Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile

"ENEA's test facilities and activities on batteries and supercapacitors"

Salerno, 31/05/2018

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What is ENEA

Italian National Agency for New Technologies, Energy and the Sustainable Economic Development

ENEA conducts scientific research and technology development activities that draw on a wide range of expertise, advanced facilities and tools located at its own Research Centers, operating in support of ENEA's programs and the Nation's productive system.

ENEA's headquarters are in Rome.

STMA Lab is in "Casaccia" Research Centre.

What is STMA – Mission and main activities

STMA: System and Technologies for Mobility and Storage

Mission

- Theoretical & Experimental activities on new technologies for low environmental impact vehicles and **storage systems for automotive and stationary applications**

Main Activities

- Series and parallel Hybrid Micro-cars for urban uses
- Electric vehicles for local public transportation purposes
- Innovative Fuel mixtures (Hydro/methane)
- **Electric energy storage systems (test and design): Lithium batteries and/or Supercapacitors**
- Propulsion systems for industrial and off-road applications (overhead cranes, cableways, …)
- Complete vehicles testing on rolling test benches
- Charging systems for EVs

What is STMA – Structures and Facilities 1

What is STMA – Structures and Facilities 2

Services

- 21 Offices
- 2 Electronics Labs
- 1 Mechanical Lab
- 1 Mobile Lab for vehicle measures
- 1 Chemical Lab

Scientific Labs & Equipments

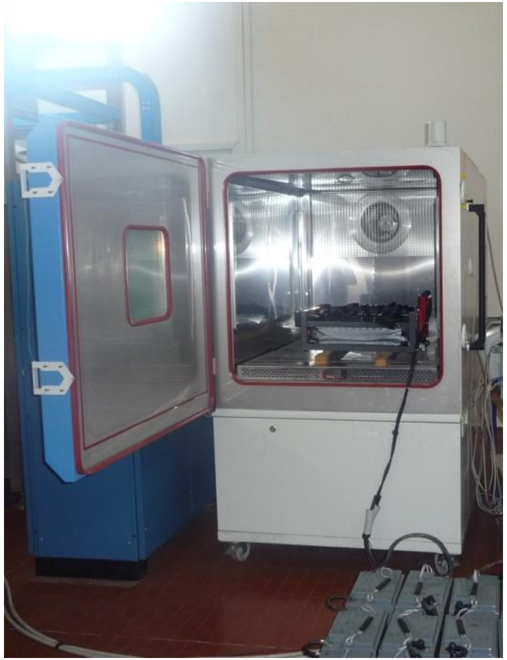
- **1 Battery Testing Hall**
- **1 Supercapacitors Testing Hall**
- 1 Vehicle Rolling Test Bench
- 1 Motorcycles Rolling Test Bench
- 3 Engine Test Benches suitable both thermal, electric, hybrid and for fuel cell propulsion systems
- 1 Charging Station for Electric Vehicles
- 1 Charging Station for methane and/or Hydrogen fuelled Vehicles

What is STMA – Battery Testing Hall 1

Cyclers

What is STMA – Battery Testing Hall 2

Environmental Chambers



What is STMA – Supercapacitors Testing Hall

Even if there's a specific SCs testing hall, SCs can also be tested in the battery testing hall

What is STMA – Equipments main characteristics

Battery Testing Hall		
Battery cycler E-8376	ELTRA	0÷330 V; ± 400 A
Battery cycler E-8135	ELTRA	0÷165 V; ± 600 A
Battery cycler E-8049	ELTRA	0÷72 V; ± 140 A
Battery cycler E-8619	ELTRA	0÷600 V; ± 175 A
Battery cycler E-8325	ELTRA	0÷12 V; 80 A ch; 150 A dsch
Battery cycler RTS-DC-3855-001A-525	**AVL**	**0÷800 V; ±600A; 250 kW**
Battery cycler BNT 50-080-8 BDBT	**DIGATRON**	**8 x (0÷80 V; ± 50 A)**
Climatic chamber EOS 1000	ANGELANTONI	-40 ÷ +180 °C; 15 ÷ 98% R.H., 1 m^3
Climatic chamber DY 1200 C EX	**ANGELANTONI**	**-60 ÷ +150 °C; 10 ÷ 98% R.H., 1 m^3 abuse testing**
Climatic chamber UY 2250 SP	ANGELANTONI	-40 ÷ +180 °C; 15 ÷ 98% R.H., 2 m^3
Charging station	CIRCUTOR	Mode 4 (50 kW) + Mode 3 (22 kW) IEC 61851-1

Super capacitor Testing Hall		
DC Power Supply HP 6682 A	Hewlett Packard	0 ÷ 21 V,0 ÷ 240 A
DC Electronic Load	Hewlett Packard	2 x (60 V, 120 A, 600 W)
Climatic Chamber CH 250	ANGELANTONI	-75 ÷ +180 °C, 10 ÷ 98% R.H., ¼ m^3

What is STMA – Storage devices testing

	Characterization				Reliability			Electrical and thermal abuse			Mechanical abuse	
	Capacity and energy @ different C-rates and temperatures	Internal resistance, OCV, power	Fast charge	Self discharge	Life cycle *(standard procedures and real working profile)*	Accelerated life cycle	Vibration and mechanical shock	Short circuit	Overhcarge/overdischarge	Thermal runway	Crush	Penetration
cell	x	x	x	x	x	(x)	x	(x)	(x)	(x)	(x)	(x)
module	x	x	x	x	x	(x)	x	(x)	(x)	(x)	(x)	(x)
system	x	x	x	x	x	(x)	x	(x)	(x)	(x)	(x)	(x)

x = operative, (x) = to be operative soon

What is STMA – Main Projects list

European Projects

- HCV (Volvo)
  tests on battery system
- HySys (Daimler)
  tests on battery system

National Projects - Industria 2015

- LIVE (IVECO)
  tests on battery system
- MUSS (Piaggio)
  tests on battery system
- Meccano (Fiat Research Centre)
  tests on battery system
- HiZEV (Univ. Roma 1, Picchio)
  battery system: design, supply and tests

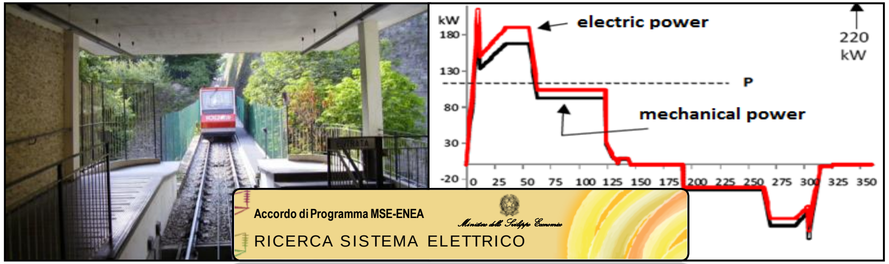
National Projects – Research on Electric System

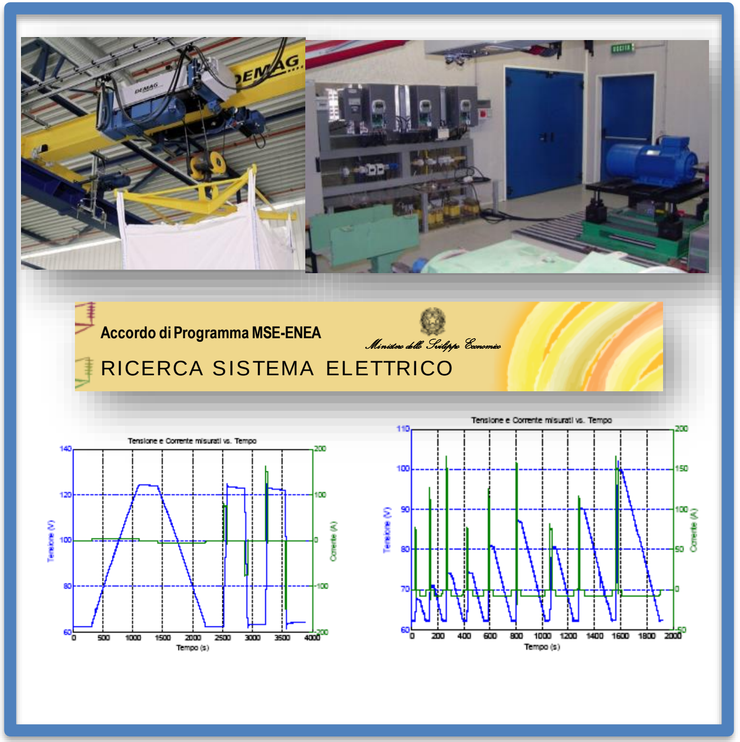
- Headcrane (Univ. Roma 3, Naples, Milan)
  energy recovery with SCs
- Bergamo's cableway (Univ. Pisa, ATM, EEI)
  battery system for peak shaving: design, supply and tests
- Battery modules (Univ. Pisa)
  design, realization and tests

Other

- Tests under NDA

What is STMA – Projects example





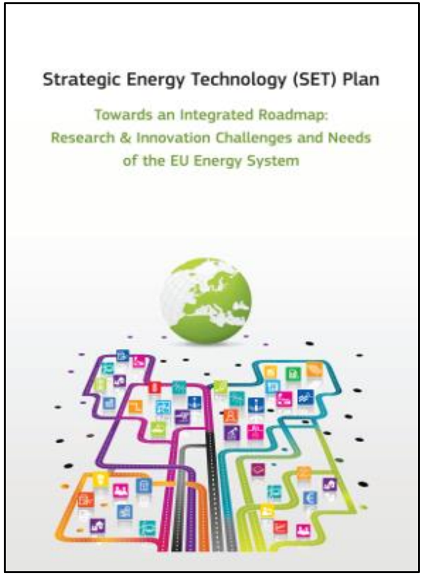
SET-Plan Action 7 on Batteries

Declaration of Intent (DoI)
12/07/2016

Temporary Working Group (TWG)
20/03/2017

Implementation Plan (IP)
22/10/2017

IP endorsed by the SET-Plan Steering Group
(EC, EU-28, NO, IS, TR, CH)
29/11/2017



SPA7 – Declaration of Intent - Targets

Table a

		Current (2014/ 2015)	2020	*2030
Performance targets for automotive applications unless otherwise indicated				
1	Gravimetric energy density [Wh/kg]			
	pack level	85-135	235	> 250
	cell level	90-235	350	> 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	22	12
6	Battery life time (at normal ambient temperature)			
	Cycle life for BEV*** to 80% DOD [cycles]		1.000	2000
	Cycle life for Stationary to 80% DOD [cycles]	1000-3000	3000-5000	10000
	Calendar life [years]	8-10	15	20

*: Post-Lithium ion technologies are assumed relevant in this time frame
**: May also be relevant to stationary applications
*** Cycle life for PHEV must be bigger

Table b

	TARGETS	Current (2014/ 2015)	2022	2030
Cost target				
1	Battery pack cost for automotive applications [€/kWh]	180-285	90	75
2	Cost for stationary applications requiring deep discharge cycle [€/kWh/cycle]		0,1	0,05

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)	0,15 – 0,20	5 (50% of the 0.5 M EVs with 20 kWh)	50 (50% of the 2 M EVs with 50 kWh)
2	*Utility Storage (Li-ion and next generation post-lithium) battery cell production in EU [GWh/year]	0,07 – 0,10	2.2	10
3	Recycling			
	**Battery collection/take back rate	45% (Sept 2016)	70%	85%
	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

* The energy storage capacity in GWh depends strongly on the implementation rate of intermittent renewable electricity sources and market models behind those.

** These targets are based on numbers defined in Directive 2006/66/EC. This Directive is being revised and targets should be consistent with the revised Directive.

SPA7 - TWG

European Commission

Updated list of participants to the TWG

SAFT
BASF (invited)
SOLVAY
LECLANCHE
BOSCH
DAIMLER
BMW
VW
ENEL
VATTENFALL
EDF
VALDI
RENAULT NISSAN
UMICORE
UNIPER

EUROBAT
BOUYGUES
PEC

France
Austria (invited)
Belgium
Germany
Estonia (invited)
Spain (invited)
Italy
Norway
Sweden
Turkey
United Kingdom (invited)

KIC InnoEnergy
EERA
RS2E
MEET
ISEA Aachen
EUA-EPUA

« Newcommers »

FRAUNHOFER
NORTHVOLT
BLUE SOLUTIONS
VARTA
AVL
M+W Group
SCANIA
KLiB
LITHOPS
xxxx
xxxx

thanks!

SPA7 – Implementation Plan

Content

1.1 Advanced Lithium-Ion batteries for e-mobility

1.2 Influence of Fast/Hyper charging of Li ion batteries on materials and battery degradation

1.3 Advancement of batteries for stationary energy storage

1.4 Beyond Li ion / Li based batteries for e- mobility

1.5 Develop circular economy and de-bottleneck availability of critical raw materials

1.6 Lithium recovery from European geothermal brines and sustainable beneficiation processes for indigenous hard rock occurrences of lithium

2.1 Foster development of materials processing techniques and components for fast industrialization compatible with present mass production lines

2.2 Foster development of cell and battery manufacturing equipment

3.1 Hybridisation of battery systems for stationary energy storage

3.2 Second use and smart integration into the Grid (Flagship)

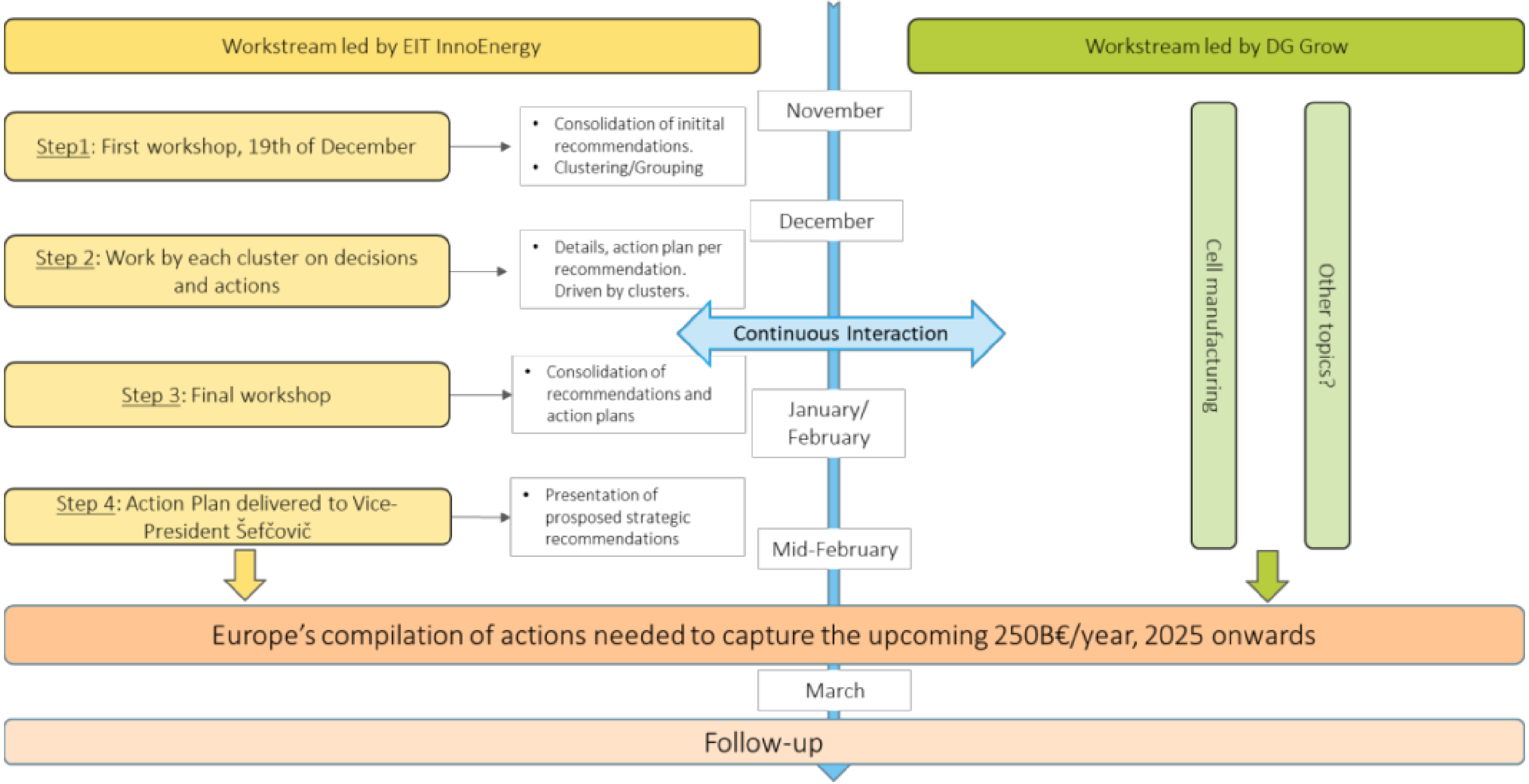
SPA7 – Next steps

- **TWG will be continued** (format and composition tbd) in a more permanent structure (European permanent forum on batteries, IWG)

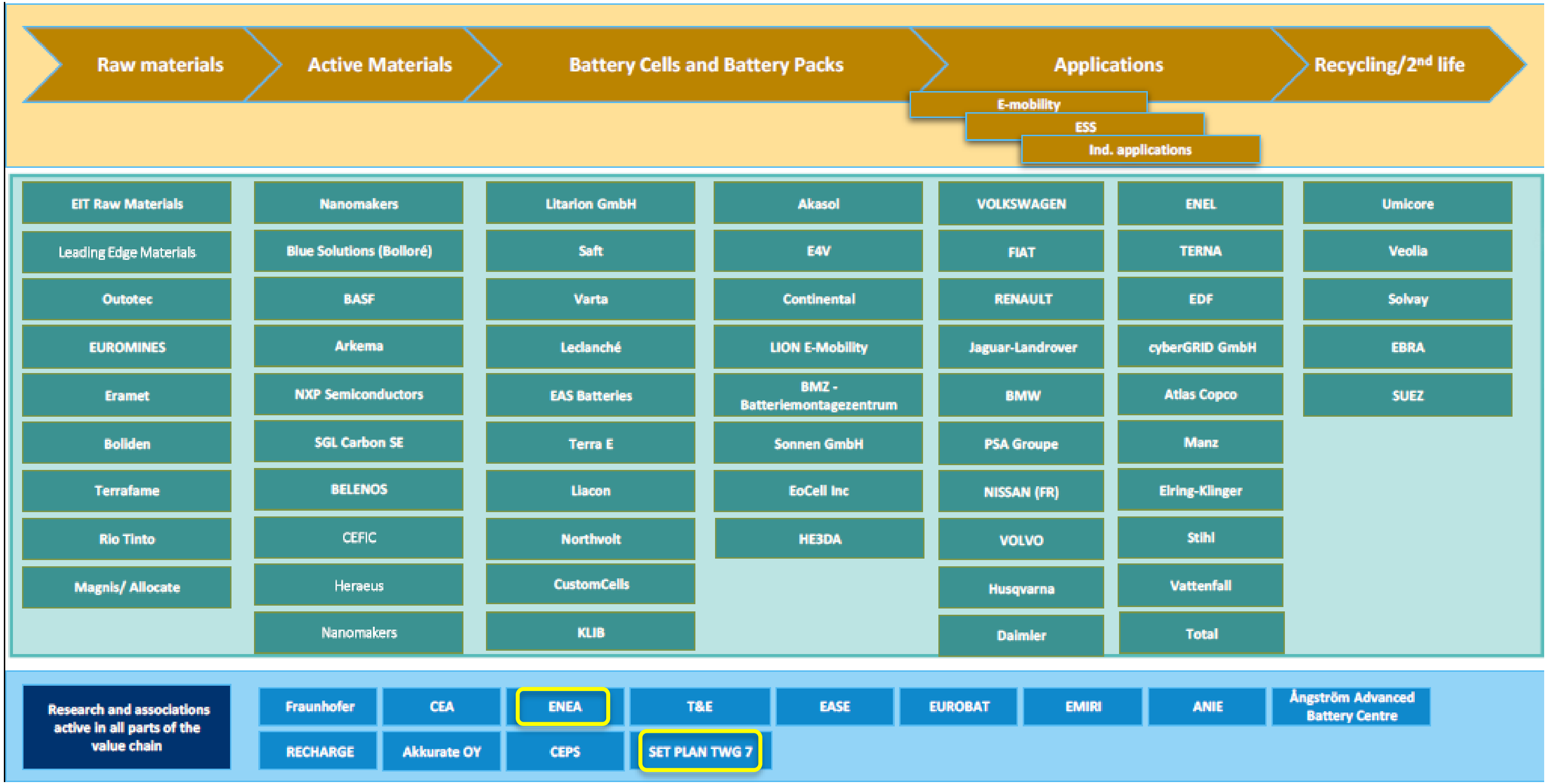
- **IP** is welcome as an **input for European Battery Alliance's** R&I activities

- The objectives of the TWG and the Alliance are **different but complementary, mutual sinergy** has to be exploited

European Battery Alliance - Workstreams



EBA - Technical Workstream Participants



EBA – Proposed recommendations/actions (1^)

Objective	Recommendations	Actions	Groups	Priority (1 highest-3 lowest)
Secure access to sustainably produced battery raw materials at reasonable costs	1. Secure access to raw materials from resource rich countries outside the EU	1a. Apply diplomacy, strategic investments and stretch trade agreements (e.g. Canada, Republic of Congo) to secure access to raw materials	Group 1	1
		1b. Implement same compliance rules to foreign battery products imported to Europe as applied to European products	Group 1	1
	2. Facilitate the expansion/creation of European sources of raw materials	2a. Build European alliances between industries from different parts of the value chain and politics to boost mining and intermediate product production in EU	Group 1	1,5
		2b. Map geological and urban sources, and potential scenarios considering conflicting interests – and possible actions to take from a European and National perspectives	Group 1	2
		2c. Define and implement a simplified application process for opening of new mines	Group 1	2
	3. Secure access to secondary raw materials through recycling in a Circular Economy of Batteries	3a. Define and implement regulation and demonstration projects for recycling and second life of batteries.	Group 1	1
		3b. Improve regulation and align with strategic objectives: Battery Directive, Energy Union, REACH, Critical Raw Materials, Mobility Package, Permitting, Transport Regulations	Group 1	1
Make Europe the global leader in sustainable battery technology	4. Support the growth of a cell manufacturing industry that comes with the smallest environmental footprint possible. This will provide a key competitive and commercial edge versus competitors.	4a. Develop a standardised EU life cycle assessment scheme, with targets of carbon footprint including guidlines for the calculation thereof	Group 1	1
		4b. Define and implement certification/labelling of batteries made in Europe. Use the declaration as a tool in trade agreements / tax treatment with non-EU battery providers	Group 1	1
		4c. Reduce carbon footprint of advanced battery materials making and cell manufacturing by securing access to renewable Energy	Group 1	2
		4d. Develop a standardised life cycle assessment for all transport technologies	Group 1	2
	5. Create and sustain a cross-value chain ecosystem for batteries, incl. mining, processing, materials design, 2nd life, and recycling within the EU, encouraging cross-sectoral initiatives between academia, research, industry, policy, and the financial community.	5a. Invest in R&D and pilot plants to take the technology lead in primary and secondary raw materials processing	Group 1	1
		5b. Establish a clearing house for battery recycling	Group 1	2
		5c. Strengthen all currently existing battery collection systems	Group 1	2
Support European Battery manufacturing in order not to miss the hockey stick phenomenon in market demand (250B€/year in 2025)	6. Ensure the availability of high quality and high-performance cells for European industries to maintain the competitiveness of several European industries.	6a. Define cell manufacturing as a strategic industry for the hight-tech area Europe.	Group 2	1
		6b. Suggest tax incentives can help establish cell manufacturing in Europe	Group 2	2
		6c. Generate and secure European IP	Group 2	2
	7. Front loading financially, e.g. IPCEI (important projects of common European interest) and/or other financial instruments such as tax incentives, the needed investments is a must for not missing the demand uptake.	7a. Investigate and implement funding possibilities (direct funding and funding bridges) for cell manufacturers to convince the first consumers	Group 2	1
		7b. Define and implement criteria for IPCEI projects for cell manufacturing.	Group 2	1
		7c. Strengthen competiveness by stronger up- and downstream integration of cell manufacturers	Group 2	2
	8. Accelerate time to market to meet market demand and international competitors	8a. Standardize and simplify approval procedures ("Fast track") and permitting (environmental, manufacturing, construction) process	Group 2	2
		8b. Investigate and implement investment risk sharing between companies along the value chain, EU and member states to support new cell manufacturing	Group 2	1

EBA – Proposed recommendations/actions (2^)

Create and support new markets for batteries in order to support sustainable solutions for power, transportation and industry sectors in line with EU climate goals and winter package.	9. Increase the demand for e-mobility solutions including "yellow machines"	9a. Set clear targets for charging infrastructure for homes, urban areas and public roads as well as along freeways. Provide incentives for building charging infrastructure.	Group 3	1
		9b. Define and implement a consistent incentivizing framework for the uptake of the EV market (e.g. emission standards for "yellow machines", promotion schemes for ZEV sales, public procurement targets for clean vehicles including public transport, tax and "soft" incentives such as use of public lanes and free parking)	Group 3	1
		9c. Implement favourable tax incentives for e-taxi operators e.g. special VAT schemes	Group 3	3
	10. The function of batteries and battery systems must be seen pluri-functional, in a context of both power and transportation sectors. For ESS, regulation (or absence of it) enabling of right business models is crucial.	10a. Develop a power market design that enables the integration of ESS (including EV batteries through vehicle to grid) allowing ESS and EV batteries to support the power system management with high penetration of EV charging. Battery based actors/systems shall be able to participate in all parts of the power market and network tariff shall not penalize storage while driving electrification (capacity based + Time-of-use, with no generation charges)	Group 3	1
		10b. Establish a transparent data hub for use data for e-vehicles (similar to best practice data for hub metering data of electricity customer)	Group 3	2
	11. Incentivize storage as alternative to conventional grid reinforcement.	11a. Integrate battery storage options and V2G in grid planning and resource planning (addressing security of supply)	Group 3	1
	12. Enable integration of ESS on all levels of the power system including behind the meter	12a. Develop standardized interoperability interfaces allowing seamless secure integration of battery management systems of ESS and EVs and bi-directional communication with aggregation platforms or Energy markets. Evolution of digitalized innovative energy services shall be enabled.	Group 3	1
Grow the European R&I capacity. Develop and strengthen skilled workforce in all parts of the value chain and make Europe attractive for world class experts.	13. Create competitive advantage with constant incremental (e.g. Lithium ion) and disruptive (e.g. solid state) R&I connected to the industrial ecosystem in all the steps of the value chain (advanced materials, new chemistries, advanced manufacturing process, BMS, recycling, business model innovations).	13a. Define how to reach TRL 7 in 2023 on Generation 3b (advanced lithium-ion technologies with liquid electrolyte) for e-mobility	Group 2	2
		13b. Define how to reach TRL 7 on Generation 4 (all-solid-state lithium-ion technologies, e.g., with polymer or ceramic electrolyte) for e-mobility in 2023 by concentrating R&I efforts on this strategic topic	Group 2	1
	14. Conduct advanced research in battery chemistry, battery systems, manufacturing, recycling and increase university output in these areas by involvement of industrial stakeholders.	14a. Create stronger focus and more prescriptive R&I calls, co-defined with Industry and sustained over longer periods	Group 3	1
		14b. Establish a technology board within the EU Battery Alliance, with the mandate to update the roadmaps and the R&I orientations, and manage the project portfolio (R&I project portfolio management)	Group 3	1
	15. Sufficient and key human capital skills are missing in Europe especially on applied process design. Lighthouse projects for cell manufacturing will attract worldwide talent.	15a. Actively identify and utilize synergy effect between large scale cell production and educational system to secure workforce competence transition	Group 2	2
		15b. Establish a European open access pilot line network to gain manufaturing experience	Group 2	1,5
		15c. Create a link between the educational network (Master programs in Universities) and the European pilot line network, in order to train the students on battery manufacturing	Group 2	2
		15d. Build new degree courses in consultation between universities and industries	Group 2	2
		15e. Dedicate national and ESF (European Social fund) funds for training professionals to new technologies systems and applications	Group 2	2
	16. Make Europe attractive for world class experts and create competent workforce.	16a. Define instruments to attract global key talents including process engineers and operations	Group 3	2
Involve (= inform, educate & motivate) the EU citizens in the journey.	17. At the end of the supply chain there is always a B2C transaction. Public efforts (education in schools, role modelling, ...) should be spent on citizen awareness of the whole valuechain, so there is a societal appropriation from the start. Fighting for keeping the supply chain in Europe will definitely help to bridge the gap citizen-politics.	17a. Involve Industry + Citizens + Policy makers on Use patterns/Re-use & Sustainability	Group 1	2
		17b. Highlight importance of batteries as a means to meet decarbonization goals in power and transport.	Group 1	2
		17c. Safeguard non-discriminatory access for consumers to energy service providers including charging services	Group 3	2
Ensure maximum safety for European citizens and create competetive advantage through standardization.	18. Standardize storage related installations including charging infrastructure, safety rules, active load compensation and enable vehicle to grid solutions	18a. Develop and implement performance and safety assesment standards for batteries	Group 3	1
		18b. Harmonise charging protocols and billing systems in Europe	Group 3	2

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