



How to use science and technology to address large-scale societal challenges

from defining a cross value-chain technology roadmap, to planning concrete R&I activities and attracting financing to realise them

Marcos Ierides - **Bax & Company**

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www.baxcompany.com

Agenda

- Bax & Company introduction
- The importance of collaborative innovation in addressing large-scale challenges
- Focus on the EMIRI Roadmap on Advanced Materials
- Conclusion and next steps

Bax & Company

Who we are

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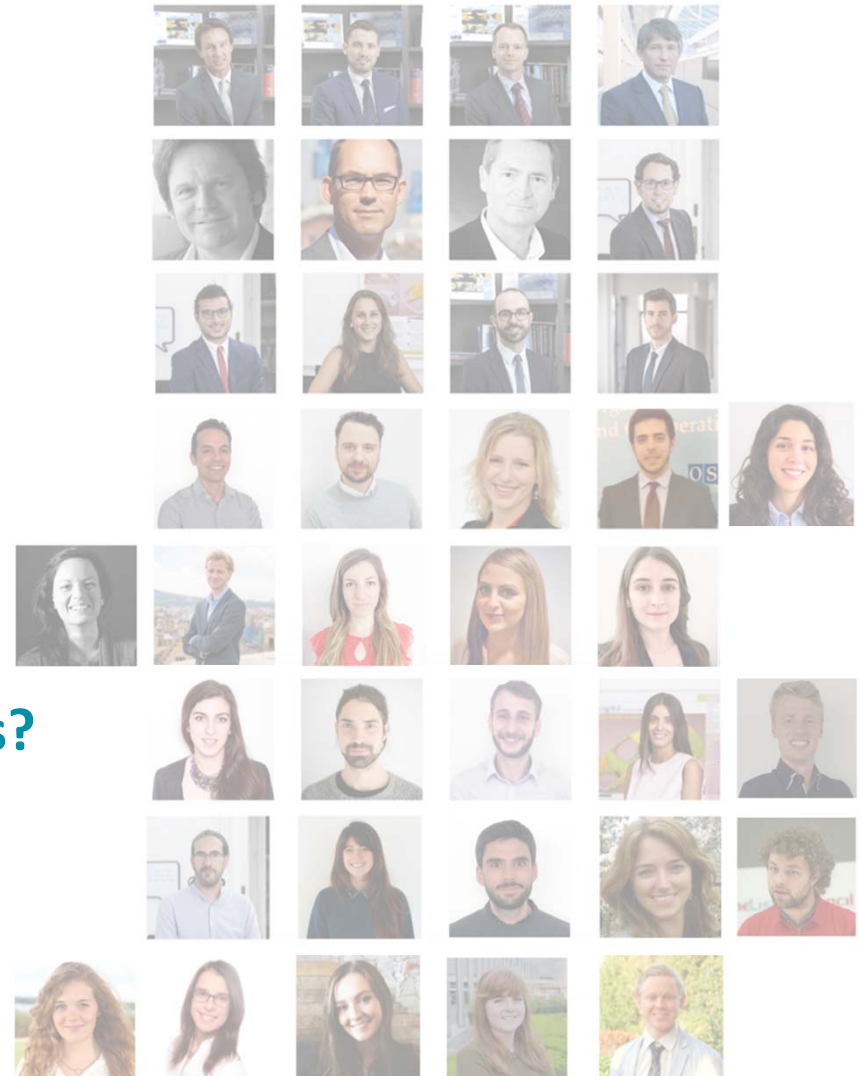
Who we are

- A team of **multi-disciplinary profiles** - engineering, design, business - we understand both science and technology as well as business and policy to connect both worlds.
- We deliver a **broad portfolio of innovation management services** applied to high-tech sectors for leading actors at EU level - academia, industry and public administration.

“Value from science & technology”

What does it mean for us?

- We help develop and implement new technologies in order to **address large societal challenges** and create a better future



What we do

We support a multitude of clients across the world in the following focus areas:

- **Advanced materials** combining deep knowledge in advanced materials, we work with innovative SMEs, large industries, and European associations, to help them elaborate technology roadmaps and plan their investments, define European policies, and gain a better understanding of the market to translate their innovations into meaningful products and services
- **Automotive** working closely with leading OEMs, suppliers and research institutes, we build research alliances to develop the cars of the future, focusing on materials and vehicle technologies to ensure sustainable and safe transport
- **Smart industry** we leverage our expert knowledge of the key drivers of change in industry (Smart Manufacturing, Industry 4.0, Internet of Things and 3D printing) to help our clients to lead change rather than be overtaken by it
- **Data and Smart cities** we bring together city authorities, technology providers and citizens, to improve the efficiency and quality of public service delivery, stimulate sustainable economic development and achieve a greater quality of life for citizens
- **Environment and climate** we assist cities and regions overcome the governance, financial and technical barriers of implementing innovative approaches to climate change resilience. We turn complex urban challenges in bankable investments by facilitating and accelerating learning between cities, business, NGOs, academia, and government
- **Urban energy** we work with cities, building owners, real estate and construction industry actors to develop energy efficiency interventions in large portfolios or real estate.

Some of our clients and partners



Collaborative innovation

Why is it important?

Large-scale societal challenges



Waste/material efficiency

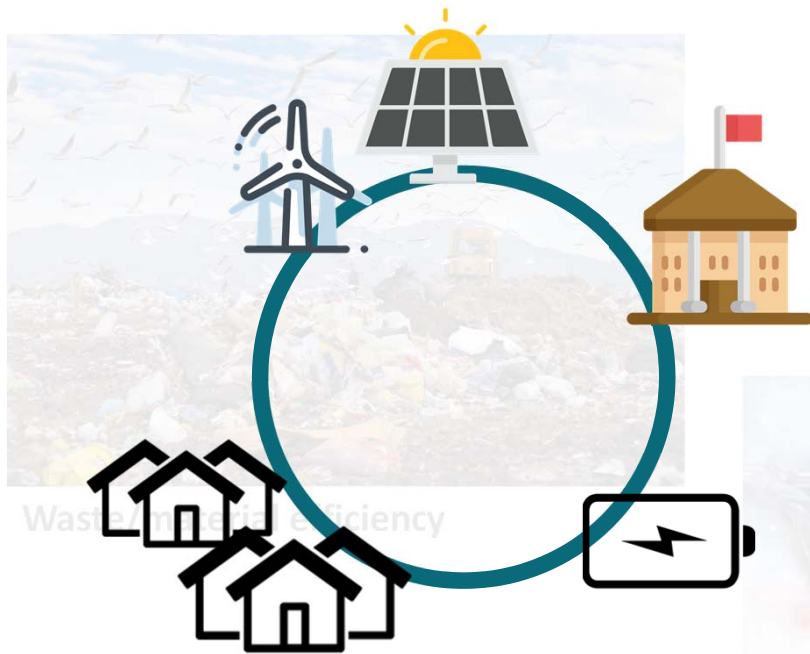


Decarbonisation of power generation



Decarbonisation of mobility

Large-scale societal challenges

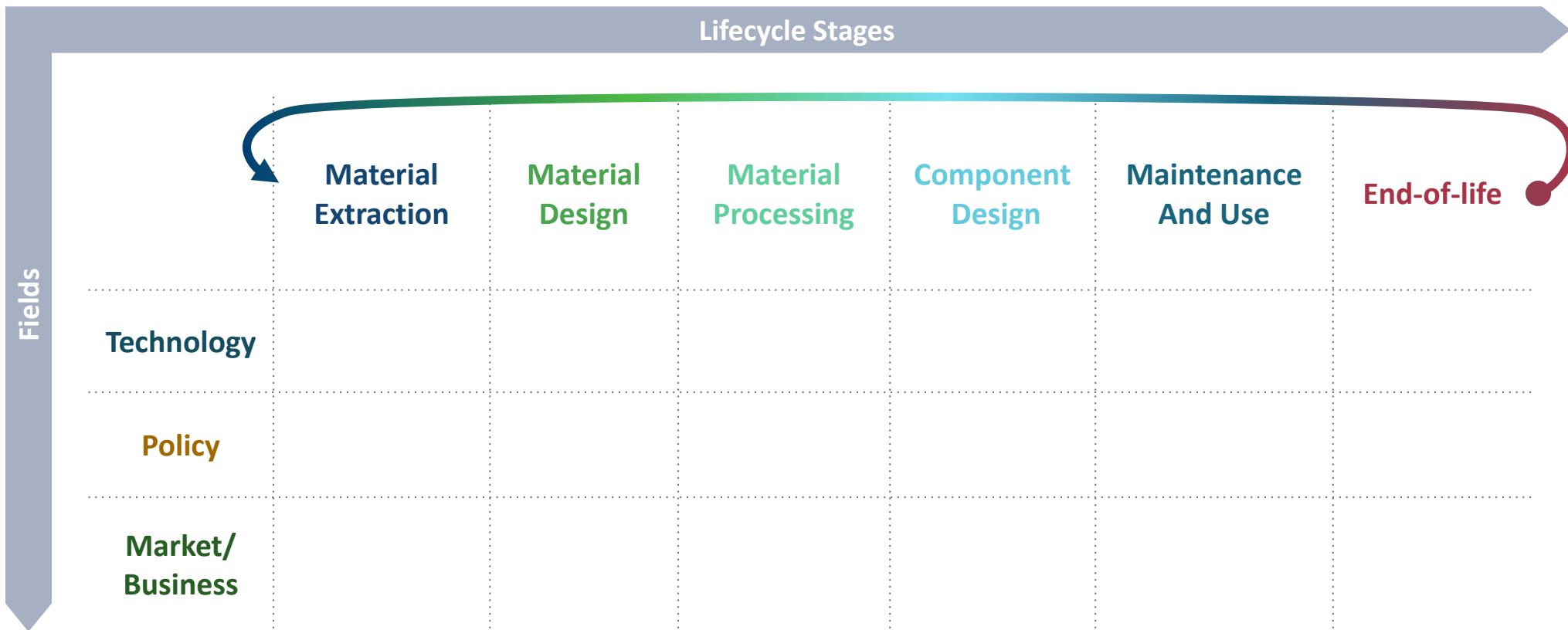


Decarbonisation of power generation

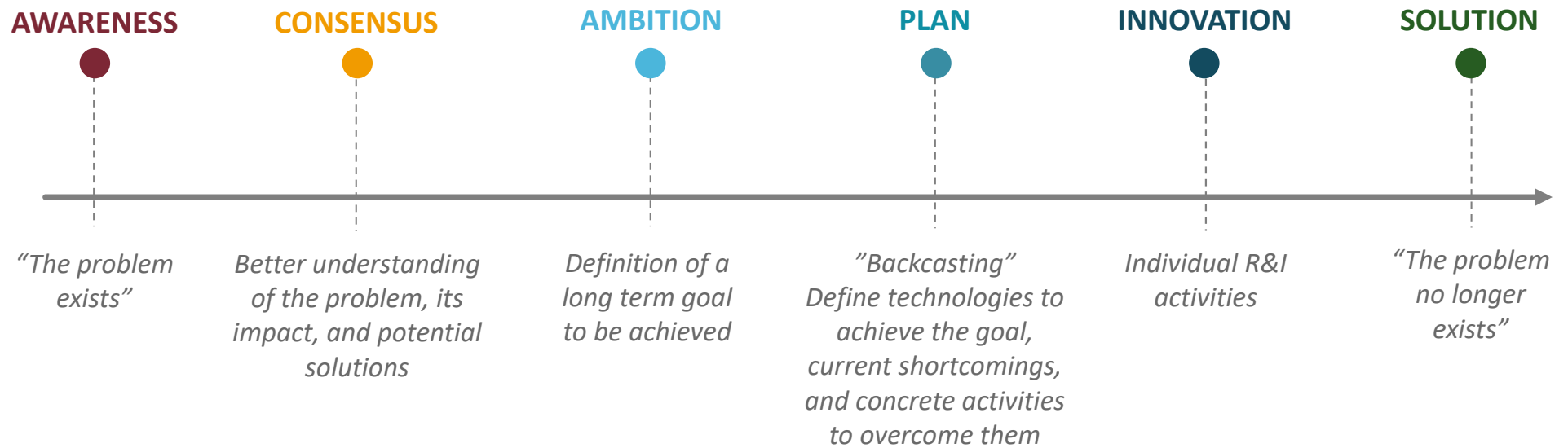


Decarbonisation of mobility

How to address such challenges



Process of addressing large-scale challenges

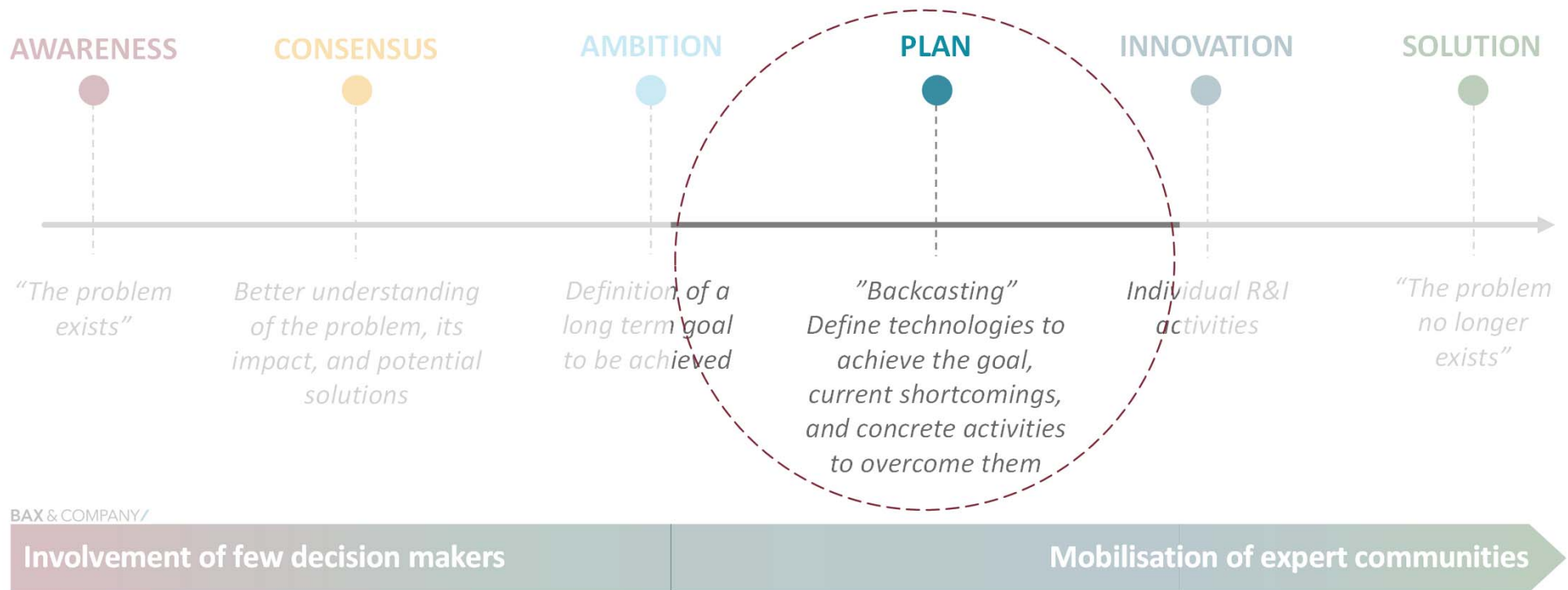


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Involvement of few decision makers

Mobilisation of expert communities

Process of addressing large-scale challenges



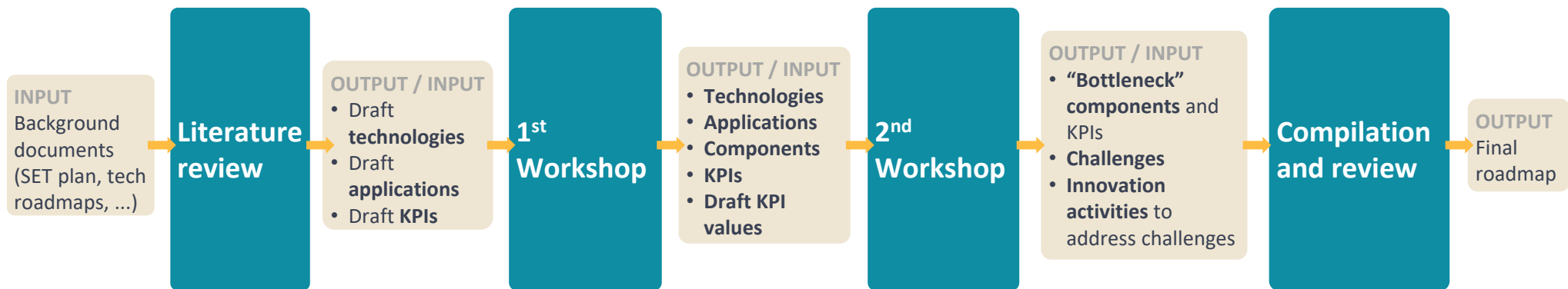
EMIRI Roadmap for Advanced Materials

A successful case study

Objectives

- Support the European Commission in **defining research priorities for the upcoming Horizon Europe programme** in the following areas:
 - Battery Energy Storage
 - Hydrogen Fuel Cells (Stationary and Mobility) and Carbon Capture and Utilisation
 - Solar Power
 - Wind Power
 - Building Energy Performance Technologies
 - Lightweighting Technologies (for mobility)
- Provide an **overview of the main technologies** in the above areas, their **applications**, and **market potential**
- Define **detailed objectives** for 2030

Methodology



Elements of the roadmap

1 Overview

- Technologies
- Applications
- Market overview
- Key players
- European landscape
- Main drivers
- Challenges

2 Suggested R&I topics

- Challenge to be addressed
- Scope of work
- Expected impact

3 Key Performance Indicators

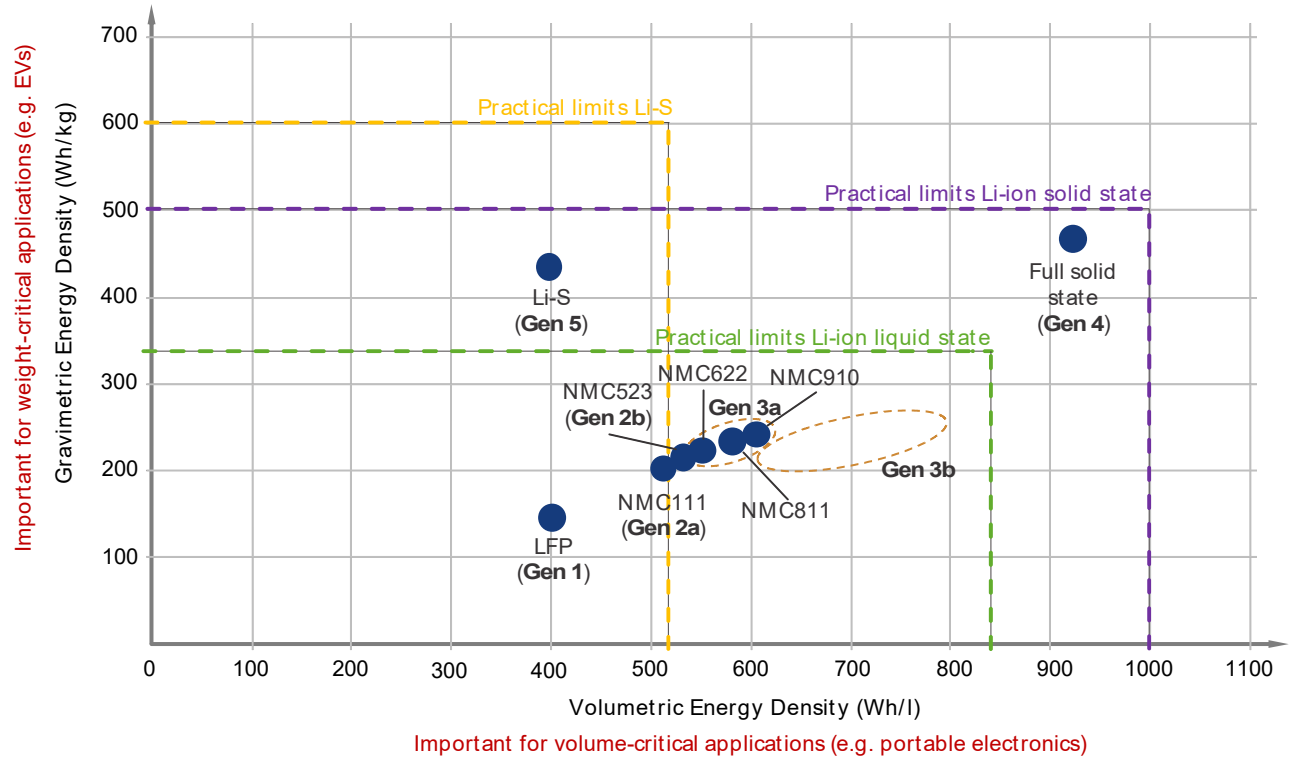
- Current status
- Objectives for 2030

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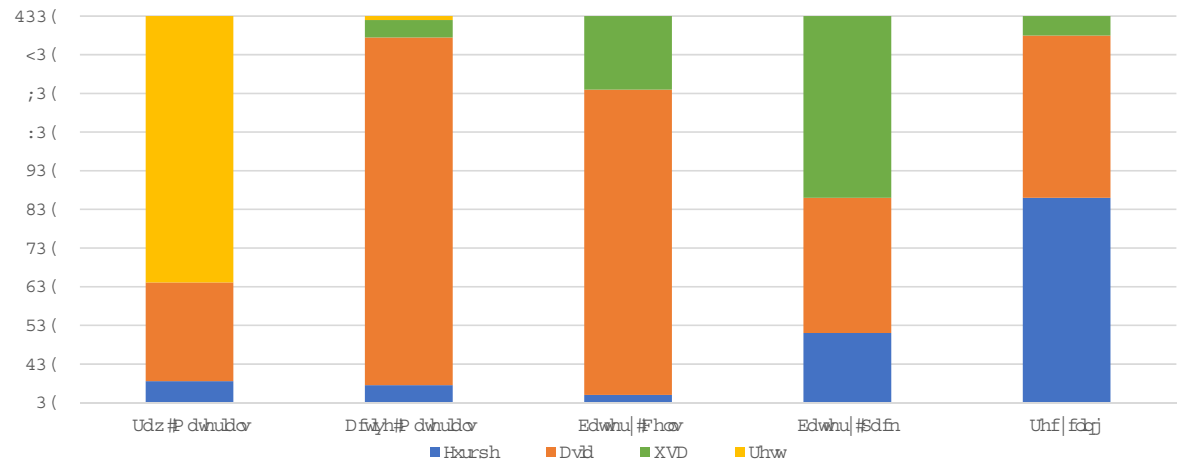
Type	Chemistry	Performance						Main Applications						
		Energy	Power	Calendar Life	Cycle Life	Safety/Stability	Cost	Consumer Electronics	Power Tools	Light Duty Vehicles	Cars	Trucks/Commercial Vehicles	Buses	Grid
LFP (Lithium Iron Phosphate)	LiFePO ₄	++	++	++	++	+++	+	•	•	•	•	•	•	•
NCA (Lithium Nickel Cobalt Aluminium Oxide)	LiNiCoAlO ₂	+++	+++	++	++	+	+	•		•	•			•
LMO (Lithium Manganese Oxide)	LiMn ₂ O ₄	+	+++	-	++	++	++	•	•	•	•			•
LCO (Lithium Cobalt Oxide)	LiCoO ₂	++	++	+	+	+	+	•						
LTO (Lithium Titanate Oxide)	Li ₄ Ti ₅ O ₁₂	-	+++	+	+++	+++	-				•			•
NMC (Lithium Nickel Manganese Cobalt Oxide)	LiNi _{1-x} Co _x Mn _{1-y} O ₂	+++	++	++	++	++	++	•	•	•	•	•	•	•
HE-NMC (High Energy Lithium Nickel Manganese Cobalt Oxide)	LiNi _{1-x} Co _x Mn _{1-y} O ₂	++++	++	+	+	-	++	•	•	•	•	•	•	•
HVS (High Voltage Spinel) *	LiMn _{1.3} Ni _{0.3} O ₄	++++	++	+	+	-	+	•	•	•	•	•	•	•
Solid State**		++++	++	++	-	+++	++	•	•	•	•	•	•	•

* currently at TRL6-7
 ** currently at TRL4-5

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Raw Material Production

Polysilicon

- GCL-Poly Energy
- Wacker Polysilicon *
- OCI Company Ltd.
- TBEA Silicon Co. Ltd.
- Hemlock Semiconductor Corporation
- China Silicon Corporation Ltd.
- Sichuan Yonxiang Co. Ltd.
- Daqo New Energy Co. Ltd.
- REC Silicon ASA *
- Tokuyama Corporation

Advanced Materials

Silicon wafers

- Photowatt
- GCL-Poly Energy
- Xi'an Longi Silicon
- Inner Mongolia Zhonghuan PV Material
- JinkoSolar
- Green Energy Technology
- REC Group *
- Yingli Green Energy
- ReneSola
- JA Solar
- LDK Solar
- NorSun *

Heat transfer fluids

- BASF *
- Wacker *
- Dow *
- Solvay *

Heat storage

- BASF *
- Fertiberia *
- SQM *

Other components*

- AGC *
- Arkema *
- DOW Dupont
- DSM *
- Henkel *
- Heraeus *
- Luvata *
- Merck *
- Pilkington *
- Saint Gobain *
- Solaxess *

Components

Solar cells and modules **

- | | | |
|-------------------------------|-------------------------|------------------------|
| • Hanwha Q CELLS * | • Suzhou Talesun Solar | • OET * |
| • JA Solar Holding Co. Ltd. | • Solarworld * | • Kaneka |
| • Trina Solar Ltd. | • Invertec Solar Energy | • Onyx Solar * |
| • JinkoSolar | • Aiko Solar | • Oxford PV * |
| • First Solar LLC | • Motech Solar | • Romag * |
| • First Solar | • Tongwei Solar | • Sharp |
| • Motech Solar | • Risen Energy Co. | • Saule Technologies * |
| • Canadian Solar | • Canadian Solar | • Solibro * |
| • Yingli Green Energy Holding | • Hareon Solar Tech Co. | • Mitsubishi Electric |
| • Shunfeng International | • Crystasol * | • Baer |
| • Clean Energy | • Eight19 * | • Kyocera |
| • Longi Solar | • Ertex Solar * | • Moser |
| • Neo Solar Power Corporation | • SoloPower | • Sunovation * |
| • Gintech Energy Corporation | • Flisom * | • Panasonic |
| • Changzhou EGing | • GreatCell * | • Trony |
| • Photovoltaic | • Global Solar | • Supreme |
| | • Heliatek * | • Hevel Solar |
| | • Megasol Energie * | • Solitec * |
| | • OC3 AG * | • Ascent Solar |
| | | • Miasolé |
| | | • Solar Frontier |
| | | • Calyxo * |

Reflectors

- | | | | |
|------------------|-----------------|------------|--------------|
| • Rioglass * | • St Gobain * | • Guardian | • PPG |
| • Fenzi Group * | • Alanod GmbH * | • AGC * | • 3M |
| • Almeco Hydro * | | • Ritec | • Aican |
| | | • Skyfuel | • Reflectech |
| | | • Val spar | |

Absorbers

- | | | | |
|----------------|-------------------|------------------|-----------------|
| • Rioglass * | • Abengoa Solar * | • Soltigua * | • Infinia |
| • Sener * | • Areva Solar * | • CMI * | • Riley Power |
| • Ferrostaal * | | • Bright Sources | • Tessera Solar |
| | | • St Gobain * | • Clean Energy |
| | | • eSolar | |

Structural elements

- | | | | |
|---------------|------------|-------------|-----------|
| • ACS Cobra * | • Flabeg * | • Acciona * | • Sener * |
| | | | |
| | | | |
| | | | |

BoS***

PV

- ABB *
- Advanced Energy
- Delta
- Eaton
- Enphase Energy
- Fronius *
- GE
- IDEMATEC *
- Pidbull *
- REFU *
- Schneider Electric *
- Siemens *
- SMA Solar Technology
- Soltigua *
- Stäubli Electrical Connectors *
- Sunfrog Power
- Solar Edge
- Weidmüller *

CSP

- Archimedes Solar Energy *
- Eastman *
- Cevital
- SQM
- Flabeg *
- Senior Berghofer *
- VDI/VDE *
- Consorzio Solare *
- Solutia *
- Rioglass *
- St. Gobain *
- Guardian
- Senior Flexonics *
- Alfa Laval *
- Sulzer *
- Batz *
- Aalborg CSP *
- Soltigua *

Applications

EPC, O&M

- Eni Spa *
- Enel Green Power *
- ENGIE Solar *
- E.ON *
- EDP Renováveis *
- EDP Energies Nouvelles *
- First Solar
- GCL New Energy
- Iberdrola Renovables *
- SECI
- Total *
- Akvo Energy *
- ALECTRIS *
- Anesco *
- BayWa RE *
- Centrica *
- Clean Solar Solutions *
- Conergy Asia & ME
- DNV GL Energy *
- ENcome *
- Fortum Growth Oy *
- First Solar
- Greentech Services *
- Mega Tis *
- Messaritis *
- QOS Energy *
- Sobolt *
- Solarcentury *
- SolarCity
- SunPower
- Solar-Log *
- Stern Energy *
- Ucair *
- Vikram Solar
- Votalia *
- Abengoa Solar *
- ACS Cobra *
- Acciona *
- TSK *
- EDF *
- Ferrostaal *
- Samca *
- eSolar
- Bright Source
- Innogy *
- Solar Reserve
- Elecon *
- Novatech
- Sener *

End of life

Recycling

- Rinovosol *
- First Solar
- Jiangsu Juxin Energy Silicon Technology
- Kunshan Suda Jingwei Electronic Technology
- PV Cycle *
- PV Techno Cycle

*Other components include: Glass, coating, back sheets, encapsulants, metallisation, etc.

**Includes silicon, thin film and multi-junction technologies

***BoS includes: inverters, cables, mounting systems, and other components

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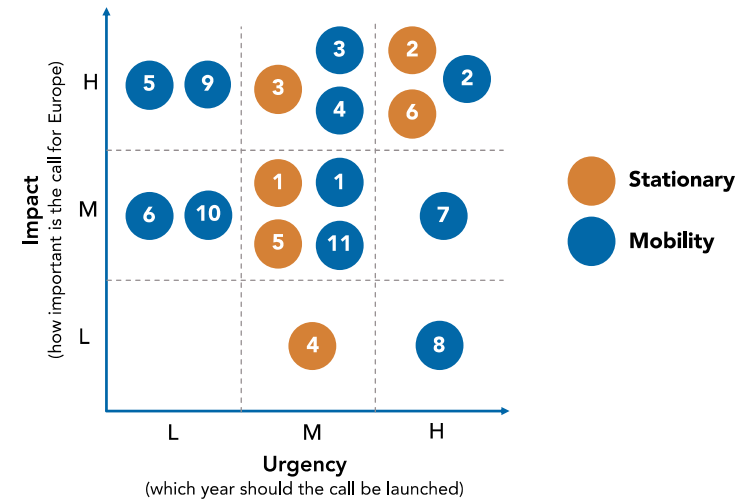
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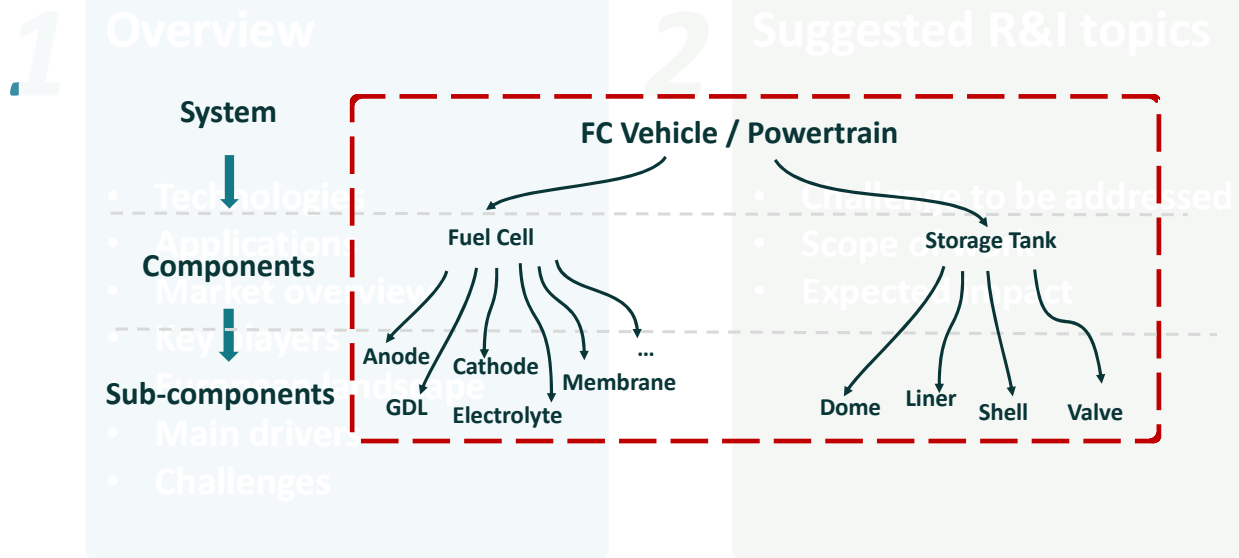
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Hydrogen for Mobility

System Component Sub-component	#	KPI	Unit	2018/2019			2030		
				PEM			PEM		
				Low Temperature	High Temperature	Storage	Low Temperature	High Temperature	Storage
FCEV	1	TRL		9	7-8	9	9	9	9
	2	TCO	€/km	0.55-8*		-	0.3**		-
	3	CAPEX	€/kW	100** ^a / 1000-1500*** ^a		-	40		<75 ^b
	4	Power density	W/kg	659		-	650		-
	5	Consumption	kg/100km	1.2-34		-	1-28		-
Stack	1	Gravimetric Power density	kW/kg	0.77		-	2.3		-
	2	Volumetric Power density	kW/l	4		-	2		-
	3	Cost	€/kW _{net}	26		-	15		-
	4	Max operating temperature	°C	60-80	80-120		110	120	
	5	Cost (storage)	€/kg H ₂	-		1000-1500			<800
	6	Refilling times (storage)	minutes	-		4			<4
Catalyst	1	Pt loading	mg/cm ²	0.3-0.35		-	<0.2		-
	2	Durability with cycling	h	2500		-	>5000		-
MEA	3	Performance @0.8V	mA/cm ²	240		-	>300		-
	4	Mechanical durability (cycles until >15mA/cm ² crossover)	cycles	23,000		-	<20,000		-
Bipolar Plates	5	Weight	kg/kW	< 0.4		-			-
	6	Thermal conductivity	°C/m-s			-			-
GDL									

- * from light duty (0.55) to heavy duty vehicles (8)
- ** passenger vehicles
- *** heavy duty vehicles
- ^a 100,000 units/year
- ^b 50,000 units/year

3

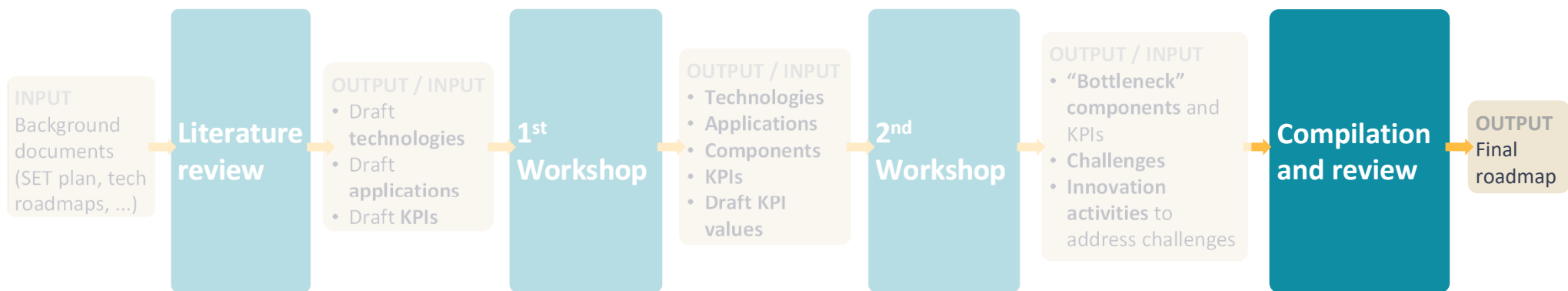
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What is next?

Following steps

Next steps



Conclusions

Benefits for organisations involved

- Opportunity to express their views and influence the future technological landscape in Europe
- Network with leading institutions in the field and create meaningful and tangible collaborations
- Get updated about ongoing work in other parts of Europe



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THANK YOU!

GET IN TOUCH



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