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SET Plan Secretariat



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ISSUES PAPER No 7

"Become competitive in the global battery sector to drive e-mobility forward"

The following EERA members have contributed to this response:

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Purpose of this document

This document¹ is intended to progress the implementation of the actions contained in the SET-Plan Communication [1] and specifically one of the two actions concerned with the priority "Diversify and strengthen energy options for sustainable transport". It is part of a series of Issues Papers jointly prepared by the services of the European Commission and discussed with the representatives of EU member states and countries part of the SET Plan, working together in the SET Plan Steering Group.

The Issues Papers propose to stakeholders strategic targets in different areas of the transport and energy sector. The input from, and positions of stakeholders will be used to come to an agreement on targets in a dedicated meeting of the SET Plan Steering Group with a representation of key stakeholders.

Stakeholders are invited to take position on the proposed targets in accordance with the guidelines set out in the paper [The SET Plan actions: implementation process and expected outcomes](#) and submit their positions to SET-PLAN-SECRETARIAT@ec.europa.eu by **25/05/2016** at the latest. All relevant documents and material are available on the SETIS website (<https://setis.ec.europa.eu/>).

¹ This document is a working document of the European Commission services for consultation and does not prejudice the final form of any future decisions by the Commission.

Introduction

The Energy Union strategy [2], adopted by the European Commission and endorsed by the Council, is built on the ambition to achieve a fundamental cost-effective transformation of Europe's energy system. This will be achieved by moving to more flexible, more decentralized, more integrated and therefore smarter, more sustainable, secure and competitive ways of delivering energy to consumers. One of the core priorities of the Energy Union strategy is to speed up energy efficiency and decarbonisation of transport through Research and Innovation (R&I) in e-mobility. The strategy will put the EU at the forefront of the next generation of clean transport technologies and energy storage solutions with the aim of turning these into a motor for growth, jobs and competitiveness. Within the fifth dimension of the Energy Union strategy dealing with Research, Innovation and Competitiveness, the integrated SET-Plan will steer European energy R&I designed to accelerate the energy system transformation.

E-mobility facilitates the reduction of greenhouse gas (GHG) emissions through the electrification and consequent decarbonisation of transport. Road transport accounts for some 80% of all GHG emissions related to transport [3] and so electrification in this sector has massive potential for decarbonisation. At the same time e-mobility provides an opportunity for enhancing EU industrial competitiveness, a major enabler of future economic growth and job creation, in addition to providing benefits in terms of energy security, health and environmental protection.

Traction batteries are considered a Key Enabling Technology in electric vehicle (EV) drive trains [4]. Current traction batteries are to a large extent based on lithium-ion (Li-ion) chemistry, however in the future other lithium (Li) and non-Li based chemistries are expected to gain ground. In recent years the development of hybrid electric vehicle (HEV) batteries has yielded a relatively mature generation of vehicles (nearly 2 million HEVs had been sold worldwide by 2014 [5]). More recently the focus of battery development has shifted towards higher energy systems specifically suited for Plug-In Hybrid Vehicles (PHEV) and Battery Electric Vehicles (BEV). Since BEVs are more demanding in terms of energy density and power requirements, development of batteries for BEVs drives R&I in the field. Such developments are nonetheless beneficial for different vehicle categories, chiefly passenger light duty vehicles, as well as 2-3 wheelers, quadricycles, SUVs, minivans, short range heavy duty vehicles (buses and trucks), and fuel cell electric vehicles (FCEV).

As important as they are, evolutionary and/or disruptive technology improvements achieved through R&I are not sufficient to drive EU competitiveness in the battery sector, which is explicitly targeted in this Key Action. Competitiveness in this sector also hinges on having a stable and secure battery manufacturing base. The EU has a leading position in the lead-acid battery industry with well-developed battery producing capacities. Furthermore the EU maintains a strong position in lithium-ion cells and other chemistries (sodium nickel chloride, i.e. "Zebra") for niche applications (e.g. aviation/space/military) and this could be beneficial for the e-mobility sector. However unlike in Asia, a significant European automotive cell manufacturing capacity does not exist for mainstream traction battery cells, especially Li-ion and NiMH. This despite the EU's strong car manufacturing industry which is expected to maintain its strong position also in EV production, although arguably their actions to date have not been aggressive enough compared with some newcomers who have less legacy investments to protect. To reverse foreign dominance of the battery cell manufacturing industry an opportunity exists for Europe to "break into" this by exploiting European R&I competences in disruptive battery technologies and to extrapolate these competences to the development of a corresponding battery cell manufacturing base.

The lack of an EU automotive battery cell manufacturing base leads to a dependence on battery cells imported from Asia, forcing EU's car manufacturing industry to purchase 'off the shelf' cells. This endangers OEM's competitive advantage because of security of supply chain issues, increased costs due to transportation, loss of part of the value, time delays, relinquished control on quality and

limitations on design options. It also raises concerns related to the potential loss of Europe's knowledge base [4, 7]. Initiatives have been triggered to address this situation. As an example, at least one Member State has recently started discussions to set up a national or even European cell production capacity. This can be seen in the context of a prospective alliance between certain OEMs to manufacture next-generation batteries. Another approach is to stimulate foreign investment by way of establishing foreign manufacturing plants in the EU – as Japanese and Korean companies already did. The US also followed this approach. Still, establishing a European battery cell manufacturing base is not a panacea since dependencies related to the supply of raw materials will remain [8-11] *[see comments below on reference 10: Annexes to the report on critical raw materials for the EU, report of the Ad hoc working group on defining critical raw materials. DG ENTR, 25 May 2014].*

Manufacturing capacities should however be considered over the whole battery value chain – from powder to power - including advanced materials development and production technologies, cell manufacturing, pack assembly and system integration for current lithium-ion technologies and also for emerging and future technologies. Although EU industry has a good knowledge and has some production base in all segments of the battery value chain, it is far from being self-sufficient (and hence is relying on imports) particularly for basic materials and battery cells. EU industry is however active in the production and supply of some basic materials, in cell integration and packaging, in battery control, power electronics, in battery plant manufacturing, cell integration and pack assembly, battery recycling, and system integration. In addition the EU has globally recognised academic and research institutions in the field with good links with OEMs and battery manufacturers.

To ensure EU competitiveness in the global battery sector in a strategic and cost-effective manner a holistic approach covering different aspects is needed:

- Potential uses for batteries beyond e-mobility applications need to be exploited. Examples include the use of battery energy storage systems in households (either standalone battery systems or EV batteries in vehicle-to-home configurations) or as utility scale grid connected assets, relevant to Key Actions 3 and 4 of the SET Plan [1], respectively. Exploitation of R&I synergies between these applications would facilitate the achievement of increased battery systems performance and safety while decreasing production costs. There is also a need to establish a manufacturing chain for these different applications, which could lead to a much needed critical mass in the size of the first-use Li-ion battery market. It also opens a potentially interesting "second life" market for automotive batteries.
- Widespread deployment of any innovative, disruptive technology requires significant transformations of the product value chain, development cycles and associated technologies and services. Acknowledging this, the SET Plan [1] underpins the importance of promoting new investments at all stages of the innovation chain. For battery technologies and systems, such investments are to be done in a coordinated way to leverage European public and private investments, thereby covering the expected high cost of R&I and the upscaling of manufacturing processes to mass production scale for Li- and future non-Li based batteries, primarily for automotive but also for selected energy storage applications.
- It is important to take into account barriers such as different Member States' approaches on industrial policy, lack of fit-for-purpose standards, chronic difficulties for incubation (e.g. access to finance), the lack of skilled and educated workforce, and specifically uncoordinated and incompatible regulatory and legal frameworks. Concerning the latter, adoption of global regulatory safety requirements for e-vehicles under development by UNECE will guarantee more regulatory stability and thereby facilitate economies of scale.
- The business case for batteries – particularly batteries for e-mobility – needs to be supported. This can be achieved through policy-pull measures, as for instance with Directive 2014/94/EU which requires the deployment of a certain level of charging infrastructure in Member States. In fact, sales of e-vehicles are picking up in some countries such as the Netherlands and Norway which could effectively act as pioneers and lead the way to a quicker rate of e-vehicle uptake in other countries. This of course will be crucial to ensure

the profitability of EU battery manufacturing capabilities once they are created or enlarged. While market uptake aspects fall outside the scope of the SET Plan, they will be addressed by the Strategic Transport Research and Innovation Agenda (STRIA) – which, along with the SET Plan, will feed the Energy Union Integrated Strategy on Research, Innovation and Competitiveness (EURICS).

- It is also critical to reinforce existing and build new strategic alliances between public and private stakeholders to promote energy storage in the transport, power, gas and residential sectors. This may include initiatives to establish new business and market models and exchange knowledge to avoid duplication of efforts. Stakeholders include battery manufacturers, core materials suppliers, automakers, power electronics, battery management system (BMS) specialists, distribution systems operators (DSOs) and the general supplier industries, as well as factory builders and research and standardization bodies.

Targets

As an overarching objective, R&I related to Key Action 7 of the SET Plan will aim at developing and demonstrating technologies, manufacturing processes, science-based standards and regulations, to increase performance and safety and reduce overall cost of battery systems used for storage purposes in the transport and other sectors. The R&I effort will cover materials, cells, packs and systems with a focus on high energy and resource efficiency, modularity and re-configurability, while also taking into account second life and recycling. In terms of chemistries, the core focus is on Li-ion batteries, while attention and a certain support may be given to post-Li-ion.

To guide the discussion with SET Plan countries and stakeholders on the prioritisation of the required activities to be implemented at regional, national and European level, targets identified below are proposed by the Commission. Their values are based on a number of sources [5, 6, 12-30] and have been subjected to internal Commission review and consensus. The set of targets should steer the R&I actions and guide coordination of EU and Member States funding in areas of materials research, nanotechnology, electrochemistry, manufacturing processes and manufacturing technologies. Achievement of the targets will require coordination of R&I activities, with responsibilities and efforts shared between different stakeholders during the implementation phase.

Targets are not relevant to batteries for portable/electronic equipment which falls outside the scope of this Issues Paper. Targets are differentiated into performance, cost and manufacturing targets. Considering the expected dominance of Li-ion chemistry in the coming decades for electrochemical energy storage, barring unexpected but possible breakthroughs, the performance and cost targets defined are application-specific and based on technology improvements deemed achievable for Li-ion batteries up to 2030. Targets may be exceeded through developments in other advanced technologies.

a) Performance targets

Successful deployment of batteries for automotive applications requires meeting a number of performance criteria:

Table a

	Current (2014/ 2015)	2020	2030	
Performance targets for automotive applications				
1	Gravimetric energy density [Wh/kg]			
	pack level	85-135	250	> 250
	cell level	90-235	400	> 400

2	Volumetric energy density [Wh/l]			
	pack level	95-220	500	> 500
	cell level	200-630	750	> 750
3	Gravimetric power density [W/kg]			
	pack level	330-400	470	> 470
	cell level		700	> 700
4	Volumetric power density [W/l]			
	pack level	350-550	1.000	> 1.000
	cell level		1.500	> 1.500
5	Fast recharge time [min] (70-80% ΔSOC)	30	15	3
6	Battery life time			
	Cycle life to 80% DOD [cycles]		1.000	5.000
	Calendar life [years]	8-10	15	20

b) Cost targets

Table b

TARGETS		Current (2014/ 2015)	2020	2030
Cost target				
1	Battery pack cost for automotive applications [€/kWh]	180-285	90	75

c) Manufacturing targets

Table c

TARGETS		Current (2014/ 2015)	2020	2030
Manufacturing targets				
1	Automotive (Li-ion and next generation post-lithium) battery cell production in EU [GWh/year] ¹ (% supporting EU PHEV+BEV production)	nearly 0	5 (50% = 0.25 M of 20 kWh)	50 (50% = 1 M of 50 kWh)
2	Utility Storage (Li-ion and next generation post-lithium) battery cell production in EU [GWh/year]		2.2	10
3	Recycling			
	Battery collection rate	45% (Sept 2016)	60%	75%
	Recycling efficiency (by average weight)	50%	50%	50%
	Economy of recycling	Not economically viable	Break even	Economically viable
4	Second Life	Not developed	Developed	Fully established

¹ Two assumptions were made when defining this target value, based on projected global sales for PHEV+BEV in 2020 and 2030 of 2.5M and 5 M vehicles respectively: (a) the percentage for EU OEMs production of PHEV+BEVs is assumed to be maintained at the current level of 20% for both 2020 (with an average energy capacity of 20 kWh) and 2030 (with an average energy capacity of 50 kWh); (b) EU battery manufacturers will supply half of the cells needed for the PHEVs+BEVs produced by EU OEMs.

For stationary energy storage the SET-Plan R&I will aim at developing and demonstrating technology, manufacturing processes, standards and systems, which have the potential of driving high-efficiency (>90%) battery based energy storage system cost **below €150/kWh** (for a 100kW reference system) and a lifetime of thousands of cycles by 2030 to enable them to play an important role in smart grid [Comment: The objective of the number of cycles that is shown in the previous table in the same document is 5000 cycles to 2030]. This will involve the evolution and development of a variety of battery chemistries and supercapacitors due to the varying operation modes, which need to be addressed. For instance, titanate-type Li-ion batteries can provide more than thousands of cycles at high C-rates with high efficiency. The main challenge of such batteries will be the cost objective that could only be reached if they are produced in very large scale plants. Technologies will include materials, cells, modules but with a focus on battery systems targeting modularity and re-configurability and considering as well second life and recycling aspects.

In addition to the targets above, there are other requirements for which it is more difficult to set SMART targets and that will be addressed by the EURICS expected by the end of the year. Such requirements include safety, manufacturing process for advanced battery materials/components production (including its efficiency, environmental footprint and impact), reduction in the use of critical materials, interoperability and system integration at pack level, standardization, workforce and education – as outlined e.g. in [21, 23, 26, 28, 31].

Next steps

Stakeholders are requested to provide their feedback and take position on the proposed targets in accordance with the guidelines set out in the paper "*The SET Plan actions: implementation process and expected outcomes*". Stakeholders should submit their positions to SET-PLAN-SECRETARIAT@ec.europa.eu by **25/05/2016** at the latest. Stakeholders' positions will be used to come to an agreement on targets in a dedicated meeting of the SET Plan Steering Group with a representation of key stakeholders.

Subsequently the parties involved will undertake to agree on an Implementation Plan for the delivery of the agreed R&I targets. In doing so factors of a technological, socio-economic, regulatory, financial, or other nature, which may be of relevance in achieving these targets, have to be considered.

Proposed actions

The annex below reproduces actions which were identified in the document 'Towards an Integrated Roadmap: Research & Innovation Challenges and Needs of the EU Energy System' (<https://setis.ec.europa.eu/set-plan-process/integrated-roadmap-and-action-plan>). These actions can be used in the preparation of the Implementation Plan but are in no way restricted to these suggestions.

Annex: Relevant actions of the 'Towards an Integrated Roadmap' document of the SET Plan

Part II Competitive, Efficient, Secure, Sustainable and Flexible Energy System

HEADING 2 *Ensuring Energy System Integration*

Challenge 1 Energy Grids

ADVANCED RESEARCH PROGRAMME

Action 5: Research and development of tools development to support new market designs at Pan-European and regional levels

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

Action 5: Demonstration of novel tools to prepare recommendations for novel market designs

Challenge 2 Storage (Heat and Cold, Electricity, Power to Gas or other energy Vectors)

ADVANCED RESEARCH PROGRAMME

Action 1: Enhanced Storage materials

Action 2: New Technologies for Next Generation Central and De-central Storage Technologies of any scale

Action 3: Improved second generation technologies for Next Generation Central and De-central Storage Technologies of any scale

Action 4: Storage System interfaces

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

Action 1: Storage System Integration and Benefit Assessment via Simulation of System Embedding

Action 2: Central and De-central Storage Technology Demonstration of any scale

Action 3: Storage System integration Demonstration

Action 4: Storage Manufacturing Processes

Action 5: Storage Recycling

INNOVATION AND MARKET-UPTAKE PROGRAMME

Action 1: Storage Standardisation

Action 2: Storage Business Case Evaluation in global market environment/systems

Action 3: Storage Business Cases in local market environment/systems

Action 4: Soft Aspects and Society Acceptance

Action 5: Closed storage material loop

Challenge 5 Cross-technology Options

ADVANCED RESEARCH PROGRAMME

Action 1: Cross-Sector Chemical Storage Technologies

Action 6: Energy Systems Integration – Testing and Evaluation of Integrated Energy Systems

Part III Fostering Innovation in Real Environments and Through a Market -Driven Framework

HEADING 3 *Fostering Sustainable Transportation*

Challenge 1 Fuel and fleet diversification

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

Action 1: Demonstrate the usage of waste brake energy through batteries in buses (B1)

Action 2: Electrification of buses and captive fleets in urban areas (B4)

INNOVATION AND MARKET-UPTAKE PROGRAMME

Action 1: Accelerating the electro-mobility deployment for passenger cars (A1)

Challenge 2 Energy performance of transportation systems

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

Action 1: Increase Information Data Management for Electric Transport Infrastructure to enable smart services and improve logistics (C1)

Action 2: Develop smart charging as a way to better integrate electric vehicles into the grid and promote renewables i.e. real time control of charging power of an electric vehicle according to the user needs, the availability of network capacity, the cost of energy and its sourcing (A3)

INNOVATION AND MARKET-UPTAKE PROGRAMME

Action 1: Promote the “Human Factor” (B2); Promote more sustainable mobility choices.

Part IV Cross-cutting Aspects

HEADING 4 *Advancing higher education and lifelong learning and fostering the link between education and training institutions, business and research institutes*

Action 1: Develop networks of higher education institutions with links to business and research

Action 2: Develop networks among training institutions, business and research institutes for lifelong learning

Action 4: Develop a quality assurance framework for higher education and lifelong learning programmes on energy

Action 5: Development of energy-related education programmes for decision-makers

References

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The focus on "critical raw materials" unfortunately means that silicon and magnesium are materials one should find replacements for. From our point of view it is meaningless to put this in a BATTERY document. Some specific comment on the applicability of silicon and magnesium, and that these elements for batteries are not necessarily as 'critical' (=monopolized by China) as in solar could be good to get from more quarters.

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Joint Programme on Energy Storage

**EERA inputs to Issues Paper No.7
(vesion 10.05.2016)**

“Become competitive in the global battery sector to drive e-mobility forward”

The following EERA members have contributed to this response:

CEA, France
ENEA, Italy
IEN, Poland
IFE, Norway
IK4-CIDETEC, Spain
IMDEA, Spain
KIT, Germany
POLITO, Italy
SINTEF, Norway
University of Padua, Italy

EERA hereby gives inputs to the Issues Paper No.7 (version 10.05.2016) “Become competitive in the global battery sector to drive e-mobility forward”. The EERA JP on Energy Storage led this consultation within EERA, but to the tight time schedule it was not possible to gather contributions from all JP members. However, this feedback is also including a few inputs received from **EERA JP Advanced Materials and Processes for Energy Application (JP AMPEA)** as well as **EERA JP Fuel Cells and Hydrogen (JP FCH)**.

The input is structured according to the guidelines set forth in the document entitled “The SET Plan actions. Implementation process and expected outcomes”.

STAGE 1

Question 1: Do you agree with the targets set in the issues paper?

Overall, we agree with the proposed long-term targets. However, we have some comments on the current/ short-term targets:

a) Performance targets (Table a)

- The gravimetric energy density (Wh/Kg) at cell level (2020 = 400 and 2030 > 400) seems to be too high only for Li-ion batteries (this value would be right assuming post-Li technologies).
- The volumetric energy density (Wh/L) at cell level (current = 200-630) is also very high. At the moment, we are not aware of any Li-ion technology with more than 350 Wh/L, which is more coherent with the volumetric energy densities of 200-220 Wh/L at pack level.
- The *cycle life to 80% DOD* parameter, regarding the battery life time, appears to be not accurate enough to characterise the battery cycle life. It would be very convenient to know how many fast recharges the battery can stand. In addition the value of 1000 cycles (2020) is rather low for a conventional Li-ion battery. Additionally, the cycle life is strongly temperature dependent. Therefore, a more precise specification is required.
- The gravimetric and volumetric energy density on pack level strongly depend on the thermal behavior of the pack, the cooling requirements and the cooling system. As the size of the pack significantly influences the size and weight of the pack, larger packs can result in higher densities, which might be relevant for trucks and busses.

b) Cost targets (Table b)

Battery pack costs for automotive applications [€/kWh]

- **Current (180 - 285 €/kWh):** according to [1] this value is about 300 US\$/kWh (250 €/kWh) for market leaders and 400 \$/kWh (350 €/kWh) for a combination of different sources.
- **2020 (90 €/kWh):** according to [1] and [2] the projected cost for 2020 will be 200 \$/kWh (175 €/kWh). The objective of 90 €/kWh seems too ambitious. We would suggest a value around 150 €/kWh.
- **2030 (75 €/kWh):** according to [1] the projected cost will be about 100 \$/kWh (85 €/kWh). The objective of 75 €/kWh, although ambitious, makes sense.

Moreover, the actual operating cost of a 150 €/kWh battery with 5.000 life cycles (2030) is in fact equal to that of one that costs 600 €/kWh and has a life of 20.000 cycles. In other words, the crucial parameter is the cost related to the energy managed: €/kWh/cycles. Disregarding it, implies excluding technologies with significant potential, but not adequately considered for now in Europe (but elsewhere they are!), such as Flow Batteries. Another crucial fact is the cost of energy actually charged and discharged which, with DOD of 80%, is 20% lower than the total energy, which is instead always used by battery manufacturers, distorting the effective economic assessment.

[1] B. Nykvist and M. Nilsson. Nature Climate Change, 5, 2015, 329-332.

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c) Manufacturing targets (Table c)

We agree with the manufacturing targets proposed in the document but they appear to be unrealistic for the coming years according to the current status.

Question 2: Do you think that the level of ambition is correct?

As stated above, the balance of targets of cell level gravimetric and volumetric energy density are somewhat unrealistic to our knowledge. It is nearly impossible to reach them with standard or even advanced Li-ion batteries. The gravimetric energy density is particularly unrealistic for Li-ion, where the standard SoA is below 250 Wh/Kg in 2016. Volumetric energy density seems more achievable to our experience (750 Wh/l target vs nearly 650 today). In this sense, one option could be to split targets between energy cells (aiming at EVs and PHEVs) and power cells (aiming at HEVs). Thus making a separation of targets for energy and power oriented technologies.

Gravimetric energy density targets might be achievable for some post Li-ion technologies such as Li Sulphur, solid state and others. These high energy technologies tend to share a strong penalization in power density. Therefore hybridization of several storage technologies will probably be a must unless some breakthrough comes, where ultracapacitors or high power Li-ion may provide intermittent power delivery. Also, non Li-ion batteries can be useful for hybridization even when Li-ion are used for range. This means that for example Ni-MH batteries can have a future in European mobility. We consider advisable to possibly include this concept of hybridization of several storage technologies to achieve specific targets in the issue paper.

Question 3: Are there any standing issue(s) in the way to reaching the proposed targets/priorities?

The proposed R&I chain proposed has major limitations in not clearing considering low TRL activities (the proposed targets seem more allocated after TRL 3, as actually present in WP Energy 2016-2017 and WP Transport 2016-2017), with generic indications of fundamental research on novel Li-ion and post Li-ion technologies (Li-Sulphur, Metal-air and Sodium-ion for example): to reduce research and industrial gaps, as correctly indicated in the text, significant efforts must be allocated on novel electrochemical storage technologies on which US DoE and other countries (Japan and South Korea for example) are significantly investing with public and private funding (only DOE more than \$100M/year only on batteries for transport) in basic and fundamental research to maintain leadership and accelerate introduction of more performant, cheaper, safer and more environmentally acceptable electrochemical storage systems.

Question 4: What are your specific recommendations on prioritizing R&I activities on these issues (and building where appropriate on relevant existing initiatives)?

- Although the focus of Action 7 from SET PLAN and this Issue Paper is into eMobility, there are multiple synergies to be exploited between the stationary and the transportation battery technologies. Therefore we would suggest to take advantage of them, avoiding duplication of efforts and sharing strategies.
- It would be strongly advisable to have standards in place regarding physical form factors at the cell level, so that the EU car manufacturing industry can effectively purchase ‘off the shelf cells’. Some degree of standardization at the level of cell, module and pack might be strongly advisable. Possibly big OEMs may prefer full product personalization, however medium-smaller players may significantly benefit from availability of standardized battery related products, hence promoting competitiveness and market entry of a wider range of companies.
- We suggest introducing the concept of “cost per cycle” (i.e. €/KWh-cycle) to balance the investment cost through the expected nominal cycle life of the battery (understood as cyclability until 80% of the original charge capacity). This parameter would allow to fall in with the scope potentially higher initial cost storage technologies with very long cyclability resulting in a competitive TCO.

- We recommend giving priority to further research towards the improvement of the “base-line” Li-ion technologies, since developing EU-local manufacturing capabilities should go in parallel with the development of EU-local forefront storage technology.
- As mentioned before, transportation as well as stationary battery systems can significantly benefit from the hybridization of battery systems. However, the system technology for hybrid systems is still in its infancy. Additionally, new system concepts might be required for second life battery systems. Thus, the development of new battery system technologies offers many chances for the European industry and should be prioritized.
- With the advent of long living cells and batteries with a lifetime exceeding 15 years and charging rates in the range of 20 C new aspects concerning the design and reliability of power electronic components and of the whole battery system arise. Thus, new materials and production processes for battery tailored power electronic systems need to be addressed as well.
- Finally, we would like to emphasize that just developing manufacturing capabilities in Li-ion may be particularly challenging, since we would enter into competition with already established manufacturers in Asia and other countries. If we focus only on this, we risk never reaching the ability to offer a performing product at a competitive price. Therefore, if the final objective of this reflection is to set the basis for the deployment of future significant battery manufacturing capabilities in Europe, next generation /post-lithium technologies should not be left behind. It would be more convenient to pay attention on development of post-Li-ion and next generation batteries with certain support to Li-ion batteries. In case of power density we are close to the limit with this technology. Moreover EVs equipped with these batteries have very limited range, due to its significant weight. As mentioned in issues papers EU industry is “far from being self-sufficient particularly for basic materials and battery cells”. Instead of chasing the leader we suggest to concentrate on niche applications and developing next generation batteries which will be better adjust to e-mobility requirements and decrease the dependence related to the supply of raw materials. Simultaneously EU should promotes developing of recycling processes and try to establish targets for second life of current technologies. Hence we would highlight the convenience to focus also in the manufacturing of next generation battery technologies.

Question 5: Who are the best placed actors to implement the targets/priorities (industry, EU, Member States, regions, groups of countries, organisations, etc)?

The effort towards the establishment of some partially open platform for full-scale Li-ion manufacturing capabilities should be better driven by industry (materials & cell manufacturing companies in close cooperation with OEMs,TIER1s) backed by RTD performers and with national/EU support. Currently several private companies already have production capabilities in Europe, which is a good starting point but not a guarantee of shared knowledge.

Question 6: If possible to identify possible gaps/barriers & areas of cooperation on the priorities/targets proposed in this issues paper.

1. Disregarding for the purpose of this document the contribution fuel cells can make in the stationary power sector – in particular through stimulation of distributed, high-efficiency, flexible and clean co-generation – it needs to be underlined that fuel cell vehicles are ultimately **fuelled electric vehicles**. They therefore support and strengthen both the e-mobility supply chain (batteries, electric motors, future driving algorithms, charging points, electric grid flexibility, urban transport) and the alternative fuels supply chain (greening of fossil fuels, power-to-gas, drop-in fuels and natural gas grid injection, long-range transport). This is inadequately recognized and expressed within the Issues Papers 7 and 8.

The implications of this bridging aspect must not be underestimated, as it can lead to a multiplication

of viable options that are opened for the European industry in terms of achieving its targets for renewable energy use (27% by 2030) and tackling GHG emissions (80% of which are related to transport). For example, the integration of small fuel cell stacks with battery-powered drivetrains to extend the driving range of regular electric vehicles (BEV): optimizing the proportion of the two systems leads to 300 km drive ranges and 5-minute refuelling with a small hydrogen tank + 10 kW fuel cell added to a current-generation BEV. Similarly, renewable hydrogen could be used for the desulphurization of fossil fuels, effectively “greening” them, or fuel cells could be made to run on hythane (hydrogen + (bio)methane), a fuel already considered for conventional drivetrains.

Though a focused activity on the maturation of these technologies is currently addressed by the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU) as part of Horizon2020, it is crucial to start cross-linking these developments with the progress being achieved in the respective sectors more strictly targeted by Actions 7 and 8. Only in this way can the Strategic Energy Technology Plan effectively be called an *Integrated* Roadmap. This means encouraging overarching projects as well as supporting the alignment of disruptive, low-TRL technologies in the e-mobility, fuel cells and alternative fuels areas to leverage European excellence and ensure competitiveness in the global market place also in the long run.

2. In the issue paper, it is stated that *“Acknowledging this, the SET Plan [1] underpins the importance of promoting new investments at all stages of the innovation chain.”* (page 3). Later on in the document, it is also stated that *“The R&I effort will cover materials, cells, packs and systems with a focus on high energy and resource efficiency, modularity and re-configurability, while also taking into account second life and recycling. In terms of chemistries, the core focus is on Li-ion batteries, while attention and a certain support may be given to post-Li-ion.”*

Besides other issues, a major bottleneck for the massive use of batteries in the mobility sector is the autonomy of the batteries. Even if there is still room of improvement for Li-ion batteries, reaching higher mobilities imposes to also consider post Li-ion solutions with higher energy densities. Therefore an important R&D effort should be put in the future to explore these new post Li-ion solutions. This involves innovative materials with a well-controlled morphology and structure at different length scales, *i.e.* with 3D hierarchical structures to take full advantage of the potential of these new materials. In addition, the efforts should not only focus on batteries but also on supercapacitors that combined with batteries provide the required power densities for the mobility sector.

Yours sincerely,

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