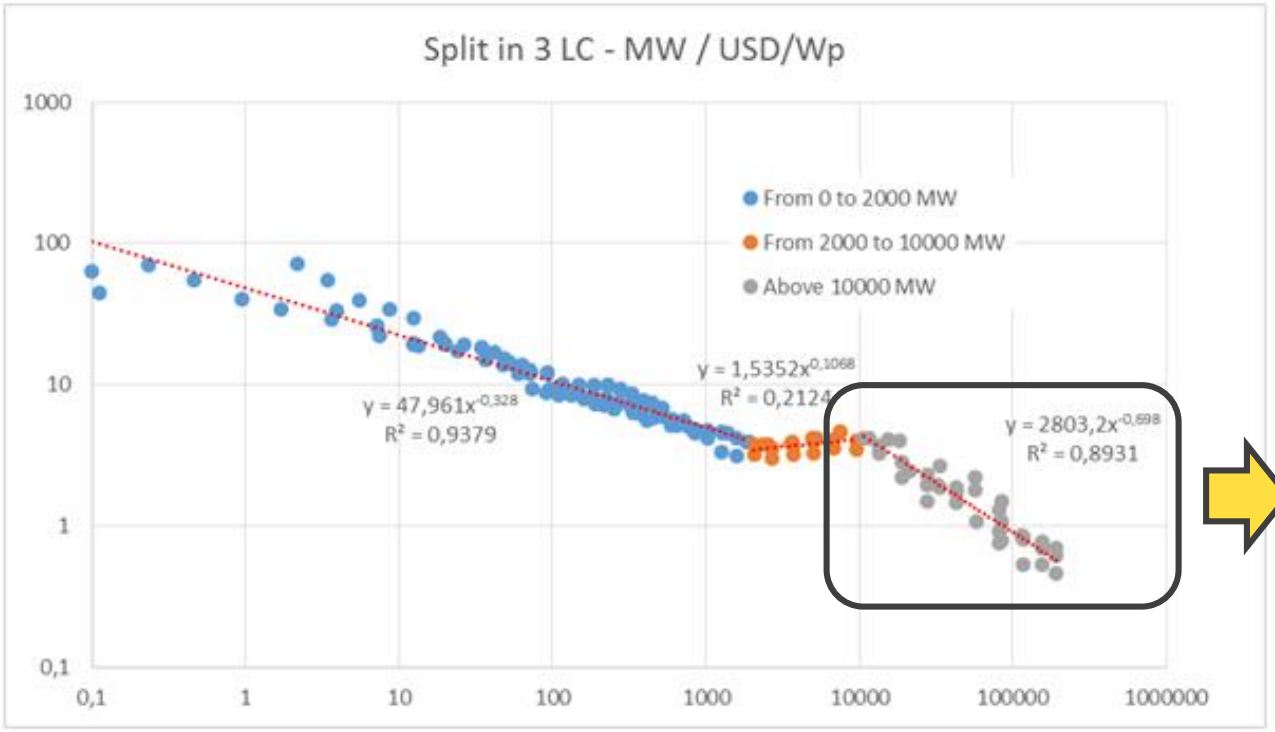
Assessment of innovations

- Methodology of how to assess the cost impact of research innovations

Existing known Learning Curves



Aggregated Learning Curve in 3 sections

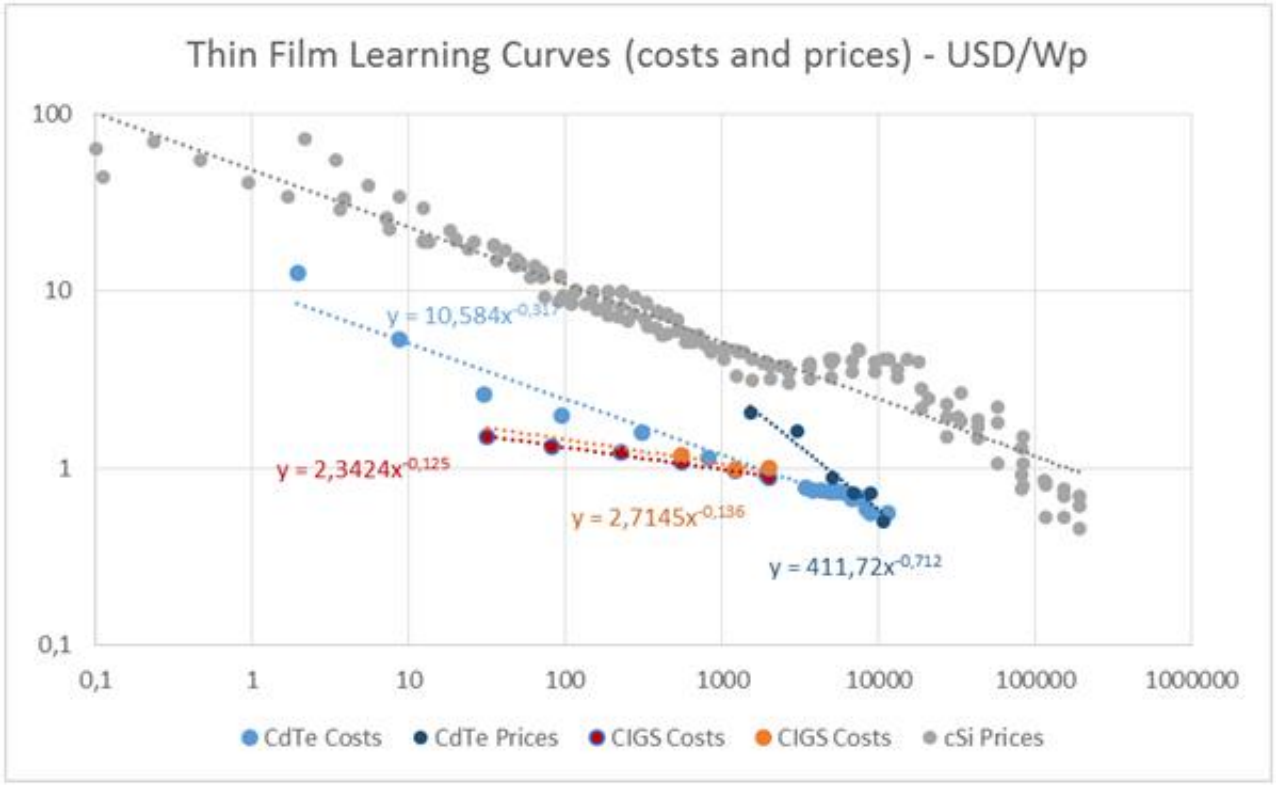


95% (190 GW) – est. June 2015

c-Si LC for modules for the last 95% of the market = 38%

c-Si LC for modules on 100% of the market = 20%

Aggregated TF learning curves

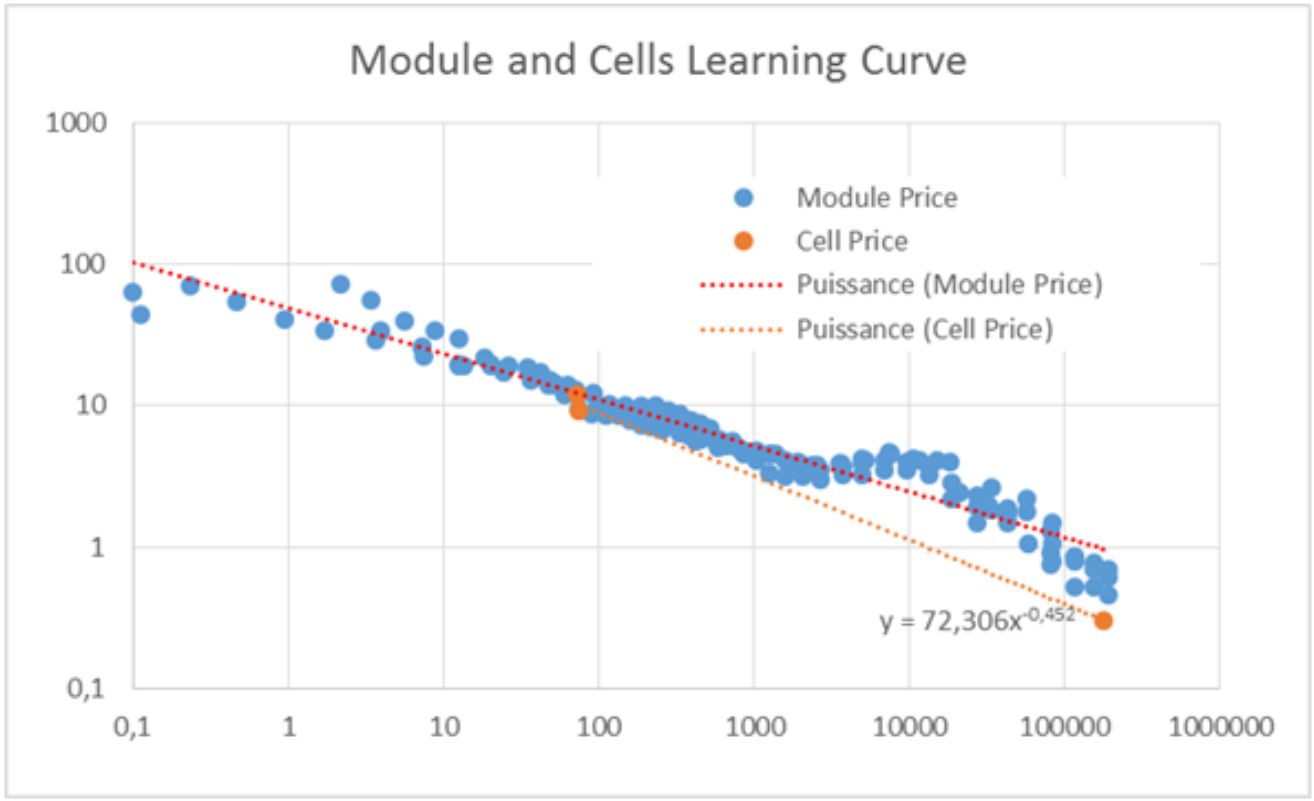


Learning Rates

- CdTe Costs: 19.7%
- CdTe Prices: 39%
- CIGS Costs: 8.3%
- CIGS Prices: 9%

- CdTe numbers are comparable to c-Si in terms of prices - however cost curve more robust)
- CIGS possibly reduced cost reduction potential in the short to medium term – more data points are needed to build a trend

Module vs Cell LC



Learning Rate:
26.9%

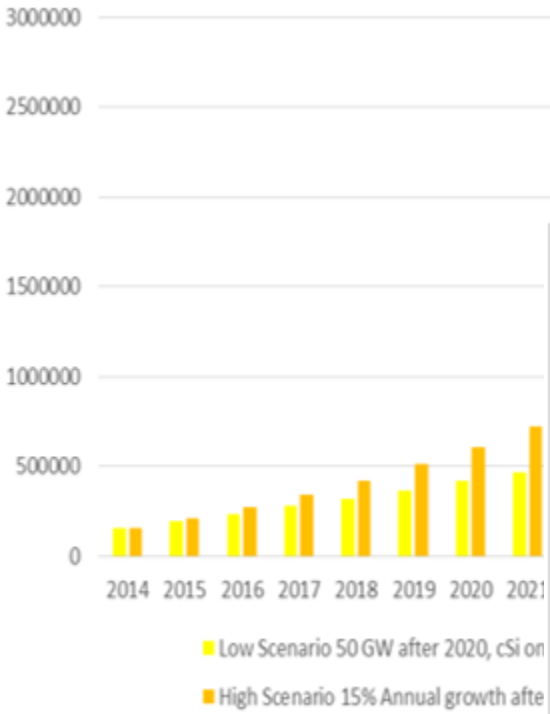
- Higher learning rate than the module – cost improvement of the rest of module materials possibly slower
- Assuming PV cell as the final product subject to LC analysis could be further elaborated

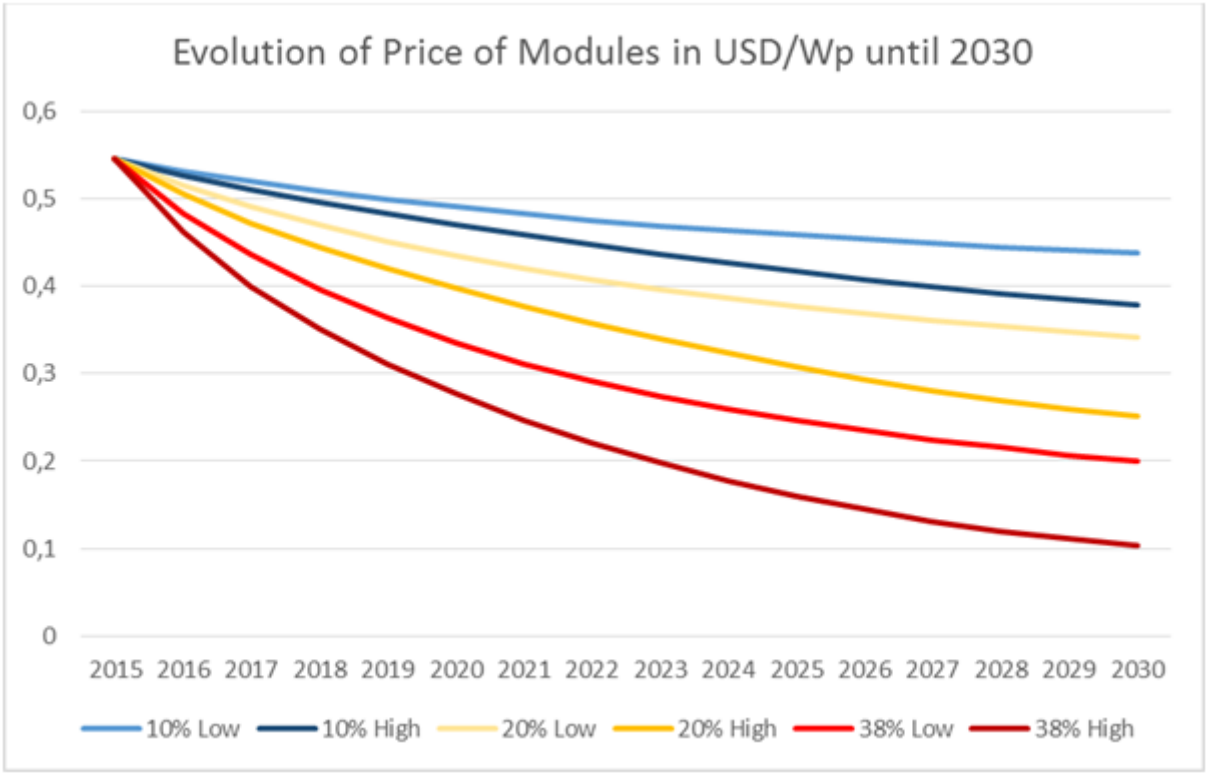
Outcomes and further research

- Existing data are subject to interpretation
- Significant cost reduction since 2007, however price data should be scrutinized – at the moment 20% learning rate remains the most conservative and reasonable
- Best practice to use credible cost data (weighted data from all regions and according to respective volumes)
- Best practice to use production data and not installation:
  - Installations are counted differently in each country
  - Inventory levels should be considered (also when using shipments)

LC is a simple indicative tool to forecast evolution of cost, however weak to be used as sole decision making tool: Assumptions and data points should be clear and verified

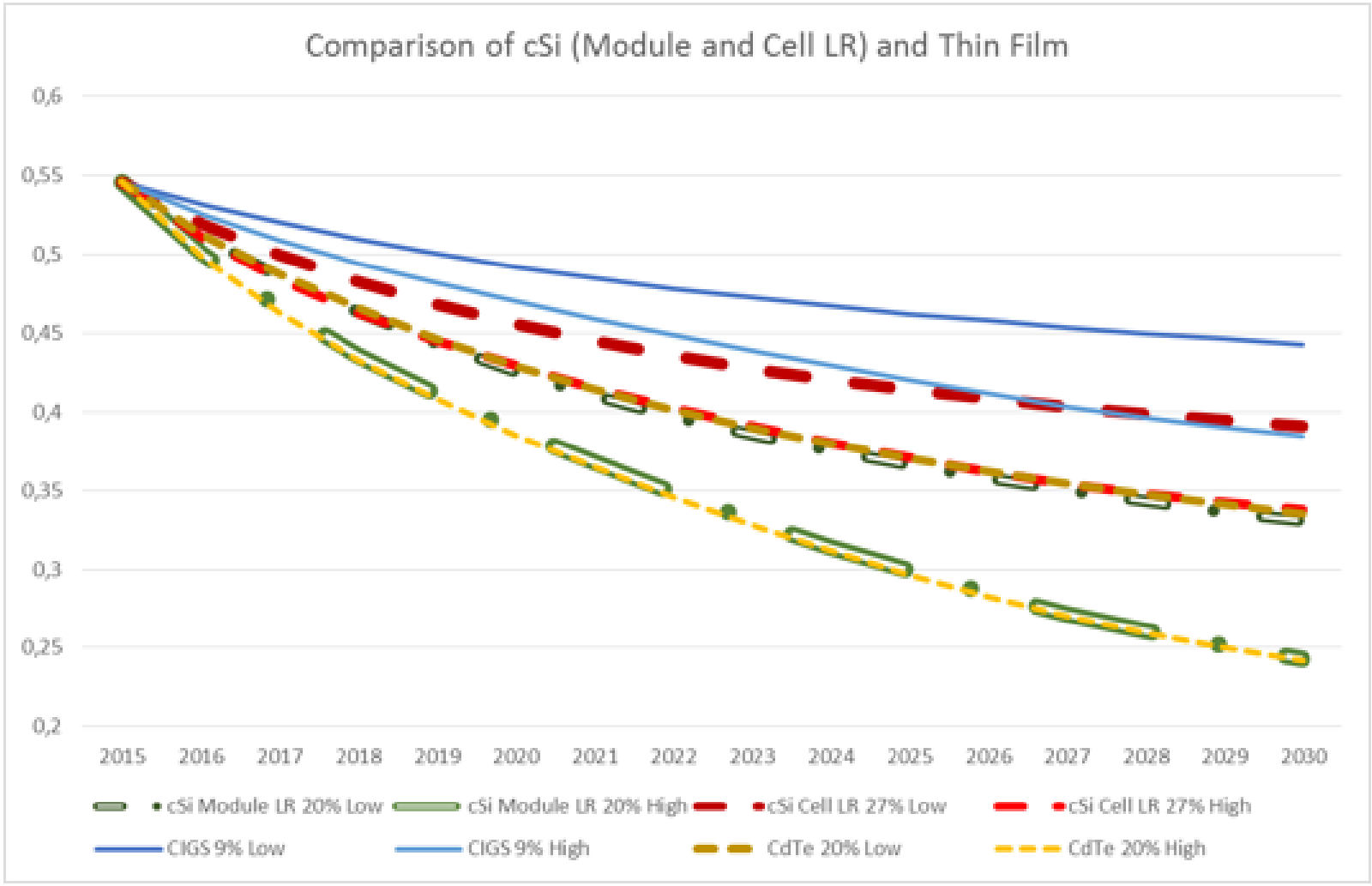
Applying LC results – evolution of c-Si prices





38% LR bring prices close to the critical material cost limit (<0.2 USD/Wp) by 2023

Evolution of prices considering own LR



LCOE assessment - Segments

- **Segment 1:** Residential with c-Si
- **Segment 2:** Residential with high efficiency technologies
- **Segment 3:** Commercial with c-Si
- **Segment 4:** Commercial with CIGS
- **Segment 5:** Utility-scale with c-Si
- **Segment 6:** Utility-scale with CdTe

System prices have been calculated considering:

- Evolution of module prices based on previous analysis – **low and high market scenario has been used**
- Evolution of inverter prices based on Agora Energiewende (Fraunhofer ISE).
- Rest of the costs based on assumptions and collection of data used in the PV TP (LCOE group)

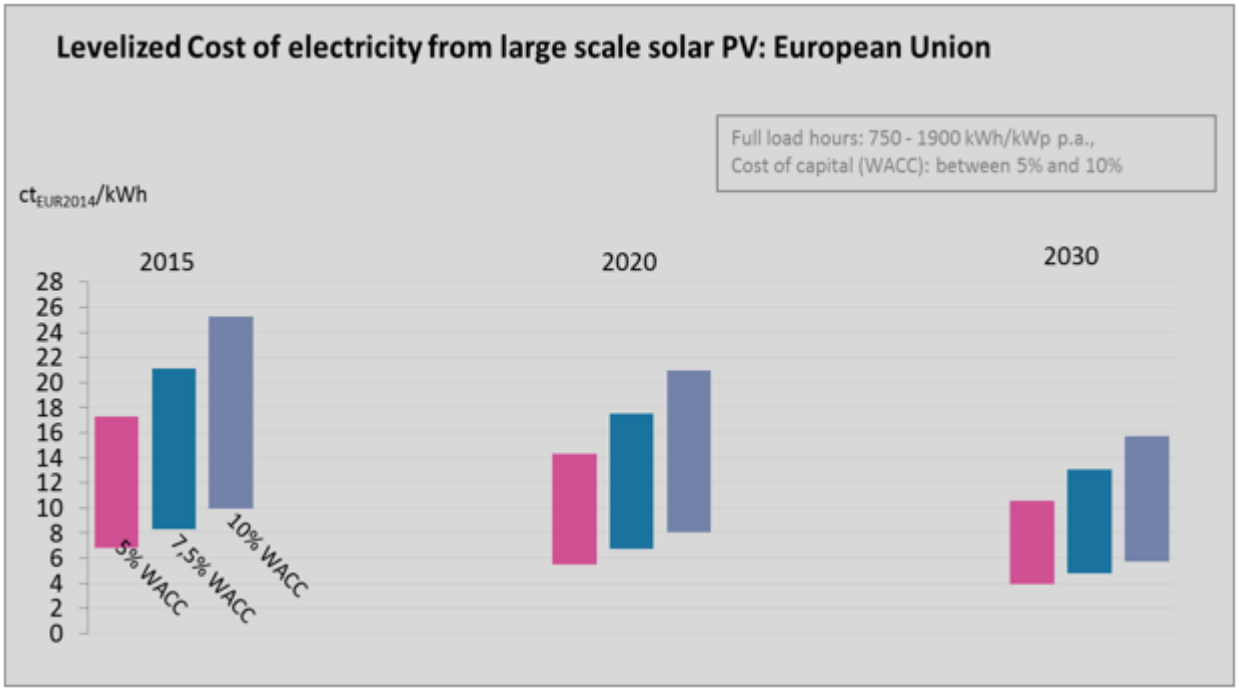
Assumptions for all segments

- Three different assumptions of weighted average cost of capital (WACC) were considered : 5% , 7.5% and 10%
- Inverter replacement after 10 years at current cost (considering the inverter learning curve)
- Irradiation level have been considered at the European level, from 750 kWh/kWp (north of Finland) to 1900 kWh/kWp (higher irradiation in Spain) in order to provide the whole range of values per each WACC assumption
- OPEX costs declining slowly (-10% in 2020, -20% in 2030)
- Lifetime starting at 25 years in 2015, increasing at 26 and 27 years respectively in 2020 and 2030.

LCOE assessment – Residential c-Si

System Prices	Segment 1 - Residential c-Si – Low Market – 20% LR	Segment 1 - Residential c-Si – High Market – 20% LR
2015	1.50 EUR/Wp	1.50 EUR/Wp
2020	1.255 EUR/Wp	1.205 EUR/Wp
2030	0.947 EUR/Wp	0.845 EUR/Wp

Year	2015						2020						2030					
WACC	5%		7,5%		10%		5%		7,5%		10%		5%		7,5%		10%	
ctEUR2014/kWh	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
European Union	6,8	17,3	8,3	21,1	10,0	25,2	5,5	14,5	6,7	17,7	8,0	21,1	3,8	10,9	4,7	13,4	5,6	16,0



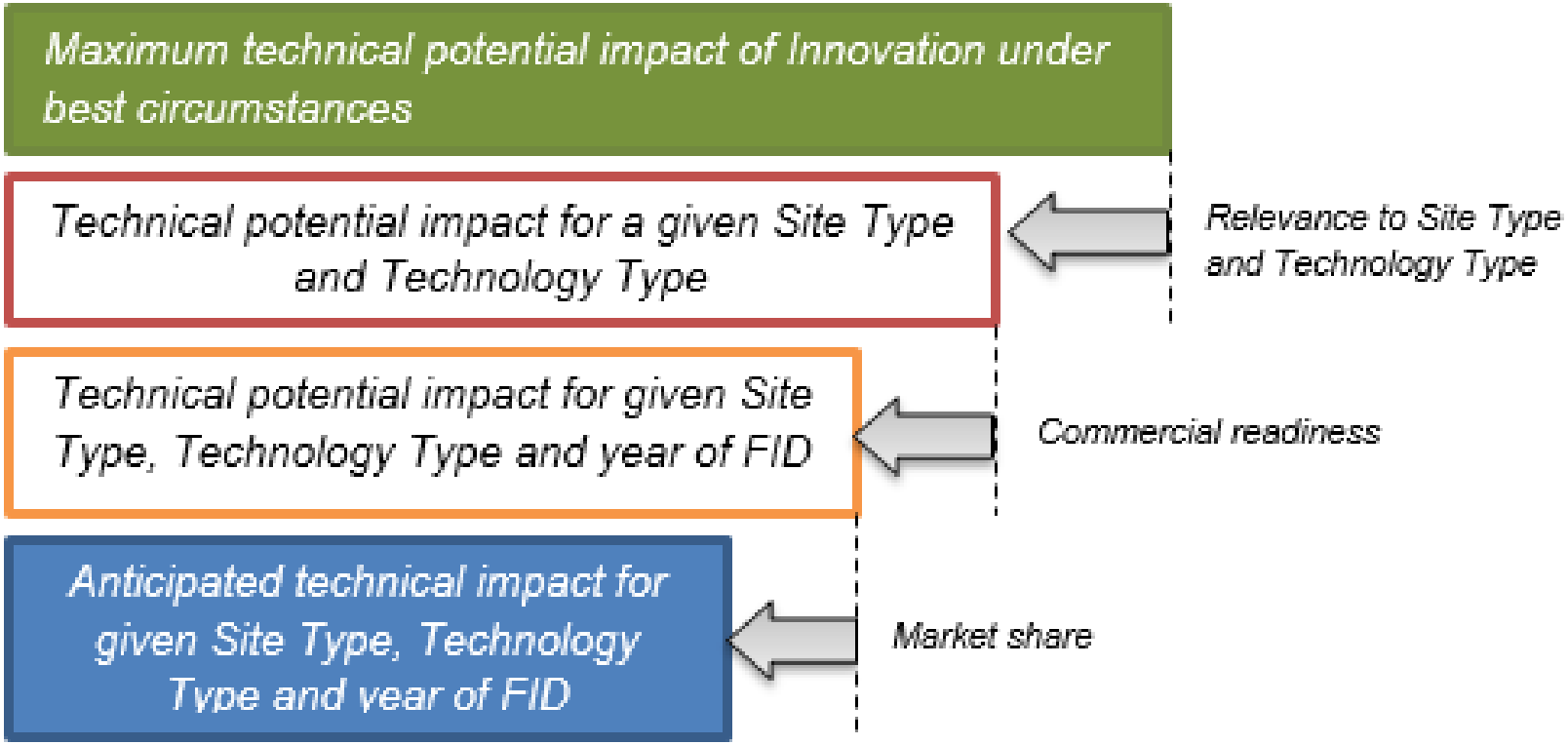
Methodology for cost impact assessment

- Creating a baseline of CAPEX, OPEX and annual energy production for a range of different PV technologies and site types
- Analysis is carried out at a number of points in time (years of FID), thus describing various potential pathways that the industry could follow, each with an associated progression of LCOE.

Nº	Site types	Generic description	Resumed specific description
1	Utility Scale Low radiation site	>5MW ground mounted Low rad / low TºC	10 MW ground mounted Orientation optimal south Example of location: Germany Global radiation: 1200 kWh/m2/y
2	Utility Scale High radiation site	>5MW ground mounted High rad / high TºC	10 MW ground mounted Orientation optimal south Example of location: Spain Global radiation: 1800 kWh/m2/y
3	Building Commercial & residential	<100kW roof mounted	100 kW roof mounted (on factory or warehouse) Orientation south but some shading problems Example of location: Europe average Global radiation: 1350 kWh/m2/y

Process of moderation

Four stage process of moderation applied to the maximum potential technical impact of an innovation to derive anticipated impact on the LCOE. Note that Technology Type in this study means PV Technology



Recorded results for each innovation

Information recorded for each innovation
% impact on cost of: • PV modules • Inverters • BOS Structures • BOS Collection girds • Development, construction and installation • Operation & Maintenance • Other OPEX
% impact on: • Gross AEP, and • Performance ratio.

Expected final results

- Simple LCOE calculations to give access to innovation-only impact, expressed and drawn as:
  - A % of changes in CAPEX, OPEX, AEP and PR
  - A % of LCOE change over the period.
- Complex LCOE calculations to give access to an absolute LCOE value taking into account the real world effect derived in the non-technology parameters.

The results give an overview of the single and cumulative anticipated impact of the innovations from present (FID 2015) to future FIDs, in 2020 and 2030, taking into account not only technical parameters but also the penetration of those innovation in the market.
Besides this, the model also allows to look beyond those dates and to identify (if populated) potential longer term activities that could impact the cost of PV on the long run (beyond 2030).

CHEETAH

Thank you very much!!!

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