
Non price criteria in renewable energy auctions and consequences for the European solar PV industry

WCERE 2026 - 2 July 2026

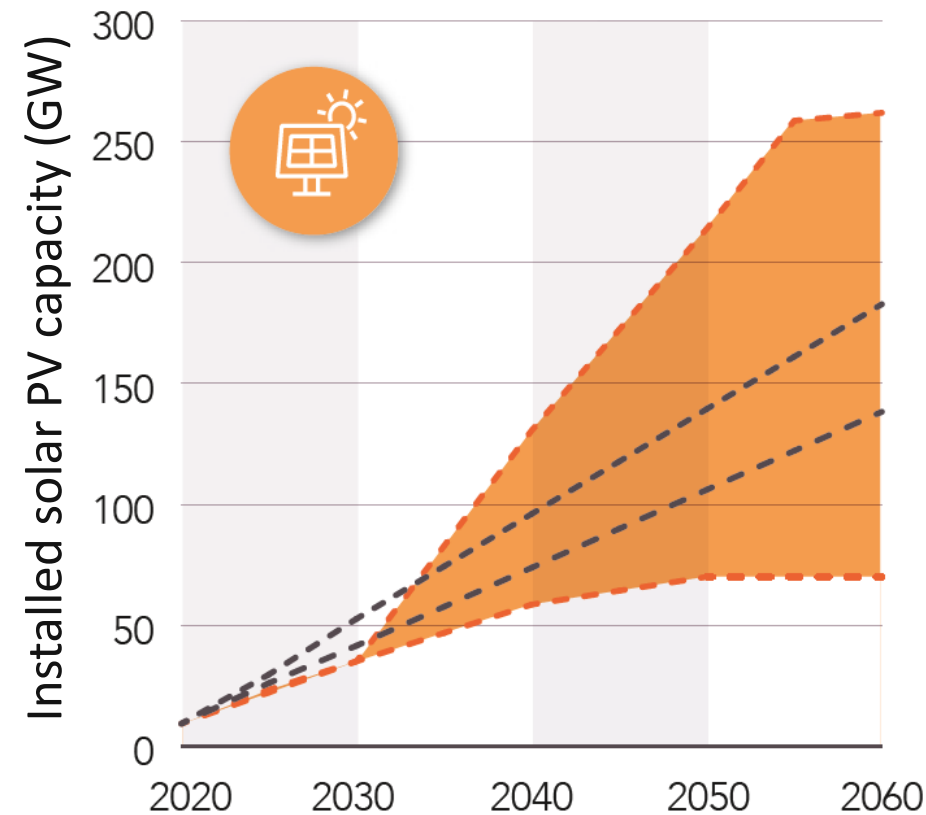
World Congress of Environmental and Resource Economists

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- Introduction
- Analytical framework
- Case study
- Conclusion

Context – Scenarios for solar photovoltaic (PV) development

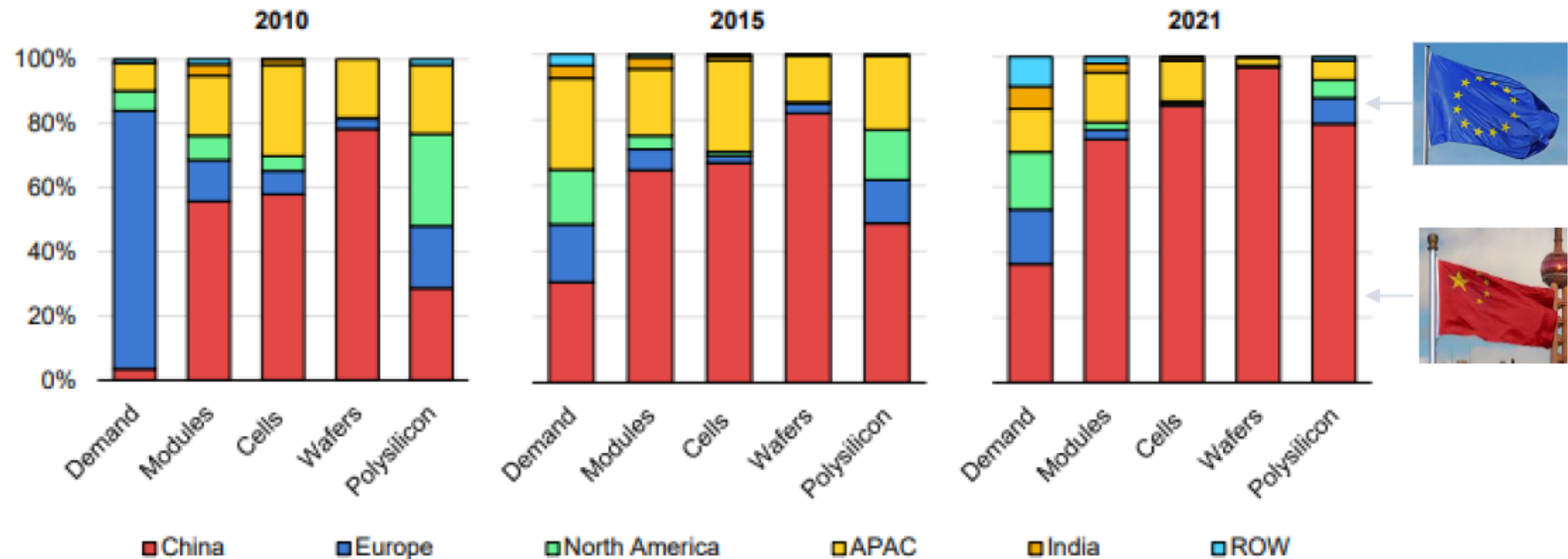
- EU solar photovoltaic (PV) capacity in 2024: 338 GW (IRENA, 2025)
- EU 2030 target for solar PV: 600 GW (European Commission, 2022)



Scenarios of photovoltaic capacity development in France (source: RTE, 2021)

Context – A concentrated global supply chain

Solar PV manufacturing capacity by country and region, 2010-2021



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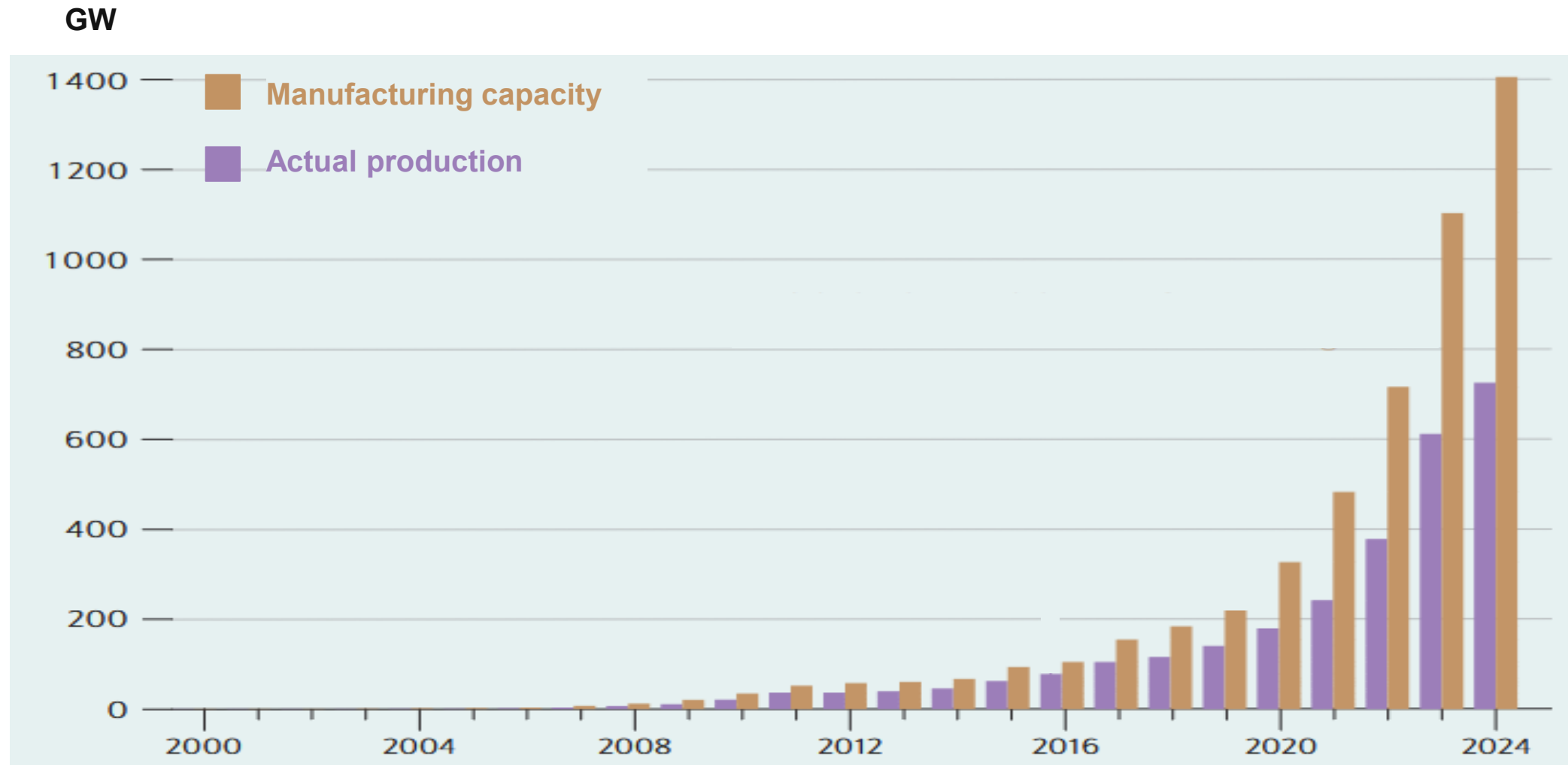
Notes: APAC = Asia-Pacific region excluding India. ROW = rest of world.

Solar PV manufacturing capacity by country and region, 2010 - 2021(source: IEA, 2022)

Context – The Net Zero Industry Act and the European solar PV strategy

- The Net Zero Industry Act declares solar PV a strategic technology and sets ambitious goals for the development of the European solar PV manufacturing sector.
- In particular, in 2030, the Net Zero Industry Act targets:
 - To **supply 40% of the European demand** for solar panels with European products
 - To **develop 30 GW of manufacturing capacity** in the EU across the solar PV supply chain

Context – A sector with significant overcapacities



Global PV module manufacturing capacity and actual production (source: IEA PVPS, 2025)

Context – Prices are below production costs

- Production costs of EU producers : 0,25 – 0,3 €/W (ETIP PV, 2024)



Solar PV price in Europe (source: pvxchange.com, 2025)

Policy instrument proposed by the Net Zero Industry Act

- The NZIA allows EU Member States to condition their support to solar PV projects based on non-price criteria

System integration	Time, space, energy carriers
Innovation	Efficiency, raw material, longevity, circularity, etc.
Environmental	Carbon, energy efficiency, circularity, etc.
Resilience	Bonus for supply outside of dominant source

Policy instrument proposed by the Industrial Accelerator Act

- Introduce Made-In-Europe criteria to create demand for European manufacturing

Motivation – First implementation of Non-price criteria are heterogeneous

First implementations of non-price criteria in solar PV support schemes are heterogeneous

- France rewards reduced carbon footprint and environmental pollution (CRE, 2025; Journal Officiel de la République Française, 2025)
- Italy rewards increased solar panel efficiency (MASE, 2025)
- Spain frames resilience as an award criterion and not a pre-qualification criterion (Boletín Oficial del Estado, 2025)

How does non-price criteria heterogeneity impact market outcomes?

Literature review

This paper relates to multiple strands of literature

- **Renewable auctions:** Bichler et al. (2020), Kröger et al. (2022), Thomaßen and Fuhrmanek (2025)
- **Green public procurement:** Krieger and Zipperer (2022), Liu et al. (2025), Chiappinelli et al. (2025)
- **Local content criteria:** del Rio and Kiefer (2023), Münch and Scheifele (2023), Anatolitis et al. (2025)
- **Competition and economies of scale:** Amir and Lazzati (2011), Gama (2019), Orland (2025)

Market fragmentation: Efficiency losses and fairness in European solar modules manufacturing

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Analytical framework – Solar PV auctions and projects selection

French renewable procurement design (CRE, 2025)

- Fixed volume of tenders: 1 GW of solar PV per period

Scoring Criteria		Value
Price	$NP = NP_0 \times \frac{P_{sup} - P}{P_{sup} - P_{inf}}$	$NPO = 70$
Carbon	$NC = NC_0 \times \left[\frac{ECS_{sup} - ECS}{ECS_{sup} - ECS_{inf}} \right]$	$NCO = 16$
Other	Environmental impact (E) Governance (G) Funding (F)	$E + G + F = 14$
Solar PV project score = $NPO + NCO + E + F + G$		

Analytical framework – Supply and demand for European solar modules

Demand for European PV modules

Country j

Solar module (i)	Quantity (W)	Price (€/W)	
	$\max_{x_{ij}} \sum_i x_{ij}$	$\left[NP0_j \frac{p^{sup} - p(i)}{p^{sup} - p^{inf}} + K_j(i) \right]$	➡ Score maximization
Solar module (i)		Price score	Non-price criteria score

Constraint

$$\sum_i x_{ij} = A_j \quad (\alpha_j)$$

➡ Volume constraint

$$0 \leq x_{ij} \quad (\delta_{ij})$$

➡ Positivity constraint

Supply of European PV modules

Solar module manufacturers sell at the average costs (Chaudhuri, 1996):

$$p(i) = (p^{sup} - p^{inf}) e^{-\frac{\sum_j x_{ij}}{s}} + p^{inf}$$

➡ Price competition

➡ Economies of scale

Analytical framework – Properties of Nash equilibrium

Only the price criterion (NCP > 0 and K = 0)

- Project developers all sourced from the same supplier to benefit from economies of scale ➡ **Cost-efficiency is maximal**
- Only one firm with non-zero production at equilibrium ➡ **Competition intensity in the market is minimal**

Price and Non-price criteria (NCP > 0 and K > 0)

- Possibly multiple firms with non-zero production depending on $K_j(i)$ heterogeneity ➡ **Cost efficiency is weakened**
- One firm cannot compete in two different auctions (market fully segmented) ➡ **Competition intensity has not improved**

Necessary conditions for M firms to compete in the market at equilibrium: $\forall i \in \llbracket 1; M \rrbracket, \delta_{ij} = 0$

- Defining $(x_{ij}^*)^c$ the unique solution of this new problem when NCP>0 and K>0
- For M>1, $(x_{ij}^*)^c$ is not the monopoly solution $(x_{ij}^*)^m$ and suffer from diseconomy of scale
- However, $\forall \varepsilon > 0, \exists (NP0, K), \|(x_{ij}^*)^c - (x_{ij}^*)^m\| < \varepsilon$
 - ➡ Auction specifications can be chosen to make the competitive and monopoly solutions arbitrarily close to each other
 - ➡ Non price criteria can incentivize smaller and innovative firms to enter the market and produce
 - ➡ With auction budget constraint, this reduces coalition chances, ensuring Bertrand competition and average cost pricing

Market fragmentation: Efficiency losses and fairness in European solar modules manufacturing

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Case study

The case study investigates how heterogeneous implementation of non-price criteria influences European solar module manufacturing in 2030

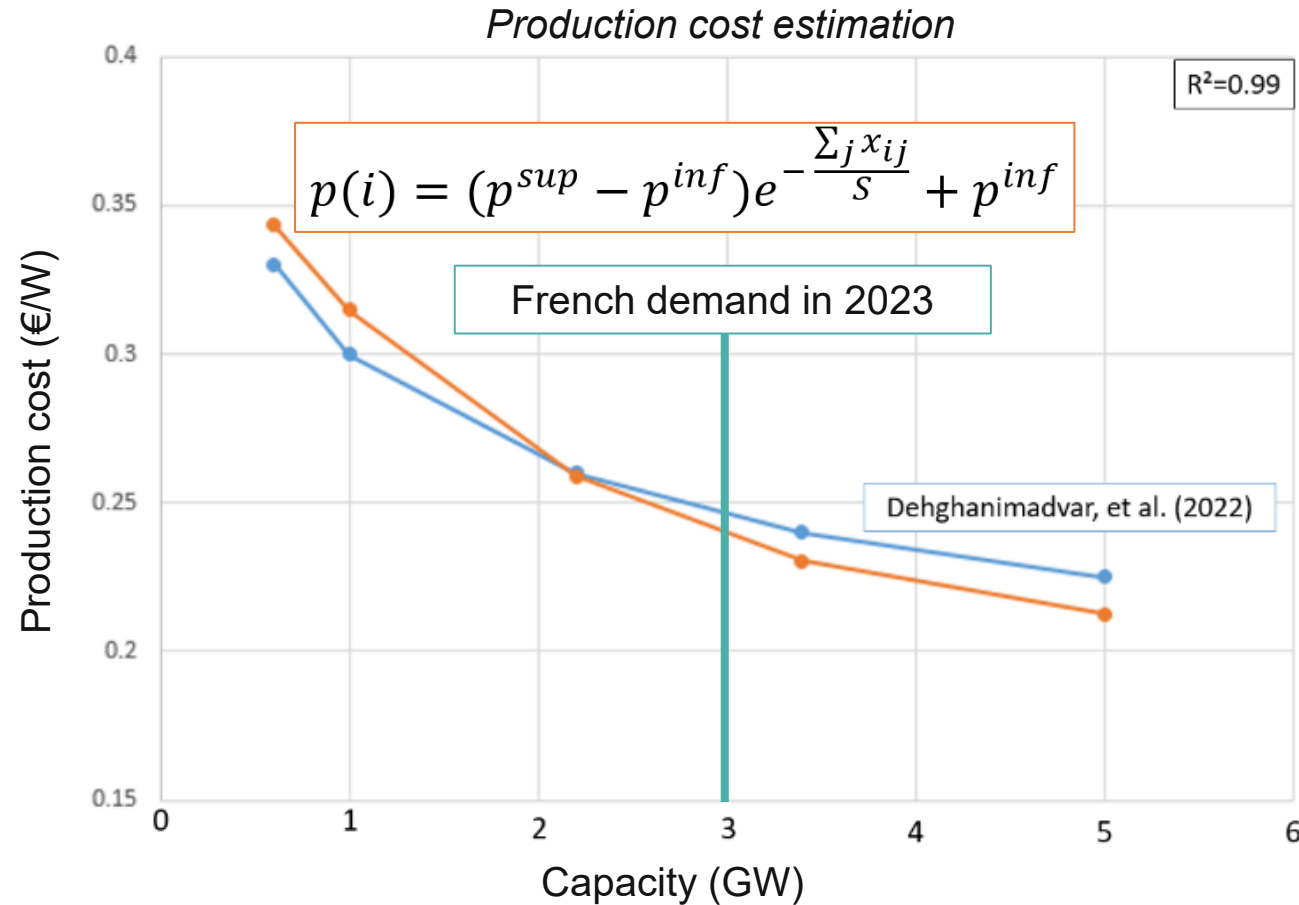
Prices (NP0) and national preferences (K_j) (K_j aggregates remaining criteria)	$\max_{x_{ij} (\forall i)} \sum_i x_{ij} \left[NP0_j \frac{p^{sup} - p(i)}{p^{sup} - p^{inf}} + K_j(i) \right]$
Volume auctioned at EU level: calibration on NZIA targets	$\sum A_j = 30 \text{ GW}$
Volume auctioned at national level: calibration on 1/3 national targets	$\sum x_{ij} = A_j$

We consider divergent implementations of non-price criteria

$For\ all\ j: NP0_j = NP0$ ➡ Price criteria homogeneous across country
 $When\ j \neq i: K_j(i) = 0$
 $When\ j = i: K_j(i) = K$ } Each country favours disjoint sets of modules but with similar intensity

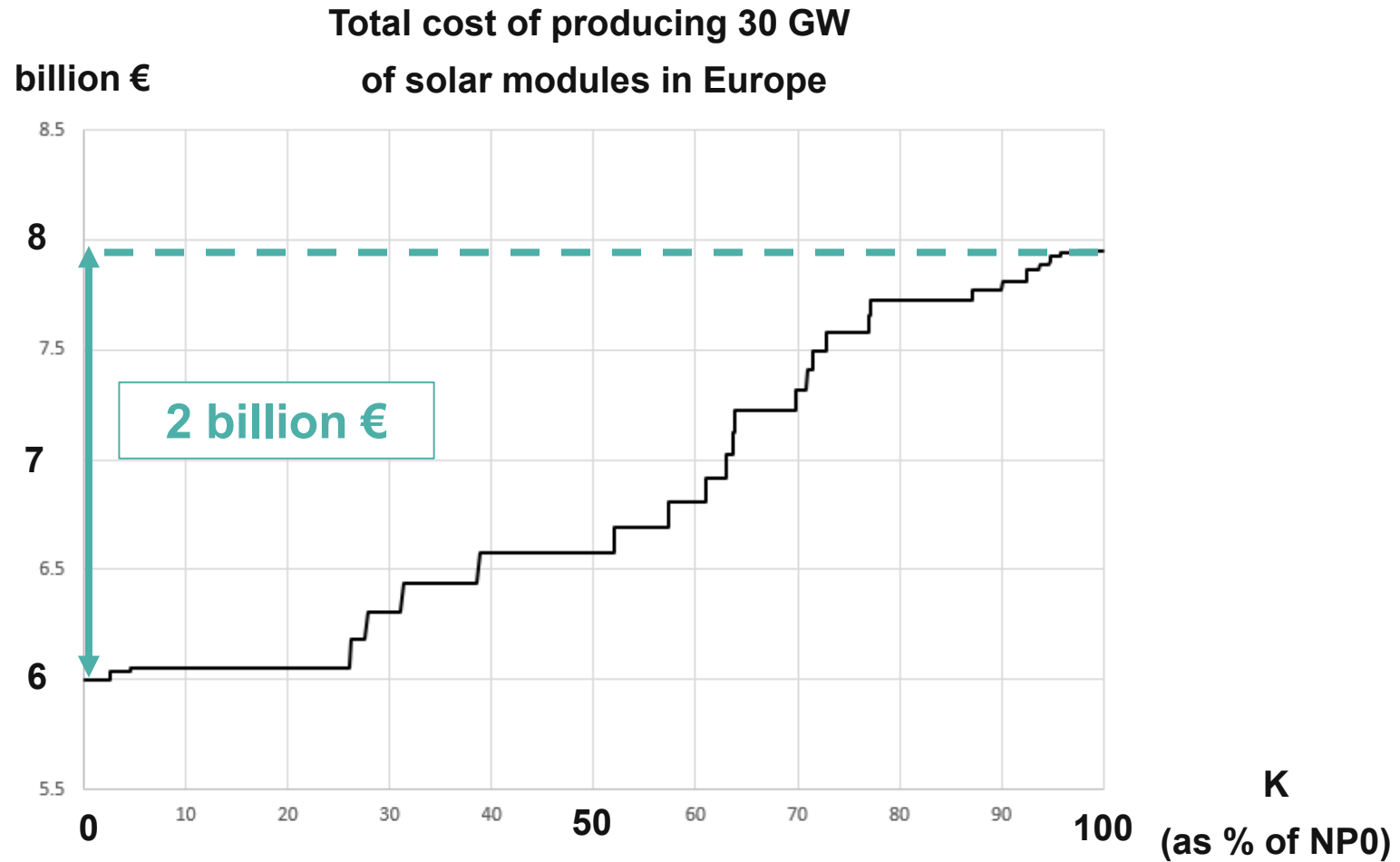
In numerical application, NP0 is kept constant, but K will increase to emulate increasingly divergent non price criteria

Case study – Module production cost and economies of scale



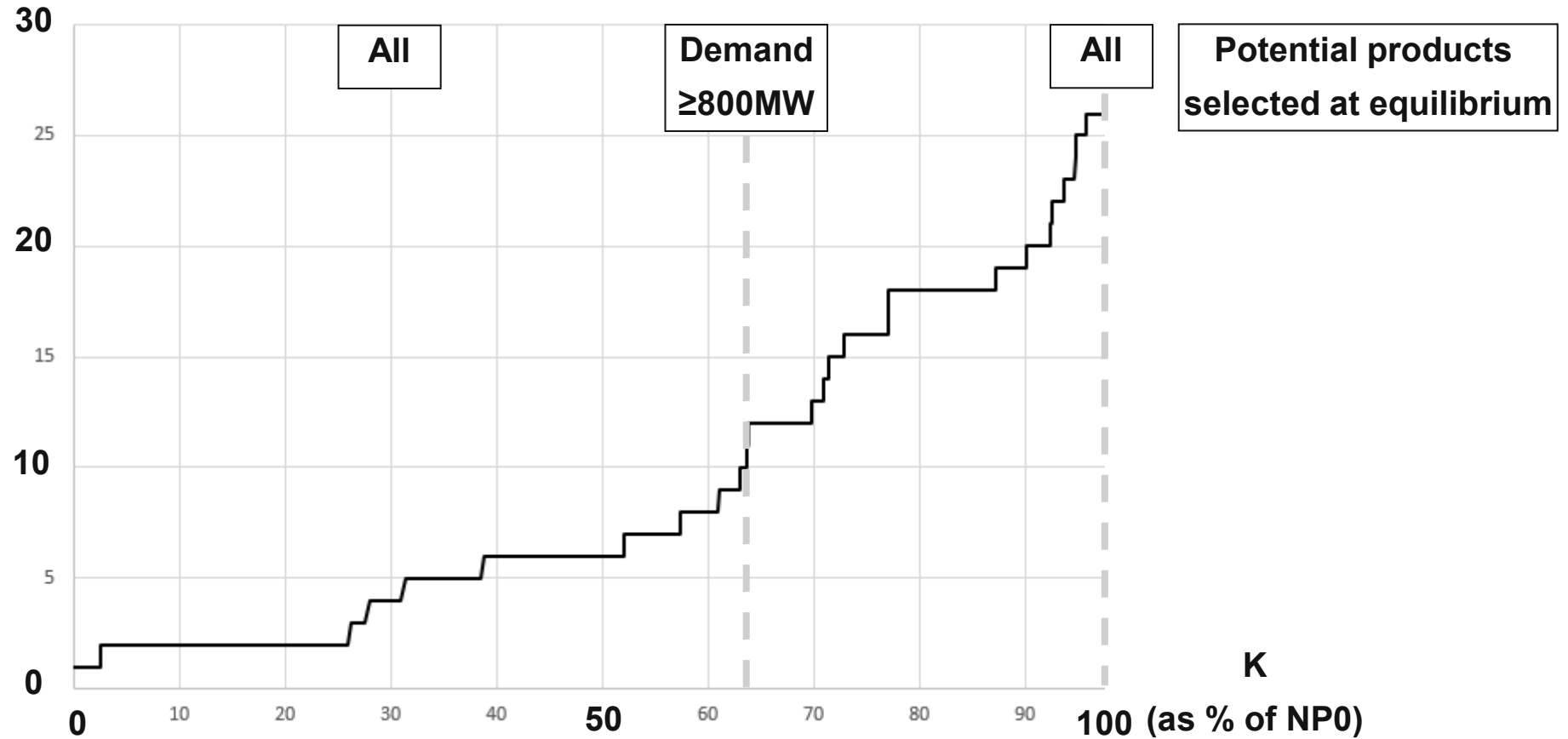
Model parameter	Name	Units	Value
Maximum production cost	Psup	€/W	0.4
Minimum production cost	Pinf	€/W	0.2
Economies of scale	S	MW	1800

Case study – Results: Efficiency analysis



Case study – Results: Analysis of modules selected at equilibrium

Number of products
at equilibrium



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Main findings

Analytical results

- Non-price criteria can fragment the market or help solve the tension between competition and cost

Numerical results

- Market fragmentation can generate substantial losses: 2 billion € per year
- Preferences divergence reduces competition and favours largest countries

Policy recommendations

A common framework to implement non-price criteria at the country level and reduce market fragmentation risks in the EU is a no-regret strategy.

Thank you for your attention

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