

Diffusion of energy technology innovations in Portugal and perspectives for decarbonization

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Institutional affiliations

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Financing

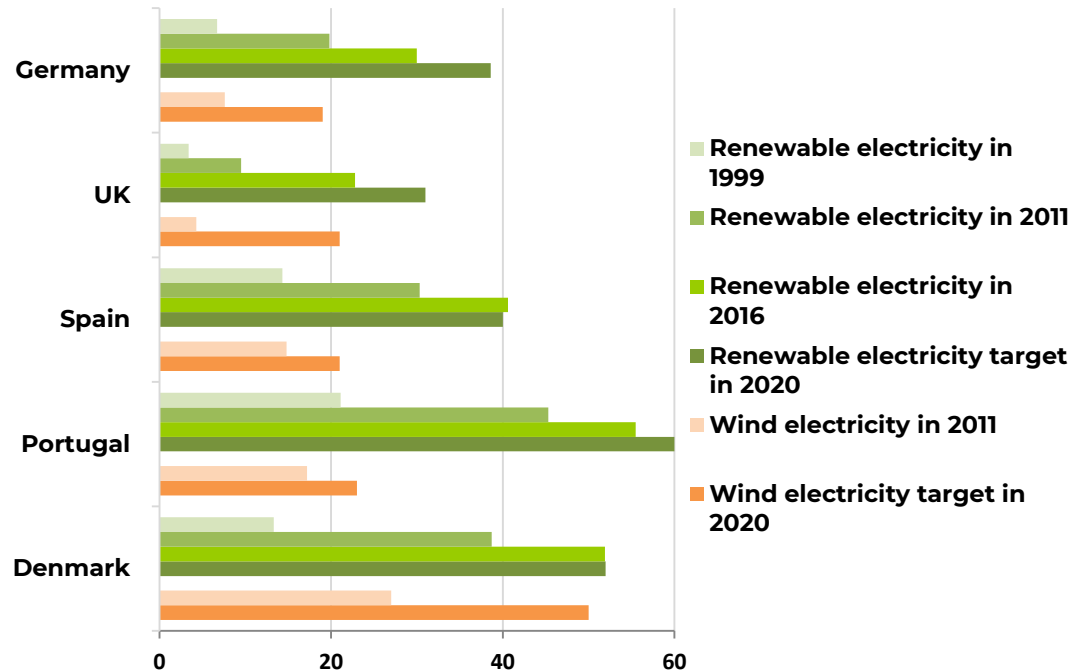
FCT Fundação
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Project



Portugal has been a fast follower in the energy transition

Share of RES in Gross Final Electricity Consumption (in %)



Sources: DGEG (2013, p.12); National Renewable Energy Action Plans (NREAPs) of the European Member States: Beurskens et al.(2013, Table 3 and 10a/b); Ren21 Map <<http://map.ren21.net>> (accessed in September 17, 2013); Plano Nacional de Accção paraas Energias Renováveis (PNAER in Resolução do Conselho de Ministros no. 20/2013, 10 April), Eurostat, 2018.

OUTLINE

I. DIFFUSION OF ENERGY TECHNOLOGIES IN PORTUGAL

**II. CONSTRUCTION OF A LOCAL INNOVATION SYSTEM
AROUND NEW ENERGY TECHNOLOGIES**

**III. MEETING THE CHALLENGE OF DECARBONIZATION BY
2050**

I. Diffusion of energy technologies in Portugal

A. DETERMINANTS OF THE DIFFUSION RATE

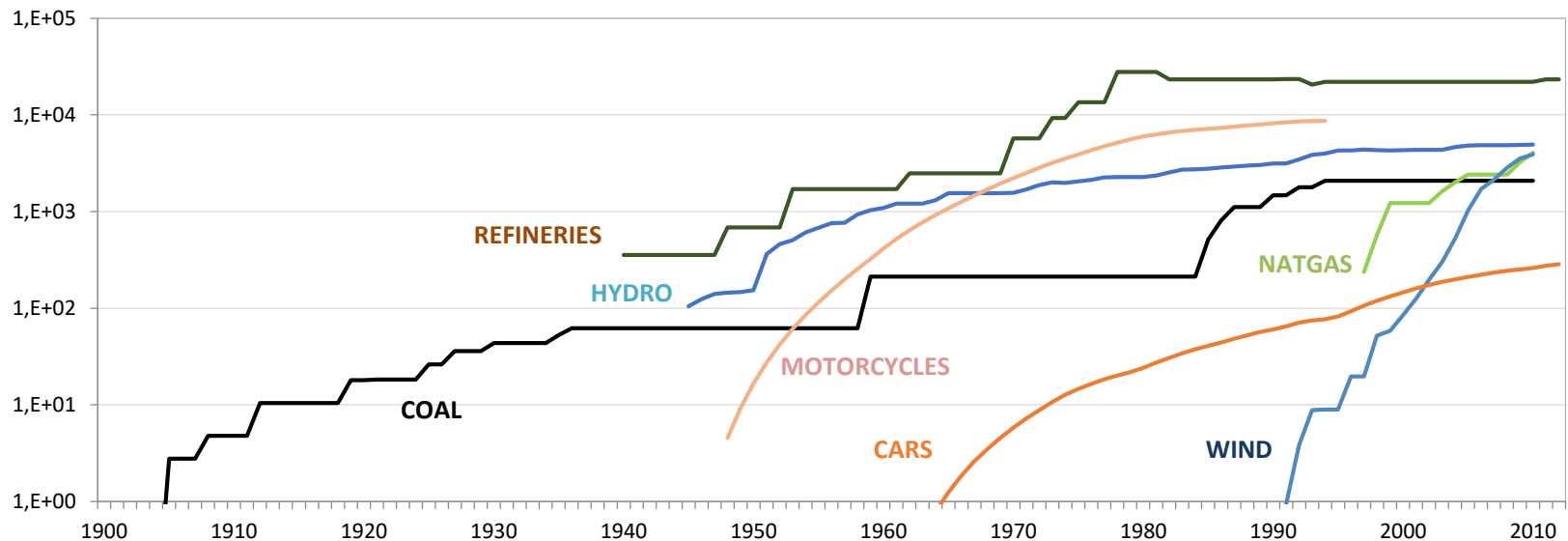
- **relative advantage**
- **size of potential market**
- **disruptiveness (existence of antecedent markets)**
- **technological complexity**
- **infrastructure needs**

B. HISTORICAL DIFUSION OF ENERGY TECNOLOGIES IN PORTUGAL

- **technology diffusion is a slow process**

Technology diffusion is a slow process

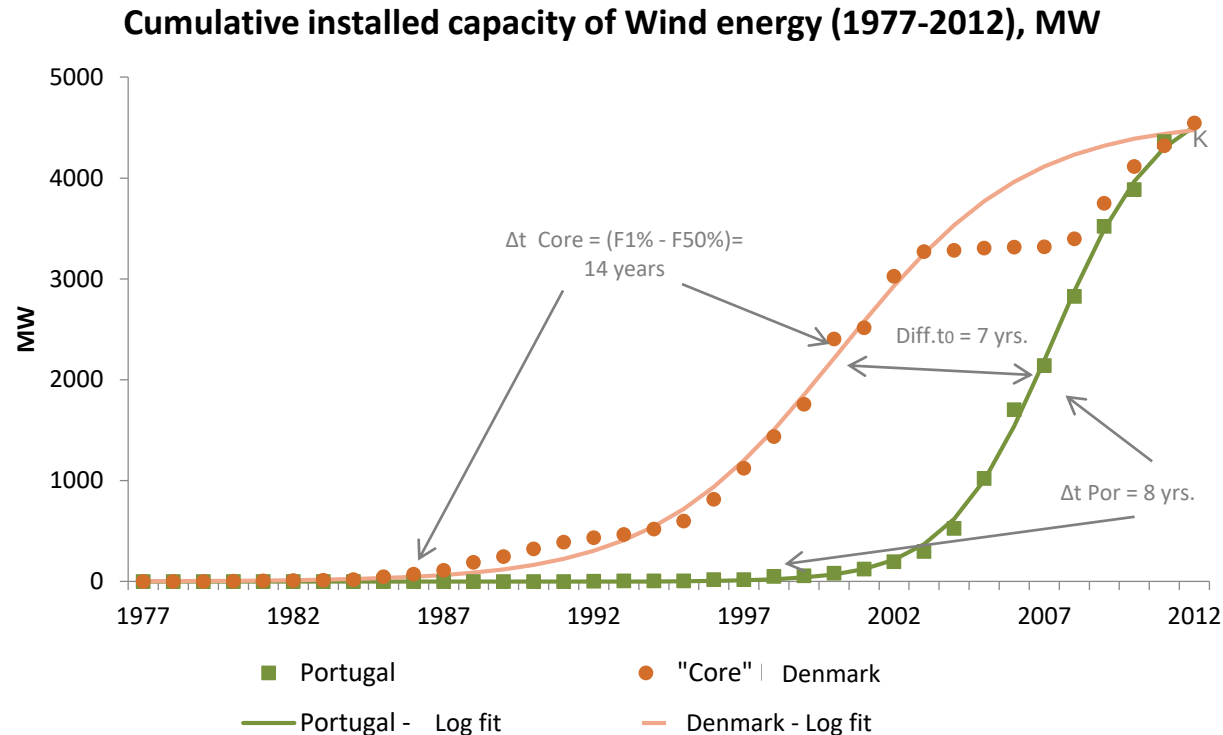
Cumulative installed capacity (MW) of several energy technologies in Portugal since 1900, log y-axis



B. HISTORICAL DIFFUSION OF ENERGY TECHNOLOGIES IN PORTUGAL

- **technology diffusion is a slow process**
- **average lag of 1-2 decades compared to diffusion in “core” countries, though reducing lately**

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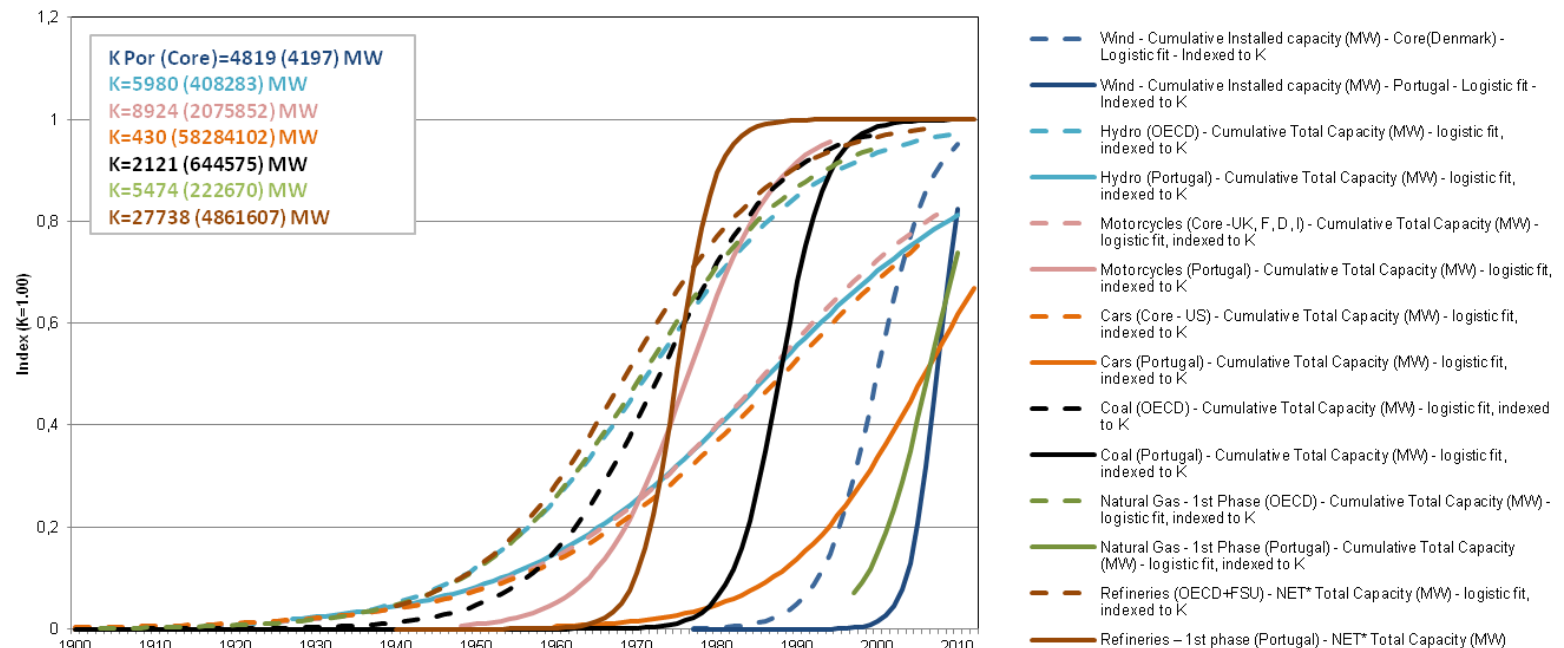


B. HISTORICAL DIFFUSION OF ENERGY TECHNOLOGIES IN PORTUGAL

- technology diffusion is a slow process
- average lag of 1-2 decades compared to diffusion in “core” countries, though reducing lately
- **speed of diffusion accelerates in comparison with the countries from the “core”**

Speed of diffusion accelerates in comparison with the “core”

**All technologies (Portugal vs Core) – Cumulative installed capacity,
Log fits, Indexed to k=1.00**



B. HISTORICAL DIFFUSION OF ENERGY TECHNOLOGIES IN PORTUGAL

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- **confirms market size and infrastructure needs as important determinants of the rate of diffusion**

Confirms market size and infrastructure needs as important determinants of the rate of diffusion

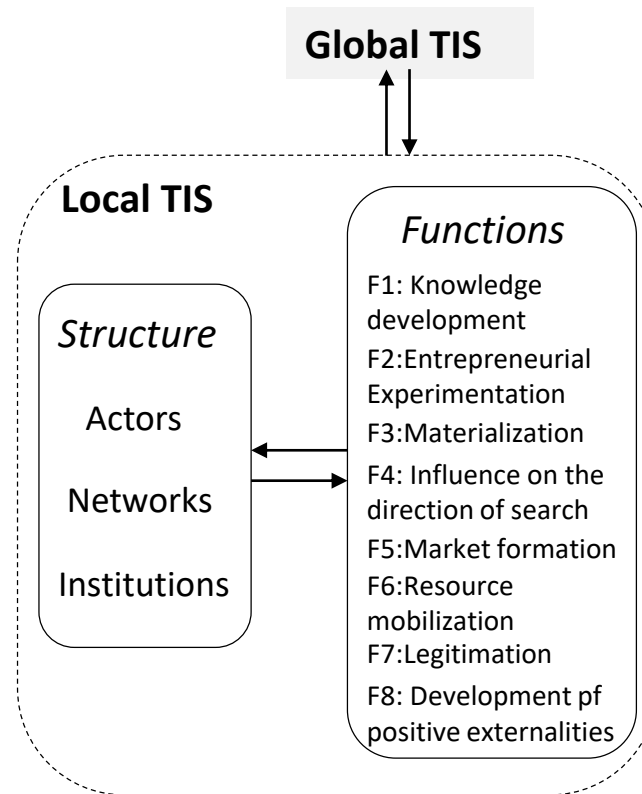
Technology	Relative advantage (price/cost)	Technology pervasiveness (market size)	Technological factors		Infrastructure needs	Structural requirements			Diffusion (years)*	Delay for the Core (years)
			Technology disruptiveness (or substitute)	Technology Complexity		Actors (value-chain)	Networks (diversity)	Institutions (laws, conducts..)		
Oil Refineries	++		.	-		+	+	.	10	6
Power – Coal	+	--	-	.	.	.	.	-	13	15
Power - Hydro	++	-	-	.	-	.	.	--	66	15
Power -Nat.Gas	+		++	+		+	+	-	16	35
Power - Wind	--	--	++	-	-	-	--	-	8	7
		-			--					
		-			+					

B. HISTORICAL DIFFUSION OF ENERGY TECHNOLOGIES IN PORTUGAL

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- **confirms market size and infrastructure needs as important determinants of the rate of diffusion**

II. Construction of a local innovation system around new energy technologies

A. TECHNOLOGICAL INNOVATION SYSTEMS: FUNDAMENTAL ELEMENTS



Binz, C., & Truffer, B. (2017). Global Innovation Systems—A conceptual framework for innovation dynamics in transnational contexts. *Research Policy*, 46(7), 1284-1298.

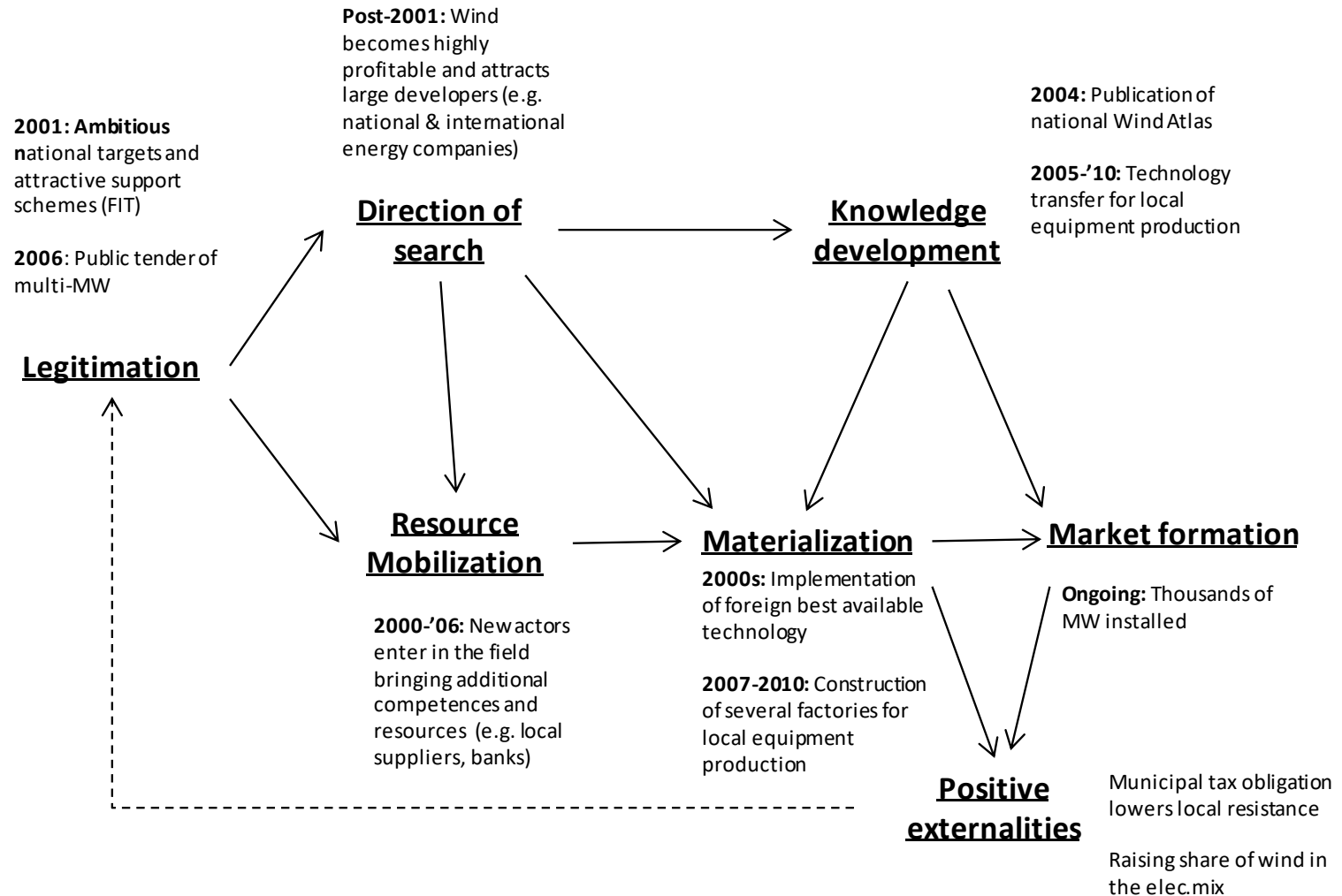
Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological forecasting and social change*, 74(4), 413-432.

Bergek, A., Hekkert, M., & Jacobsson, S. (2008). Functions in innovation systems: A framework for analysing energy system dynamics and identifying goals for system-building activities by entrepreneurs and policy makers. *Innovation for a low carbon economy: economic, institutional and management approaches*, 79.

B. CREATION OF A NEW TIS IN A FAST FOLLOWER CONTEXT - WIND ENERGY IN PORTUGAL

- 1. implementing a local wind energy TIS:
key events and functions**
- 2. integrating the international
dimension**

1) Implementing a local wind energy TIS: key events and functions



Bento, N., & Fontes, M. (2015). Spatial diffusion and the formation of a technological innovation system in the receiving country: The case of wind energy in Portugal. *Environmental Innovation and Societal Transitions*, 15, 158-179.

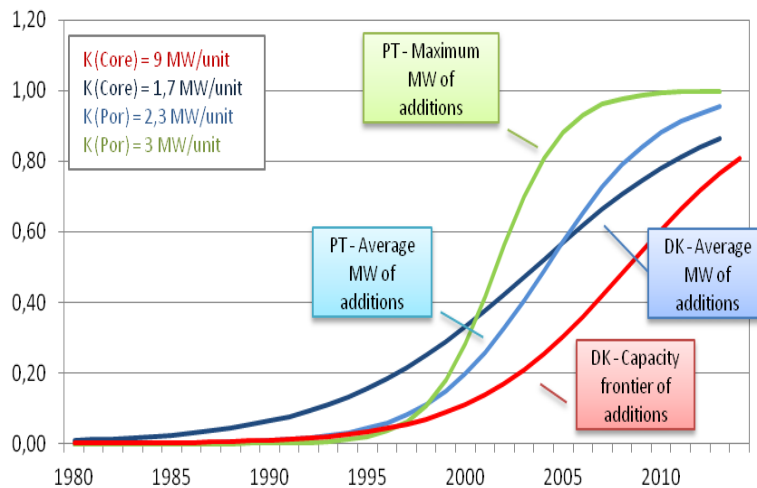
Bento, N., & Fontes, M. (2015). The construction of a new technological innovation system in a follower country: Wind energy in Portugal. *Technological Forecasting and Social Change*, 99, 197-210.

2) Integrating the international dimension

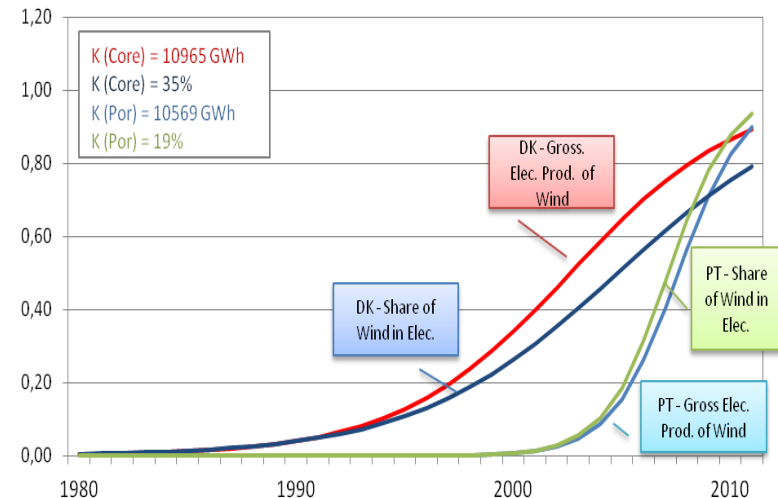
- **Knowledge spillovers**

Spatial acceleration of technology and market scaling indicates knowledge spillovers

Spatial acceleration (Unit scaling): Denmark vs Portugal
Logistic fits indexed to $K=1.00$



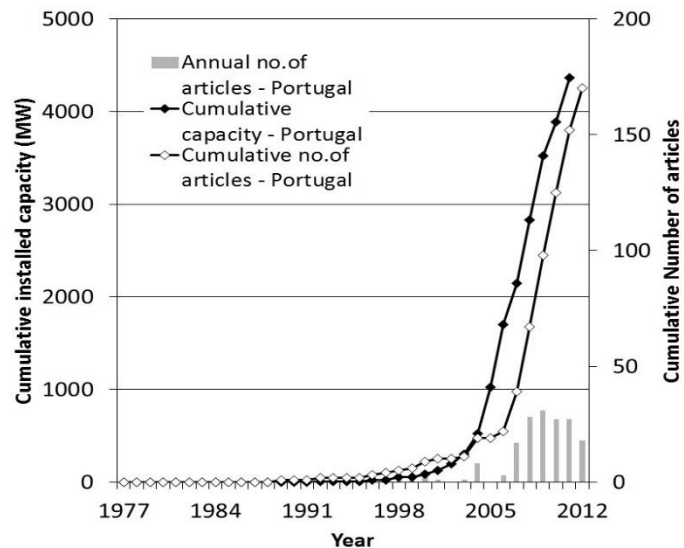
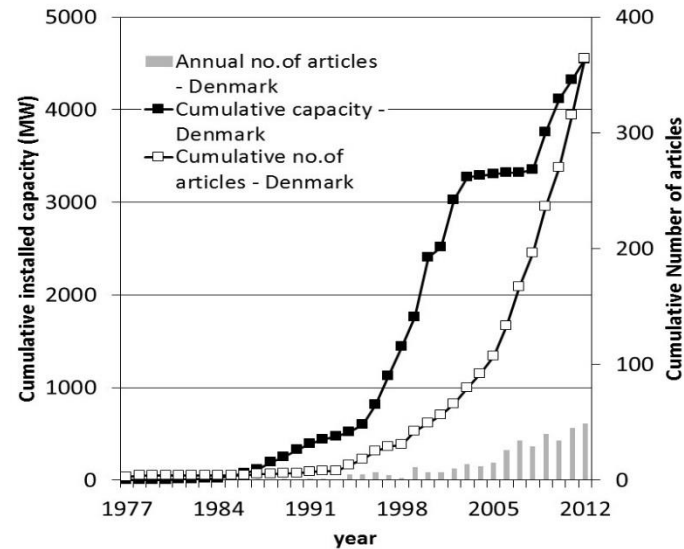
Spatial acceleration (Elec.Generation): Denmark vs Portugal,
Log fits indexed to $K=1.00$



2) Integrating the international dimension

- **Knowledge spillovers**
- **Improved absorptive capacity**
 - **R&D efforts**
 - **development of value chain**
 - **practical knowledge production**

Coevolution of knowledge production and diffusion in DT



2) Integrating the international dimension

- Knowledge spillovers
- Improved absorptive capacity
 - R&D efforts
 - development of value chain
 - practical knowledge production
- Transnational activities
 - participation in international R&D projects
 - strategic alliances with foreign companies

Contribution of domestic and transnational activities to the fulfillment of the functions of innovation system

Event / FIS	F1. Development of formal knowledge	F2. Entrepreneurial experimentation	F3. Materialization	F4. Influence on the direction of search	F5. Market formation	F6. Resource mobilization	F7. Legitimation	F8. Development of positive externalities
<i>Domestic activities (increasing absorptive capacity)</i>								
- national R&D	•	•		•			•	
- development of local value chain		•	•	•		•	•	•
- support schemes			•	•	•	•	•	•
<i>Transnational activities (capturing knowledge spillovers)</i>								
- international R&D projects	•	•		•				
- strategic alliances with foreign companies		•	•		•	•	•	•

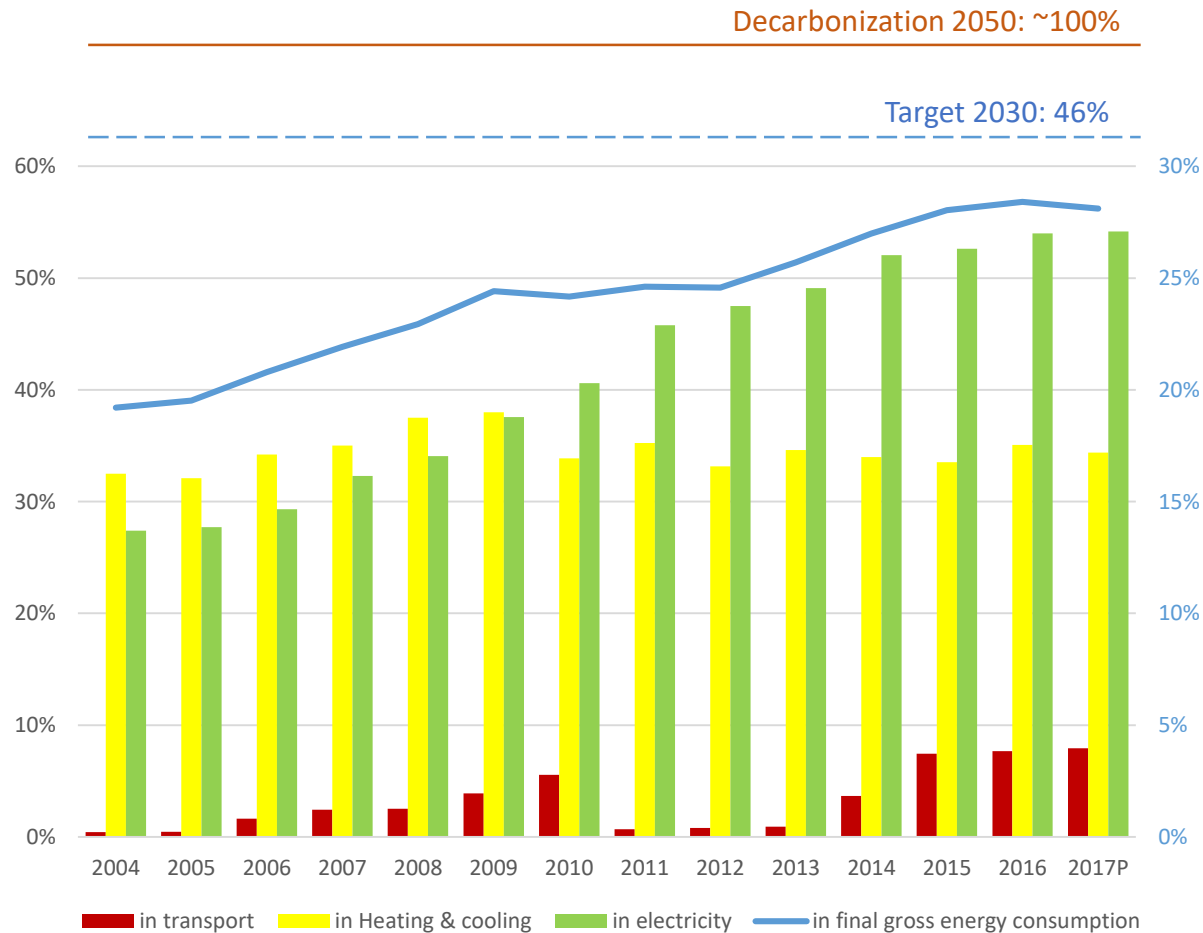
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- **Knowledge spillovers**
- **Improved absorptive capacity**
 - **R&D efforts**
 - **development of value chain**
 - **practical knowledge production**
- **Transnational activities**
 - **participation in international R&D projects**
 - **strategic alliances with foreign companies**

III. Meeting the challenge of decarbonization by 2050

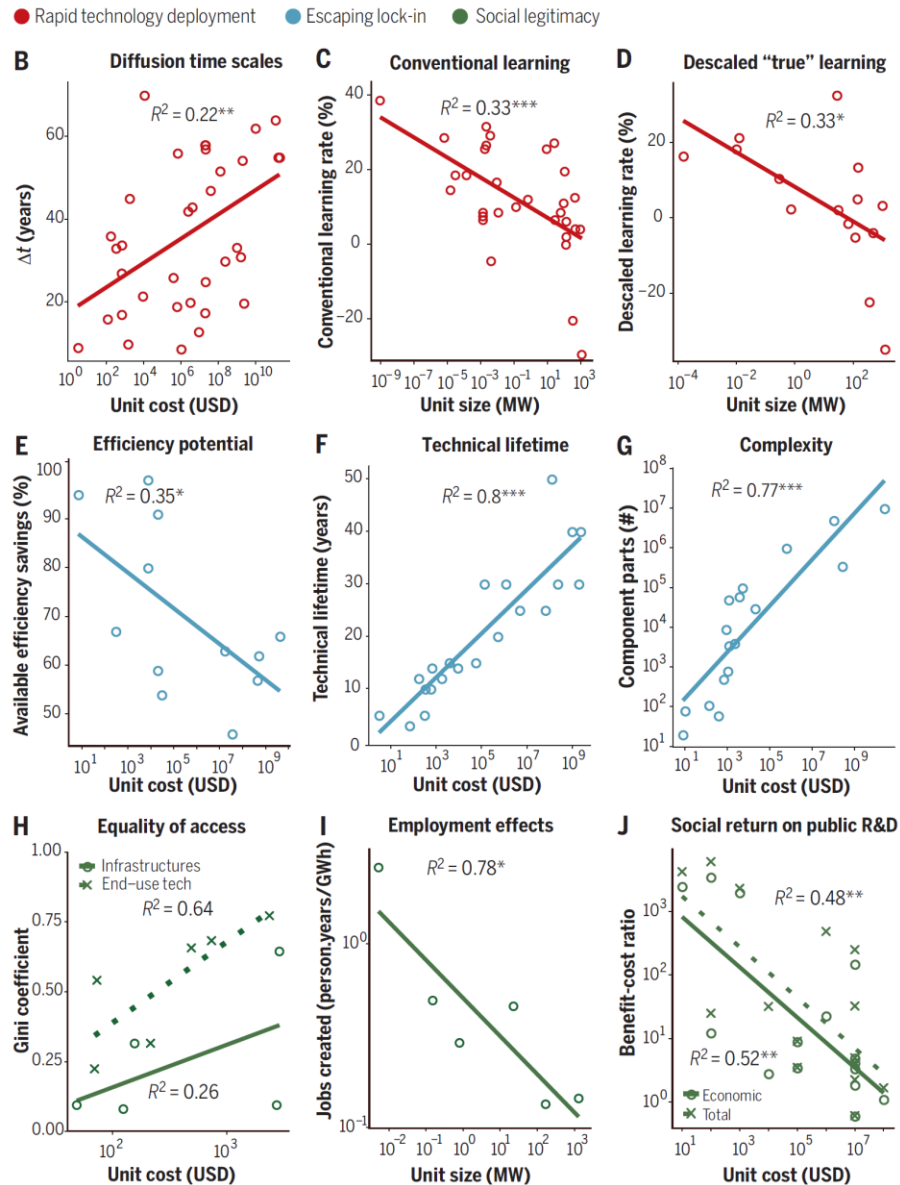
A. NEXT PHASE OF THE ENERGY TRANSITION: SPREAD ACCELERATION

Contribution of RES to gross final energy consumption (in %) in Portugal



Source: DGE, 2019.

B. TECHNOLOGICAL STRATEGIES TO ACCELERATE DECARBONIZATION: GRANULARITY



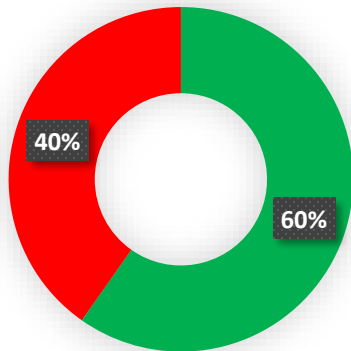
Wilson C., Grubler A., Bento N., Healey S., De Stercke S., Zimm C. (2020), "Granular Energy Technologies for Accelerating Low-Carbon Transformation," *Science* 368 (ISSUE 6486), 3 April 2020.

C. PROMOTE ECONOMIC TRANSFORMATION

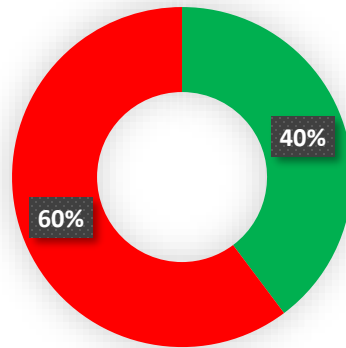
e.g. balance speed and impact in Ocean energy technologies

Organizational changes by technology

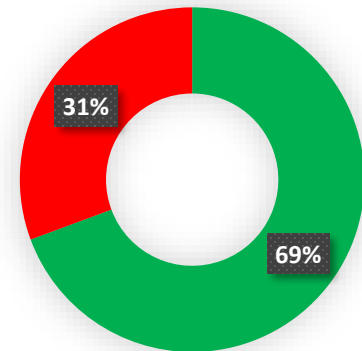
Wave



Offshore



Marine



■ Changes ■ No changes

Conclusion

- **accelerate diffusion is possible**
- **monitor knowledge progress and local experiments are key**
- **non-energy sectors can transform and contribute to transition**
- **accelerating decarbonization requires rapid dissemination and transformation of activities**

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