



Into an uncertain future for energy  
innovation: ensuring balance,  
consistency, alignment and diversity in  
the EU's SET Plan

*March 2019*

Yeong Jae Kim  
Charlie Wilson



## ❖ Objectives

- Assess current EU energy innovation portfolio (SET Plan)
- Analyse energy *innovation systems* in decentralised vs. centralised pathways
- Apply quantitative indicators to measure innovation activities for specific technologies in a standardised, comparable way

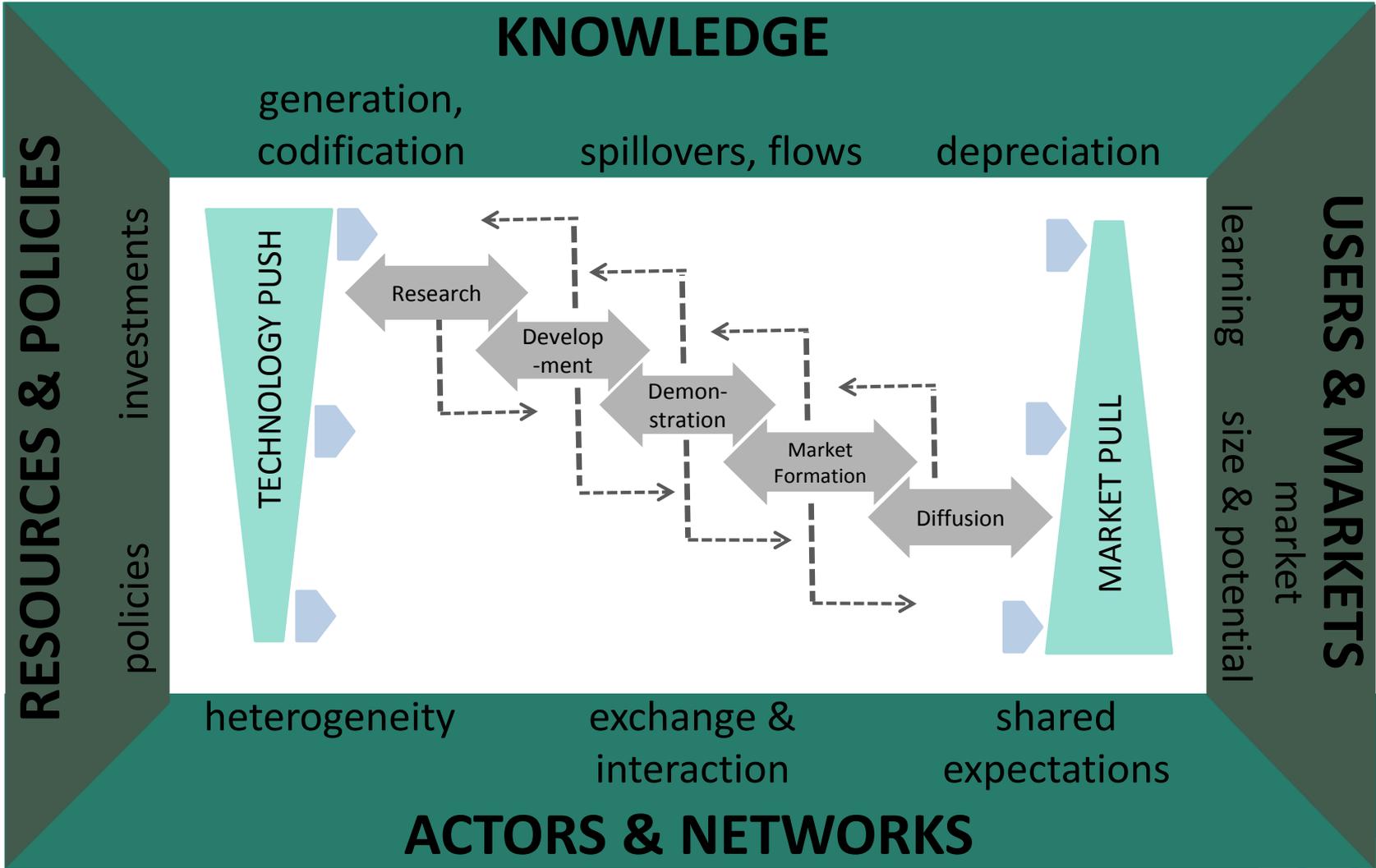
## ❖ EU SET Plan Energy Innovation Portfolio (2015)

- Analyse SET-Plan innovation portfolio for **balance, consistency & alignment** across the six technology fields

## ❖ Future Change in the EU's Energy Innovation System (2000-2015, and in future pathways)

- Analyse historical relationships between innovation inputs, policy, and outputs
- Test the importance of **policy characteristics** (durability, consistency, and diversity)
- Apply historical insights to understand future pathways

**THE INNOVATION LIFECYCLE FROM R&D THROUGH TO DIFFUSION TAKES PLACE WITHIN AN INNOVATION SYSTEM**



# Examples of knowledge-related indicators

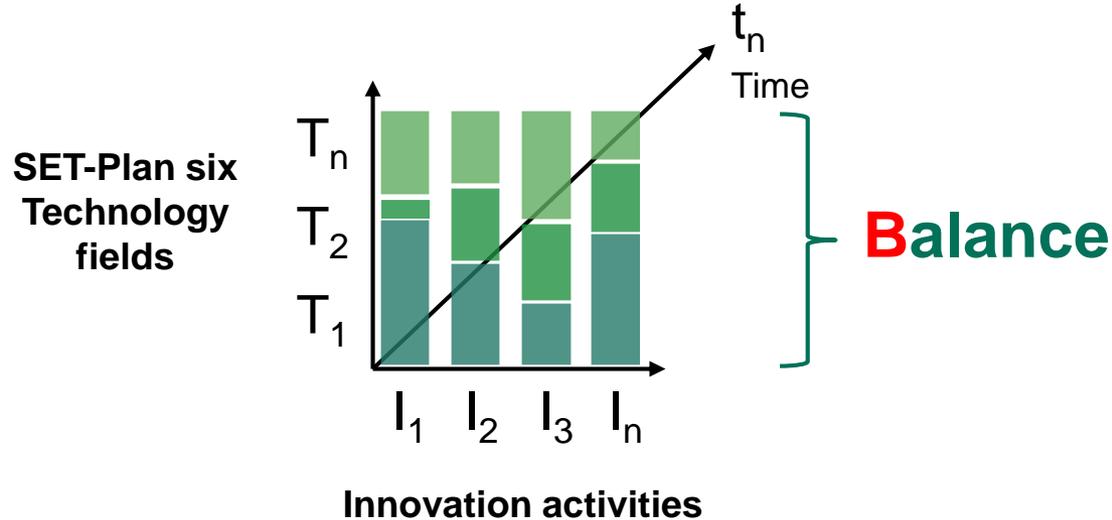
Innovation system processes in the ETIS framework	Technology-specific indicators (illustrated for the EU)	Absolute values for renewable energy in the EU in 2015 (with units)	Data availability
<b>KNOWLEDGE</b>			
Generation	Public energy RD&D expenditure	880 (euros, millions)	Country*
	Demonstration budgets	91 (euros, millions)	Country*
Codification	Scientific publications	16,030 (number of articles)	Country
	Citation-weighted publication counts	123,372 (number of articles)	Country
	Patents <sup>^</sup>	2,422 (number of patents)	Country
	Citation-weighted patent counts <sup>^</sup>	1,414 (number of patents)	Country
Spillover	Energy technology imports	12,810 (euros, millions)	Country
International Flows	Publication co-authorships between EU and non-EU actors	598 (number of co-authorships)	Country
	Patent co-inventions between EU and non-EU actors <sup>^</sup>	1,088 (number of co-inventions)	Country
Learning	Learning-by-doing	17 (% learning rate)	Global <sup>†</sup>
Depreciation	Volatility in energy RD&D expenditure	7.1 (coefficient of variation)	Country*



Source: Table 1 in Wilson & Kim (2018). Chapter 5 of: The Global Innovation Index 2018

# Analysing SET Plan energy innovation portfolio

**Balance =**  
similar relative shares for technologies within portfolio  
across innovation activities



**Balance =**  
diversify technology risk (avoid picking winners)

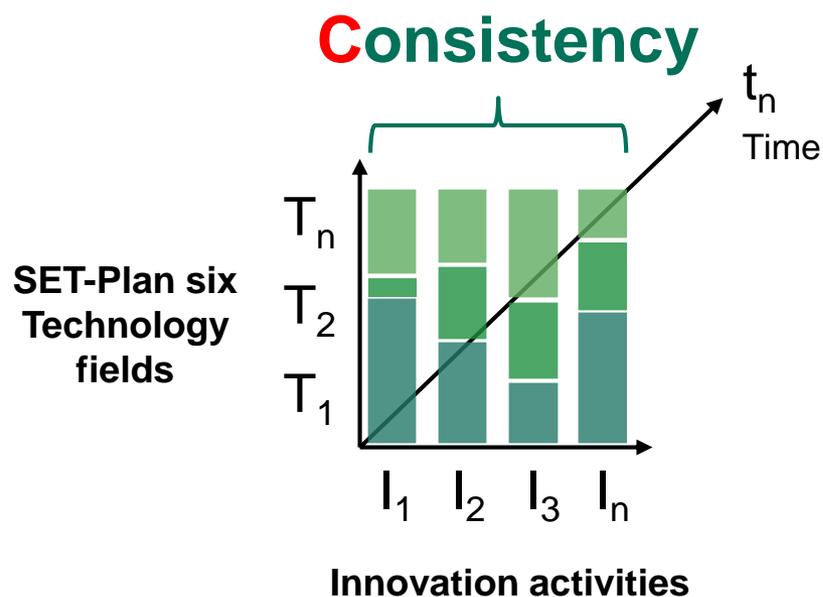
## MAIN FINDINGS

- SET Plan portfolio is **balanced** in terms of R&D expenditures and public policy instruments.
- SET Plan portfolio is **imbalanced** in terms of knowledge codification, flows and spillover (strongly towards renewable energy, energy efficiency, or sustainable transport)

## MAIN IMPLICATIONS

- Introduce tied conditions to research funding to weakly emphasised technology fields
- Support public-private research consortia with higher propensity to engage in open knowledge exchange

**Consistency =**  
similar relative shares for *related* innovation activities within portfolio



**Consistency =**  
coordinate efforts to avoid tensions and omissions

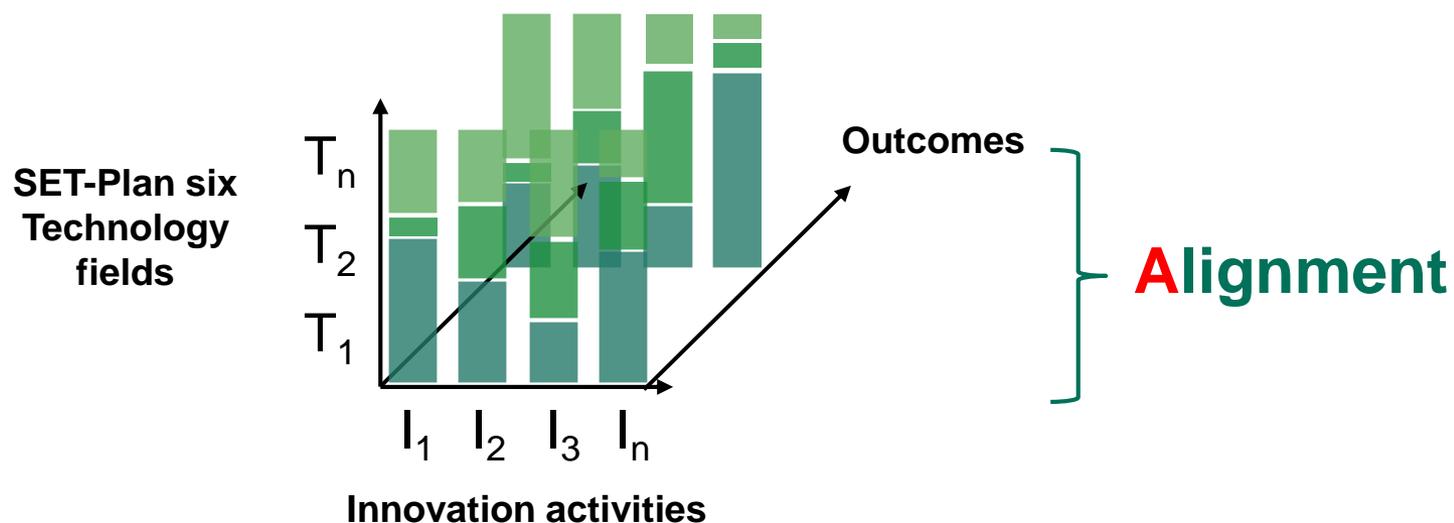
## MAIN FINDINGS

- Innovation activities are **consistent** in terms of resources, policies, actors and networks across all technology fields.
- However, innovation activities are **inconsistent** for renewable energy (patents), energy efficiency (patents), and sustainable transport (collaboration) as knowledge-related innovation is only strongly emphasised.

## MAIN IMPLICATIONS

- Portfolio managers can directly boost innovation activity in some under-performing areas.
- In particular, approaches available for stimulating **knowledge codification** (sustainable transport) and **flows and spillovers** (renewable energy and energy efficiency).

**Alignment =**  
similar relative shares for technologies within portfolio  
between directed innovation efforts and outcomes



**Alignment =**  
deliver on desired or targeted goals

## MAIN FINDINGS

- Late stage innovation activities are **broadly aligned** with learning and innovation outcomes across all technology fields.
- However, **sustainable transport** and **CCS** are **misaligned** as late stage innovation activity is not leading to rising market share.

## MAIN IMPLICATIONS

- Importance of strong market-pull incentives to support innovation outcomes in **sustainable transport**.
- EU-level coordination and direction of innovation needed for **CCS** given current uncertain price support and inadequate market deployment incentives.

# Analysing Future Change in the EU's Energy Innovation System

## OBJECTIVES

- Analyse historical relationships between **innovation inputs, policy, and outputs**
- We explore impacts of future change on **three key innovation outcomes**: patenting (innovation), co-invention (collaboration), and technology cost reduction (diffusion).
- Test the importance of **policy characteristics** (durability, consistency, and diversity)
- Apply historical insights to understand future pathways

## MAIN FINDINGS

- **Diverse mixes of policy instruments** stimulate **collaborative innovation activity** in decentralised pathway.
- Both RD&D expenditure and trade imports support knowledge generation and exchange, and that these relationships are largely robust to future uncertainty.

## MAIN IMPLICATIONS

- An implication for the future SET Plan is therefore to continue emphasising a **strong collaborative approach** by engaging industry, small and medium-sized enterprises, research institutes, policymakers, and other innovation actors in between-country activities.
- **The importance of adaptive policy** responding to rapidly changing innovation environments in the future SET Plan.

- We find that **more balance** for innovation activities for which policymakers have more direct control and **less balance** in innovation activities for which policymakers have less direct control.
- We find evidence that the SET Plan portfolio is **broadly consistent** in terms of innovation activities working in concert in each of the six technology fields, spanning both early stage and late stage innovation activities.
- We find evidence that late stage innovation processes in the SET Plan portfolio are **broadly aligned** with learning and market share as targeted innovation outcomes.
- We find that **diverse mixes of policy instruments** stimulate **collaborative** innovation activity measured by co-inventions between different EU countries in decentralised pathway.

*Navigating the Roadmap for Clean, Secure  
and Efficient Energy Innovation*



# Thank you!

Yeong Jae Kim  
[y.kim@uea.ac.uk](mailto:y.kim@uea.ac.uk)

## Project Coordinator

**Gustav Resch, Marijke Welisch**

*Vienna University of Technology  
Institute of Energy Systems and Electric Drives  
TU Wien, EEG - Energy Economics Group*

**Website:** [www.eeg.tuwien.ac.at](http://www.eeg.tuwien.ac.at)

**E-mail:** [resch@eeg.tuwien.ac.at](mailto:resch@eeg.tuwien.ac.at);  
[welisch@eeg.tuwien.ac.at](mailto:welisch@eeg.tuwien.ac.at)

**Tel:** +43-1-58801-370354

**Visit our Website**

[www.set-nav.eu](http://www.set-nav.eu)

 **Email us**

[contact@set-nav.eu](mailto:contact@set-nav.eu)

**Follow us**



@SET\_Nav  
#SET\_Nav



Group  
SET-Nav



# (Almost) all indicators can be collected for **specific technologies** using **SET-Nav** standardised search terms



		<b>SET Plan priority area</b>	<b>Target Scope of Data for ETIS indicators</b>
1	RE	Renewable energy & system integration	all renewable energy (exc. fuels) (exc. stationary storage)
2	SG	Smart technologies & grid	all grid and power systems (inc. stationary storage) ( <i>exc. smart homes</i> )
3	EE	Energy efficiency in buildings & industry	all energy efficiency in buildings and industry
4	ST	Sustainable transport (EVs, renewable fuels)	all alternative fuels and vehicles (inc. mobile storage) ( <i>inc. all H<sub>2</sub></i> )
5	CCS	Carbon capture + storage or use	all carbon capture (from large point sources), storage & use
6	NP	Nuclear power	<i>all nuclear fission and fusion</i> (inc. safety)

# resources & policies related indicators

Innovation system processes in the ETIS framework	Technology-specific indicators (illustrated for the EU)	Absolute values for renewable energy in the EU in 2015 (with units)	Data availability
<b>RESOURCES</b>			
Mobilisation of Finances	Public energy RD&D expenditure (as % of GDP)	0.006 (percent)	Country*
Mobilisation of Innovators	Patent activity (as % of total patents) ^	0.54 (percent)	Country
Policy Density <sup>+++</sup>	Policy instruments: innovation, regulatory, market-based	145 (number of instruments)	Country*
Policy Durability <sup>+++</sup>	Policy instruments: innovation, regulatory, market-based	13.05 (cumulative number of instruments, average)	Country*
Policy Mix	Diversity of policy instruments	0.98 (Shannon index)	Country*
Policy Stability	Stability of policy instruments	0.03 (cumulative years of all instruments adjusted by revisions, average)	Country*
Legacy of Failure	Decline in interest following failures	3,390 (exponent of decline function fitted to Google search frequency)	Global†
Regulatory Capture	Public RD&D expenditure on fossil fuels	164 (euros, millions)	Country*



# actors & networks related indicators

Innovation system processes in the ETIS framework	Technology-specific indicators (illustrated for the EU)	Absolute values for renewable energy in the EU in 2015 (with units)	Data availability
<b>ACTORS AND INSTITUTIONS</b>			
Capacity	Top 100 Clean-tech funds	56 (euros, millions)	Country/EU
Heterogeneity	Diversity of types of organisation in European Energy Research Alliance	0.79 (Shannon index)	Country/EU
	Diversity of types of organisation in publication activity	1.46 (index constructed by authors)	Country
	Diversity of types of organisation in patenting activity ^	0.99 (index constructed by authors)	Country
Exchange & Interaction	European Energy Research Alliance activities involving different EU actors	26 (number of activities)	Country/EU
	Publication co-authorships between different EU actors	662 (number of co-authorships)	Country
	Patent co-inventions between different EU actors ^	396 (number of co-inventions)	Country
Shared Expectations	Policy instruments: targets, roadmaps, action plans	112 (number of instruments)	Country*
	Policy instruments: targets, roadmaps, action plans	1.77 (cumulative number of instruments, average)	Country* 



# users & markets related indicators

Innovation system processes in the ETIS framework	Technology-specific indicators (illustrated for the EU)	Absolute values for renewable energy in the EU in 2015 (with units)	Data availability
<b>ADOPTION AND USE</b>			
Market Size	Potential market size (total number of physical units multiplied by cost per unit)	1,809,328 (euros, millions)	Country
Market Share	Actual market size as percentage of potential market size	34 (percent)	Country

also includes learning-by-doing

