HITECH ENERGY

aabc europe advanced automotive & industrial battery conference

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Congress Centrum Mainz, Mainz, Germany

What's The Next Standard LIB cell for LEVs and EVs Applications?

Mo-Hua Yang

January, 2016

Outline

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- LEV Market
- Li-ion battery Development for LEV
- Li-ion Battery Market
- Commercial 18650 Li-ion Cell Analysis
- Future Development of 18650 Cell
- Standard Battery-Energy Tube

Why LEV

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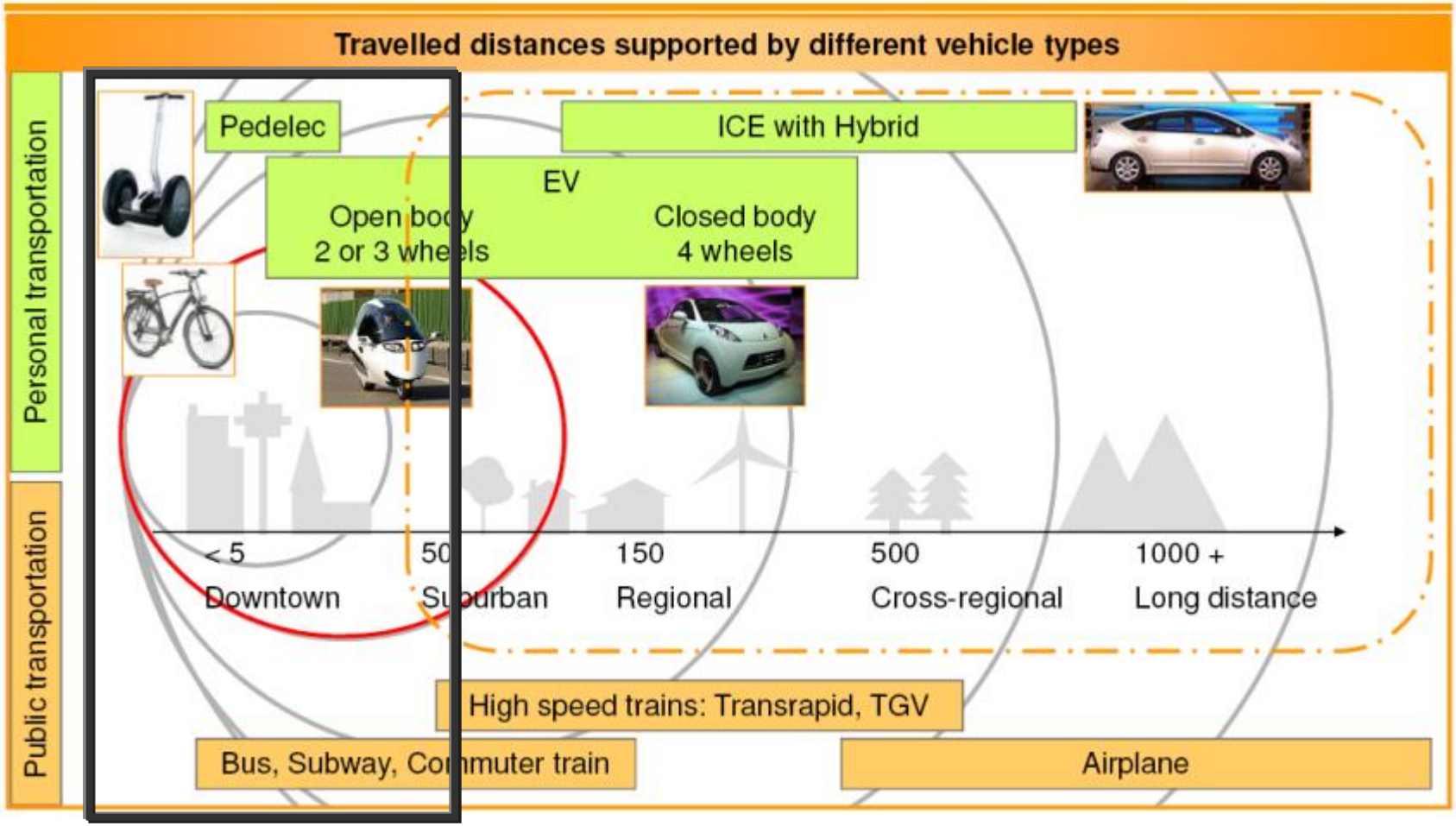
Driving Range & Convenience



Urban Mobility

Continental, 2010

Personal Motilities

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LEV Categories

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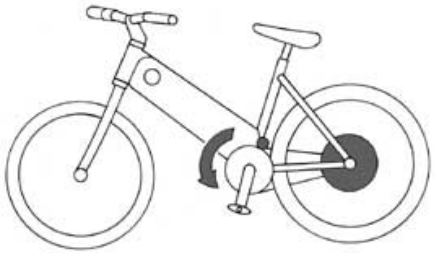
Personal mobility

Pedelec

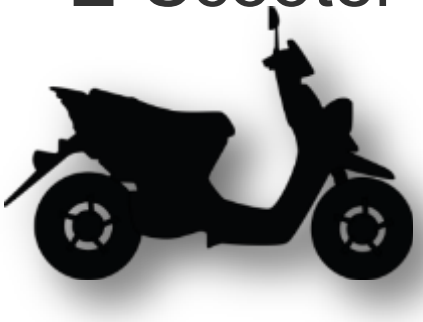


accelerates only when you pedal.

E-Bike

Accelerate independent from the muscle power input by twisting the throttle!

E-Scooter



Power on demand

Battery Demand

Energy ← → **Energy + Power**

LEV Developments

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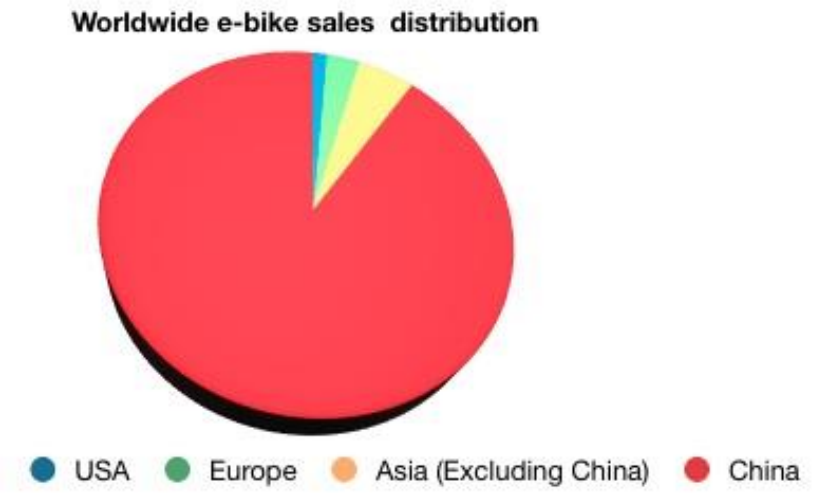
- **Market**
- **Design**
- **Technology**

Worldwide e-bike sales in 2015 estimated to be more than 38 million.
– 0.5 million USA,
– 1.8 million in Europe,
– 2.5 million in India, Japan and Taiwan,
– 33 million in China



LEV-Market

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China

Necessary




Economic & life improvement

Europe, Japan & US

Sport, Leisure, Transportation




Environment & Health

LEV-Design

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LEV-Technology

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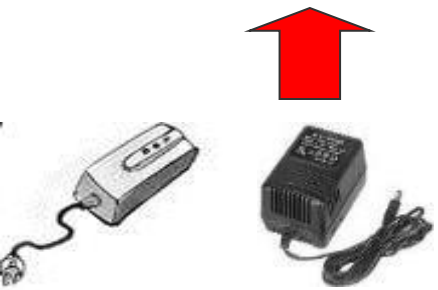
Energy Storage System

Power

Communication

Motor Propulsion System

Battery & Battery system



Charger

Electric motor & Controller

Key Successes Factors For LEV Market

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- **Interface standardization: Energy Bus**

  www.energybus.org

  Universal charging interface
  IEC/ISO/TC69/JPT61851-3

- **Safety Standardization: BATSO**

  www.batso.org

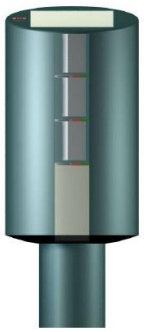
  ISO 18243 & CLC/TC21X

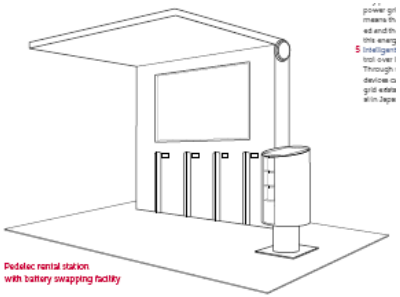
- **Energy supply service system**

  -Battery exchange system (SWAP)

  -Charging Station

  Public LEV Infrastructure Initiative:
  IEA HEV IA Task 23





Small Cell vs. Large Cell

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Large Format cell

Development considering HEV / PEV use

- High pack reliability
- Low cell quality (poor uniformity)
- High cell price (>800USD/kWh)

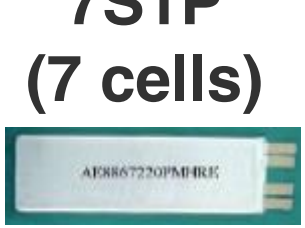
18650 type cell

Application of current technology

- High cell reliability
- Low cell price (<400USD/kWh)

For a 24V/10Ah battery pack

7S1P (7 cells)



10Ah cell

7S2P (14 cells)

5Ah cell

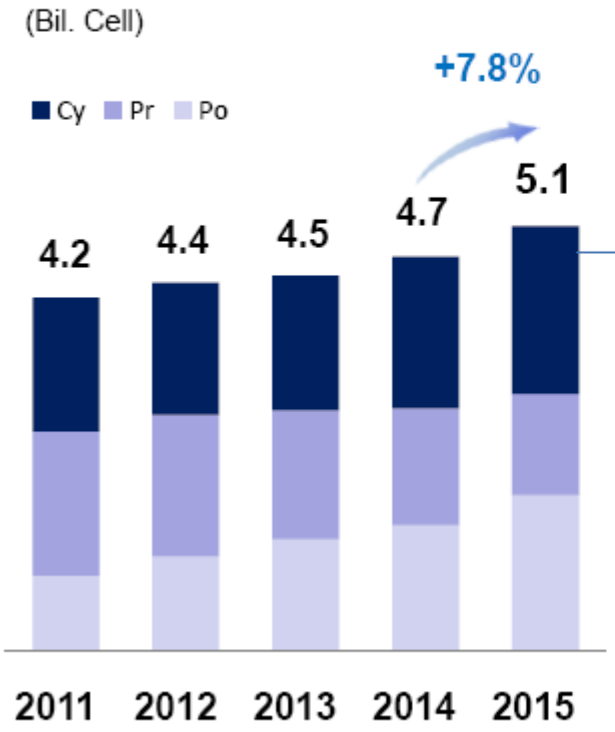
7S5P (35 cells)

2Ah cell

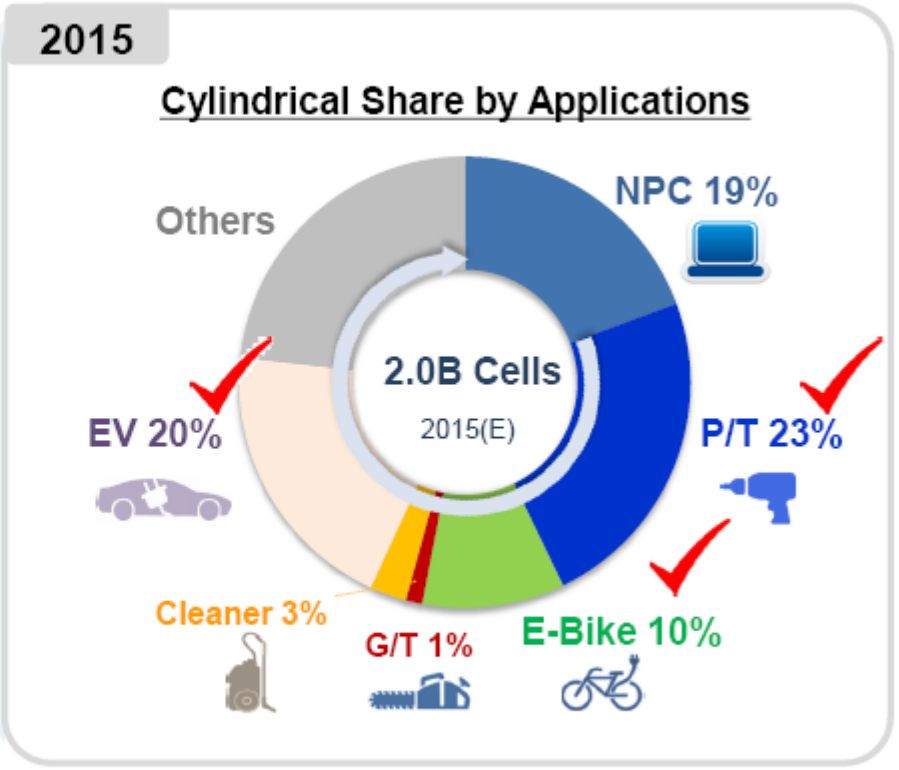
Li-ion Battery Market

LIB demand reaches to 5.1 billion cells in 2015 with 8% growth,
P/T & EV lead LIB market expansion

LIB Demand Forecast



※ Reference: B3, TSR, SDI Marketing



※ Others : Power Bank, DVC, DSC, VoIP, E-Toothbrush etc.

18650 Cell Developments

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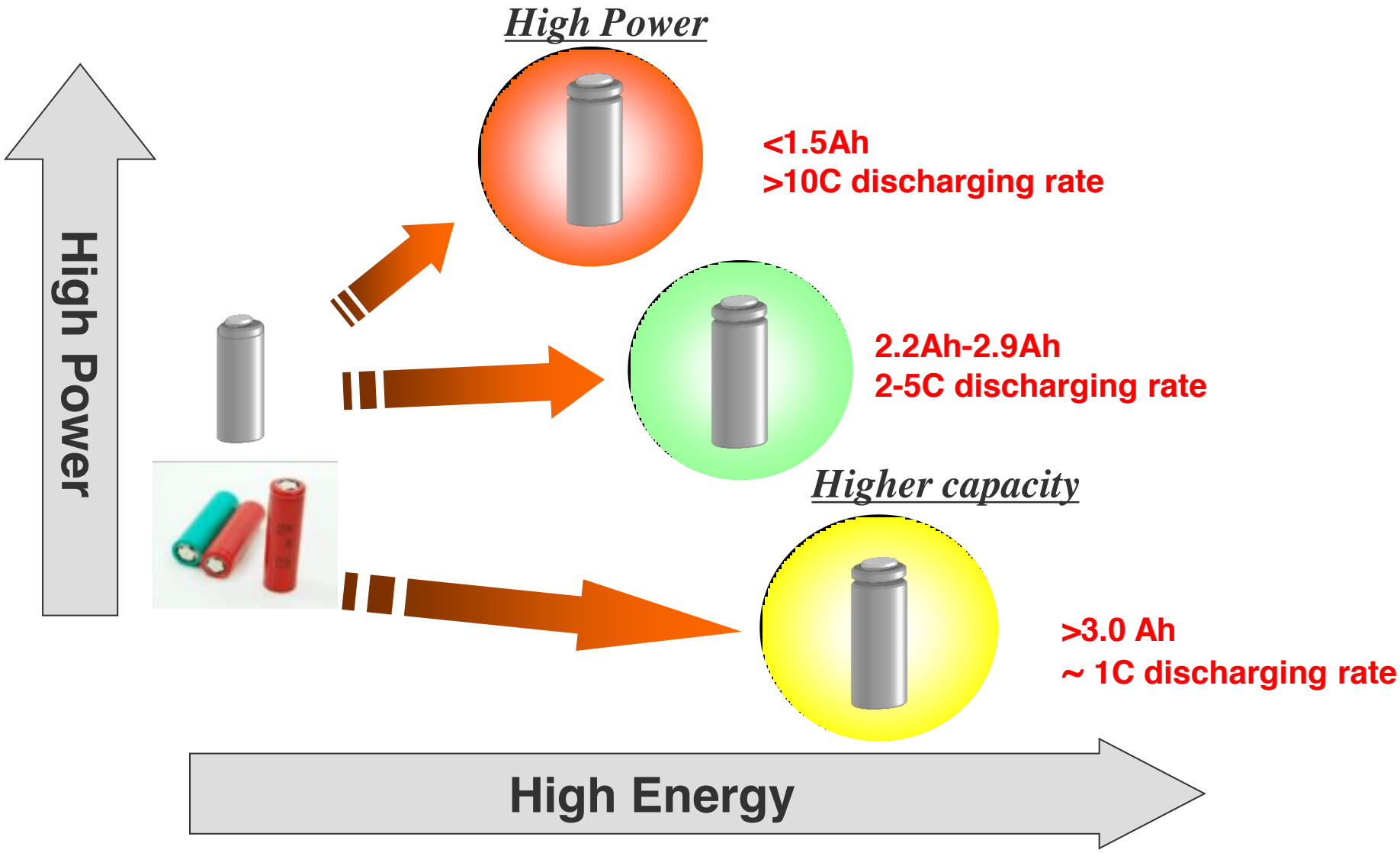

18650 Cell Design

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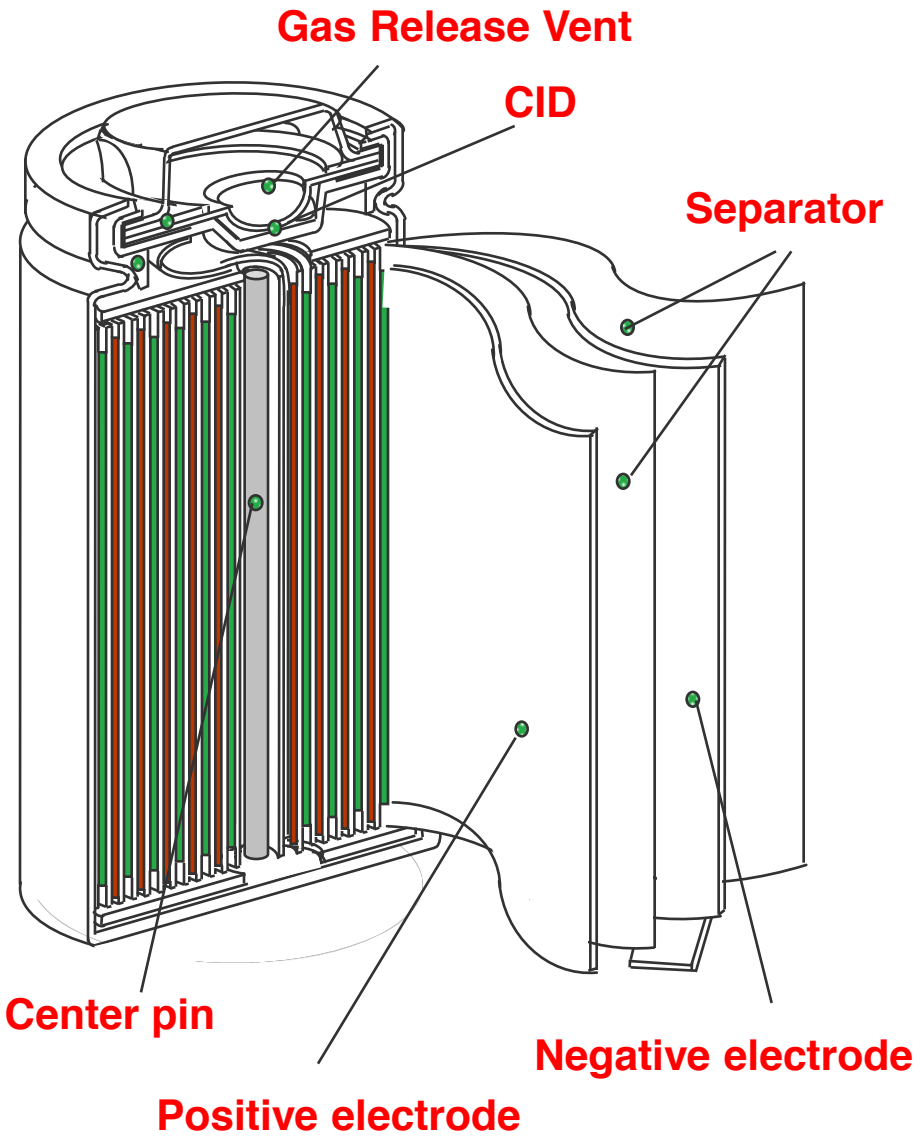

Design for safety

- CID (Current interrupt device)
- gas release vent
- shutdown separator
- separator coating
- center pin
- thermal stable active material
- stable electrolyte
- protection tape on weak point (Al and Ni tab)

Design for power performance

- NMC, NCA cathode material introduce
- PTC remove
- increase electrode tab number
- lower internal resistance (<30mΩ)

18650 Cell Design for EV

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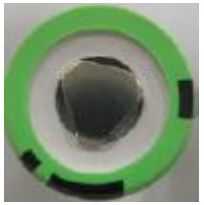
	Top cap sharp	Bottem sharp
LEV application (current 18650 standard)		
EV application		
	CIP work late for EV application	Safety vent on bottom site for EV application

Different safety design consideration on EV application:

-reduce safety device sensitivity (control by system BMS)

- PTC removal
- CID adjusted to allow large and wide current operation condition

-double safety vents, top and bottom

-HRL technology

Product Development in next 1-3 Years

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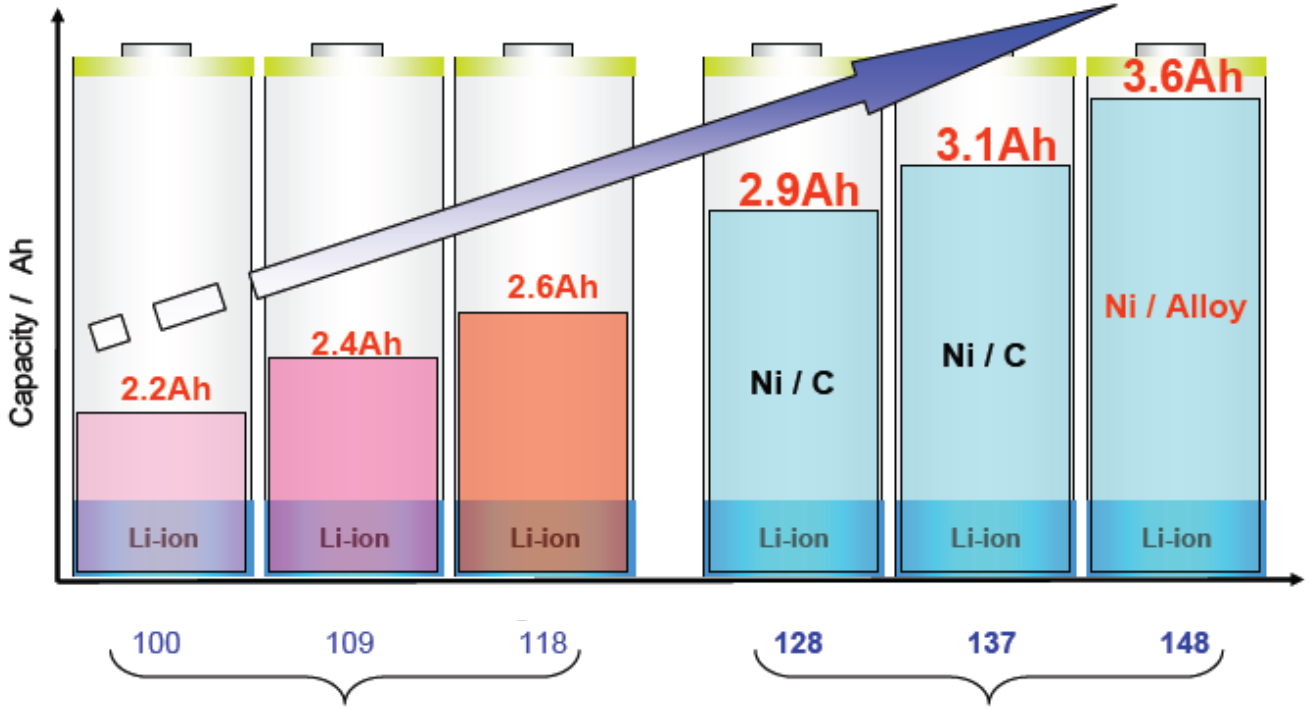
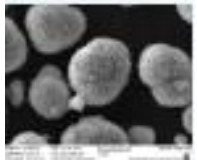
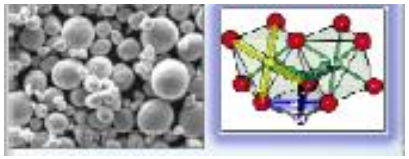
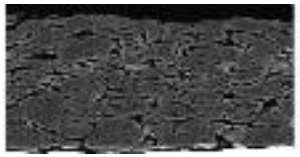
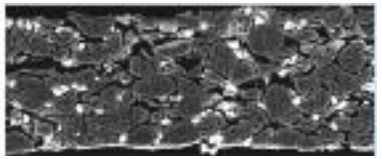


Cathode NMC  Ni-based (NCA) 

Anode Graphite  Graphite+Si 

High Capacity Cell Development

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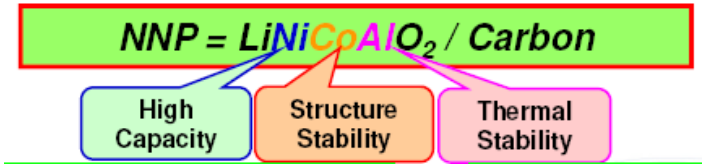
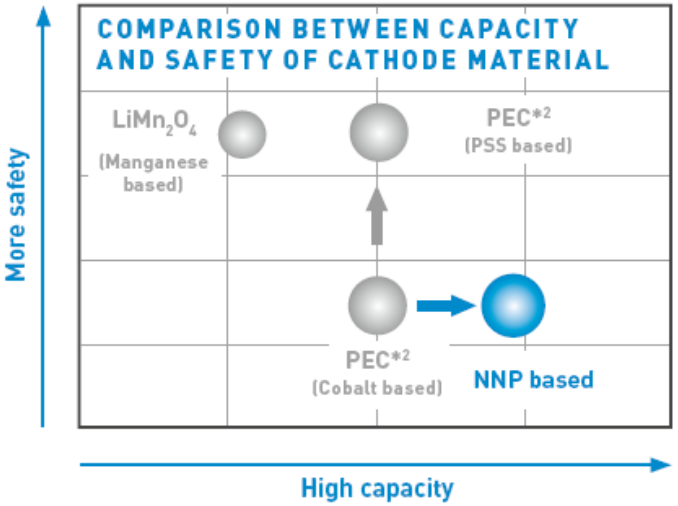
NNP: Nickel Oxide Based New Platform





Characteristics of the Panasonic NNP technology:

➜ Good cycle life performance

➜ High energy density

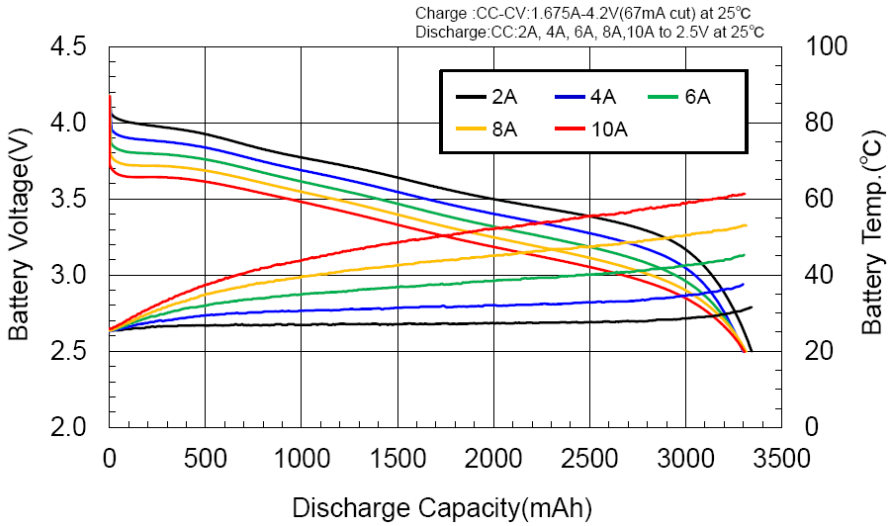
➜ The new Nickel positive electrode excels in durability in actual use and charge retention

➜ Low self-discharge

➜ Long storage reliability through reduced metal elution

		NCR18650GA
Capacity (mAh)	Rated (Min. at 20deg)	3300
	Min. at 25deg	3350
	Typ. at 25deg	3450
Nominal voltage (V)		3.6
Charging method		CC - CV
Standard charge current (A)		1.00-1.67
Max. Discharge current (A)	Considering cycle*	8
	Continuous**	10
Operating Temperature	Charge	0 ~ +45℃
	Discharge	-20 ~ +60℃
Weight (max.) (g) with insulation tube		49.5
Dimensions (max.) with insulation tube	Diameter (mm)	18.5
	Height (mm)	65.3

* Considering cycle life : 60% capacity vs initial at 300th cycle
** Continuous : cycle life is not considered

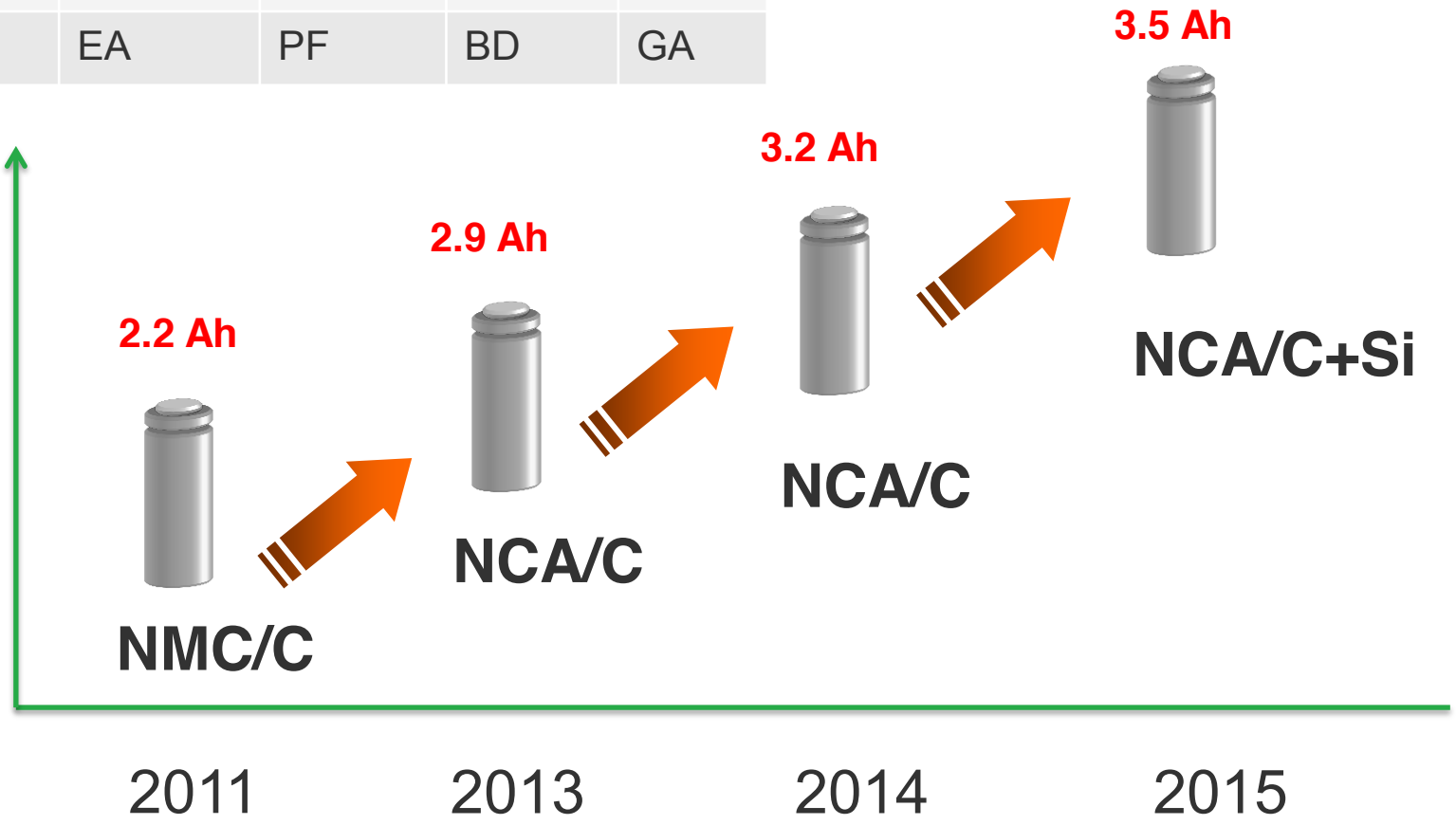


Data sources: Panasonic

18650 Cell for LEV Applications

	2.2Ah	2.9Ah	3.2Ah	3.5Ah
Samsung SDI	22P	29E	32E	35E
LG Chem	MF1	MG1	MH1	MJ1
Panasonic	EA	PF	BD	GA

Limitation of 18650 cell?
What's the next?



What's the next gen?

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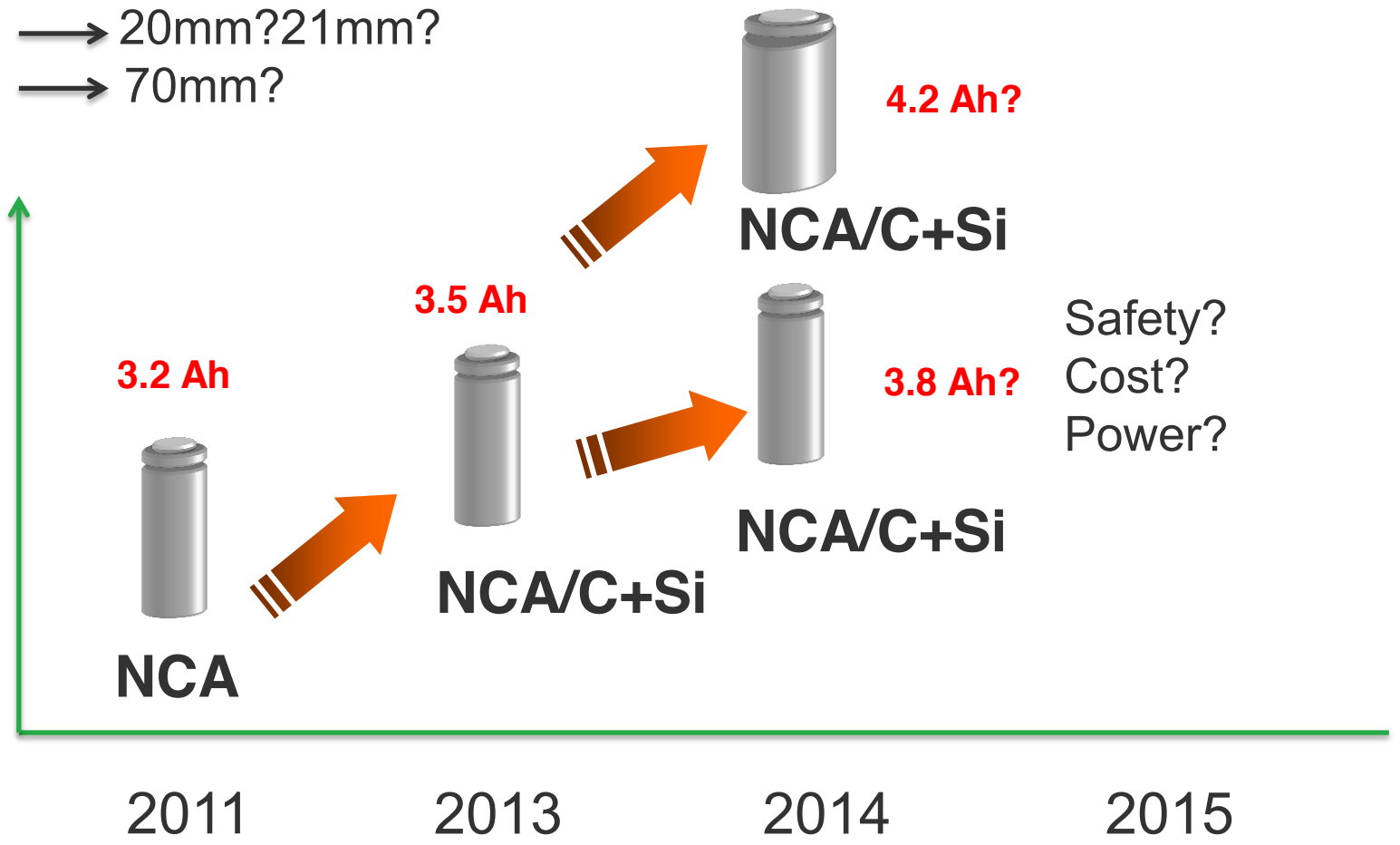
Limitation of 18650 cell?
What's the next?
Form factor change:
D: 18mm ⟶ 20mm?21mm?
L: 65mm ⟶ 70mm?



What's the next Standard cell?

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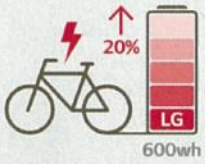
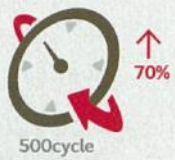
Model	M42
Diameter x Height (mm)	20×65
Nominal Capacity (Ah)	4.2
Energy (Wh)	15.3
Nominal Voltage (V)	3.64
Weight (g)	58
Max Discharge Current (A)	15

M42



Highest Capacity



Longer Life Cycle

More Compact & Light

More Powerful

Safer

Specification

Type		INR21700-38P
Chemistry		NCA-NCM /Gr.
Dimension (mm)	Diameter	21
	Height	70
Max. Weight		75g
Initial IR (mΩ AC 1kHz)-Estimated		20
Initial IR (mΩ DC (10A-1A)-Estimated		40
Nominal Voltage (V)		3.6
Charge Current	Standard current (A)	6
Discharge	End voltage (V)	2.5
Discharge Capacity	Standard (mAh) (0.2C)	3750

NCR20700 B

10~12A type

Nominal Voltage	*3.6 (V)*
Capacity	*4000 (mAh)*
Charge voltage	*4.2 (V)*
Diameter(with tube)/Max.	*20.3 (mm)*
Height(with tube)/Max.	*70.3 (mm)*
Approx. Weight	*63.5 (g)*

What's the next Standard cell?

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	Samsung SDI	Panasonic	LG Chem
Dimension	21700	20700	20650
Type	47P	NCR 20700B	M42
Capacity	4.7Ah	4.2Ah	4.2Ah
MP	2016 Q2	2015 Q1	2015 Q1

➢**18650 cell with 3.5Ah**

10S4P(40cells) 36V/14Ah=504Wh
13S3P(39cells) 48V/10.5Ah=504Wh

➢**20650/20700 cell with 4.2Ah**

10S3P(30cells) 36V/12.6Ah=454Wh
13S2P(26cells) 48V/8.4Ah=403Wh

➢**21700 cell with 4.7Ah**

10S3P(30cells) 36V/14.1Ah=508Wh
13S2P(26cells) 48V/9.4Ah=451Wh

For New cell:

- **at same capacity,**

Volume/weight reduce 40%

- **At same volume/weight,**

Capacity increase 20%

Standard Battery-Energy Tube

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ENERGY TUBE

The battery of the future

- Universally applicable
- Modularly scalable
- Robust
- Reliable
- Secure
- Connected
- Reasonably priced

Standard cell: 18650
Standard battery: Energy Tube

Energy Tube-Ready to Use Energy

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EnergyTube

100 Wh capacity
no dangerous good
Equivalent to a notebook battery

70 mm diameter
180 mm length
ca. 800 g weight, dependent on cell type

Output voltage to the application is configured by the adapter.

Energy Tube: Digital and smart interface, ready to use energy

Energy Tube-Energy Solutions

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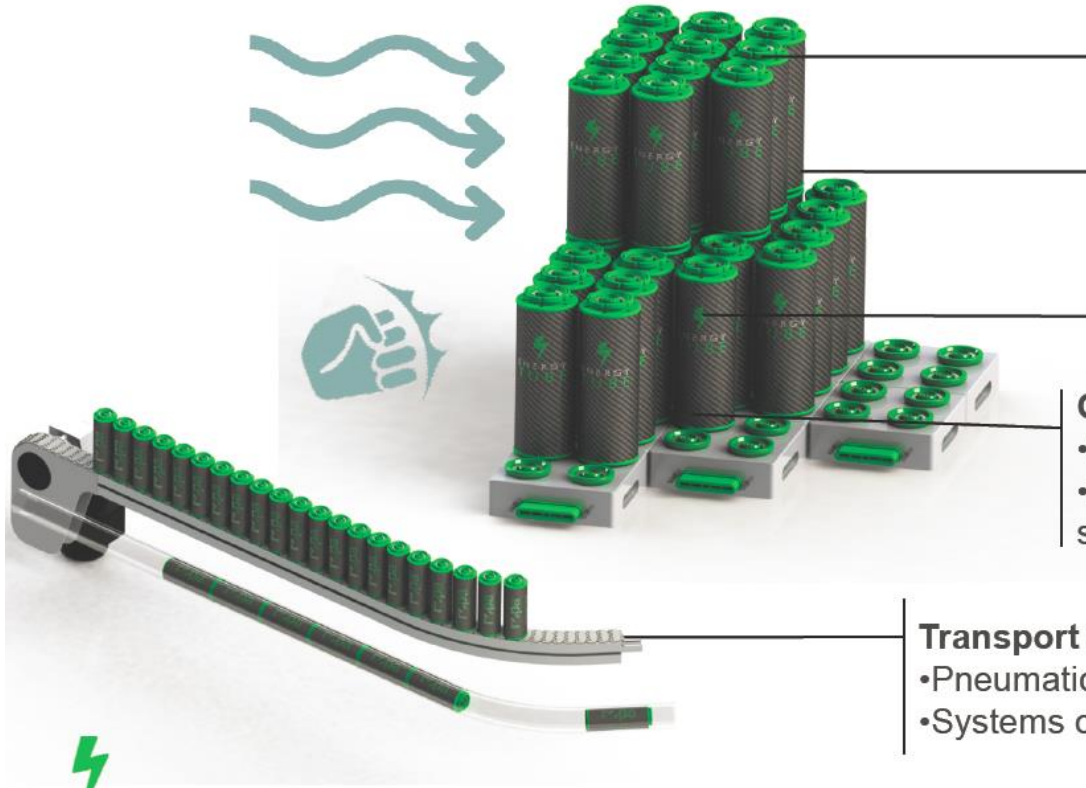
EnergyTube Advantages of the cylindrical modular structure



Distance prevents **overheating and flammability**

Large surface for **thermal dissipation**

Space for active and passive **air conditioning**

Crash behaviour:
- Crumbles into single parts
- Individual modules are mechanically stable

Transport systems and handling systems
- Pneumatic delivery and conveyer
- Systems of the beverage industry

ENERGY TUBE

Energy Tube-Facts

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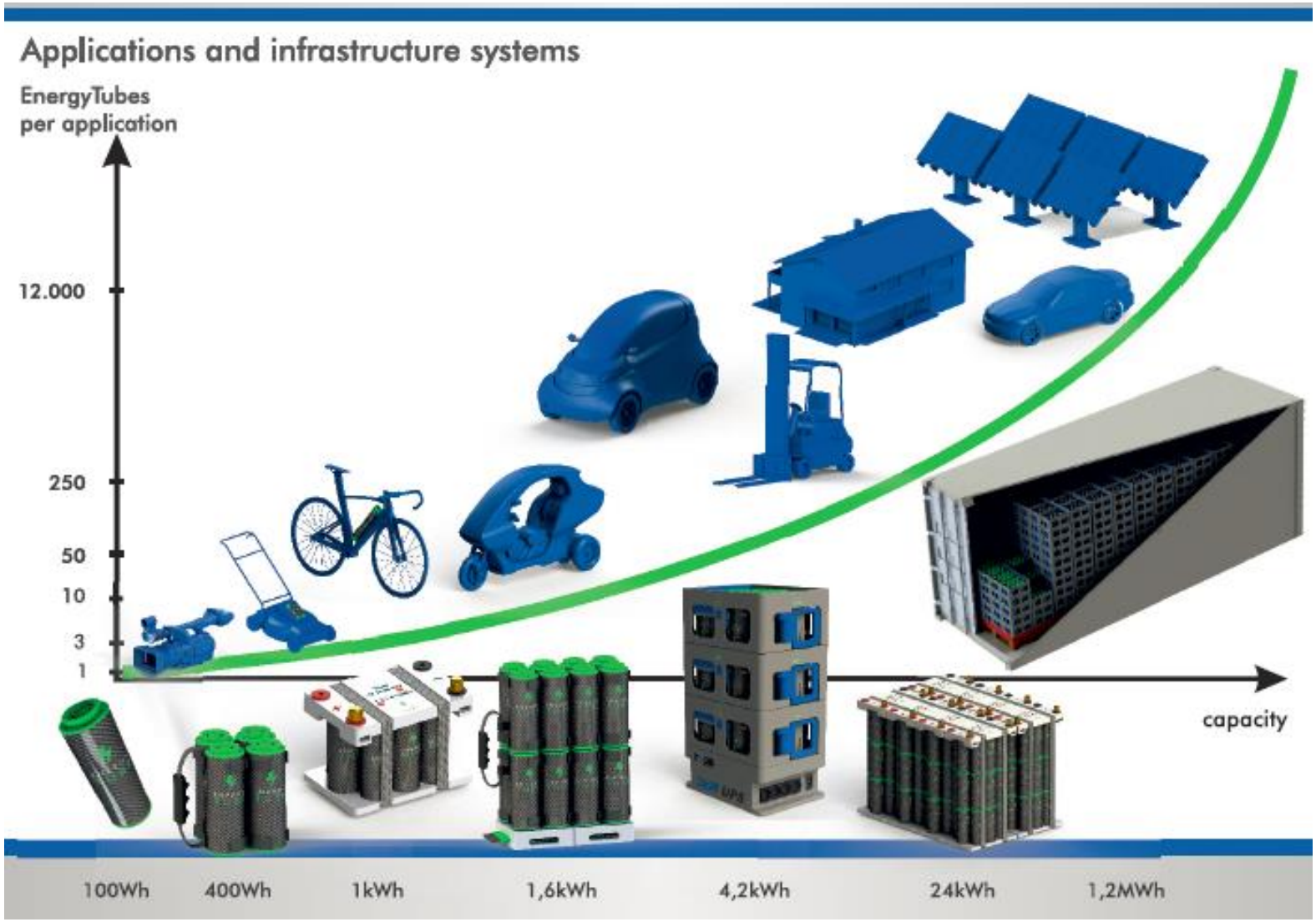
EnergyTube distinctive features

flexible	scalable without limits starting from 100Wh selection of the dimensions by the user → plug and play
secure	compensation in case of an error through distribution into multiple small cells, no dangerous good < 100 Wh! No high-voltage 48 V!
reliable	individual tubes can be turned on and off and repaired, combination of old and new batteries and different chemicals can be used
optimum price	automated mass production price structure: 80 % battery cells / 20 % packing and intelligence
standardized	one standard for many applications, suitable for a big part of the battery market
connected	The EnergyTube CloudService allows: Swapping and rental systems, remote diagnostics, measurable database, energy management, user management

Energy Tube-Applications



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謝謝 Thank you

TD HiTech Energy Inc.
3F No. 25 R&D Road 2
Science-Based Industrial Park,
Hsinchu City 30076, Taiwan
mh.yang@htenergy.com.tw
Tel +886-3-666-7959
Fax +886-3-579-8255