HUTCHINSON SAFECAP ™:
Ionic Liquids Supercapacitor

SPCD Conference
2016/10/12

We make it *possible*

M.Zimmermann,
Energy Lab

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HUTCHINSON, Key Figures at a Glance

35,213 employees | 96 sites | 23 countries

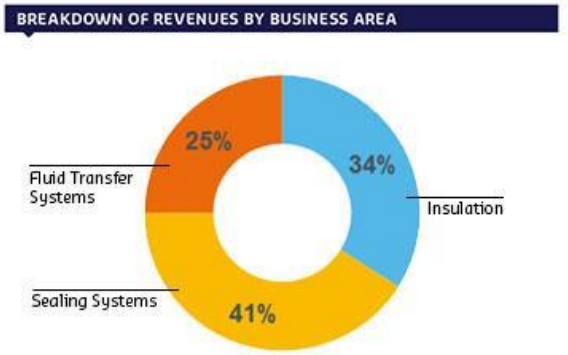
TURNOVER **3 462 M€**

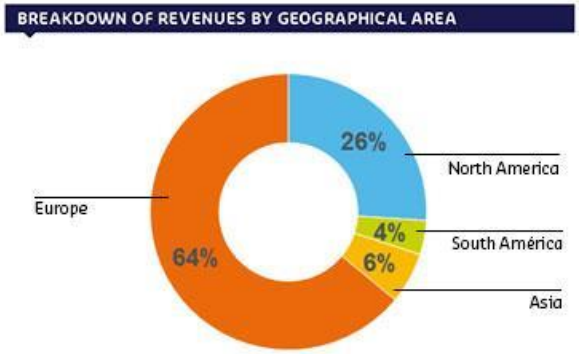
INVESTMENTS **109 M€**

RESEARCH SPENDING **171 M€**

key figures for the Financial year ended December 31, 2014

5% of revenues invested in R&D





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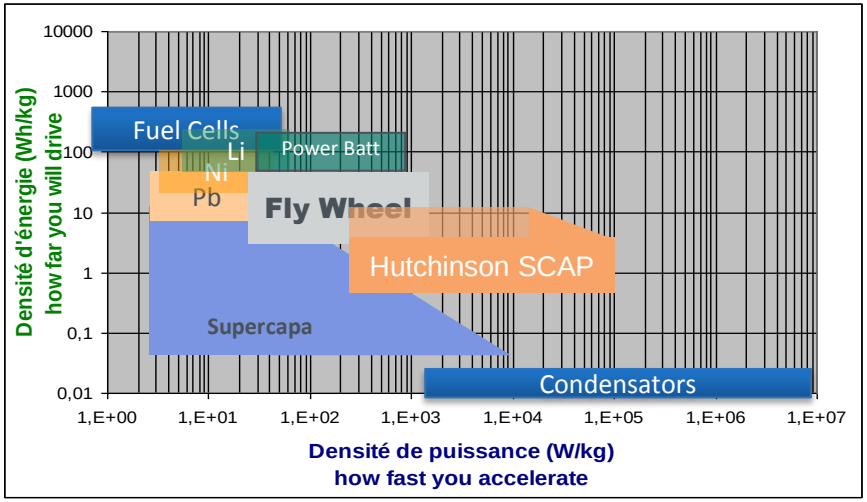
HUTCHINSON : THE RESEARCH CENTER

- **A corporate Research Center (300 people) developing its search for excellence** in 3 major areas (materials, manufacturing processes and systems) and focusing on the major industrial challenges of the Group's markets:
  - product weight saving,
  - energy management,
  - mechatronics,
  - materials,
  - comfort and safety

- **The Energy Lab (35 people)** is working on the development of materials devoted to energy storage, harvesting and conversion

Power / Energy compromise

➢ **Performances : Ragone Plot:**



SCAP = transient energy storage

- Power
- Cyclability

➢ **3 very different markets :**

- ✓ Automotive
  (fast growing, high capacitance, mid voltage, key drivers= performances, reliability)
- ✓ Public transportation
  (fast growing, high capacitance, high voltage, key drivers= performances, reliability)
- ✓ Electronics
  (mature, 97% Asia, low capacitance, low voltage, key driver= cost & mass production)

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Safety concerns with acetonitrile based Ucap

The common electrolyte used in supercapacitors: acetonitrile

Safety datasheet

- **Acetonitrile** = Deleterious substance, irritant, toxic, and flammable

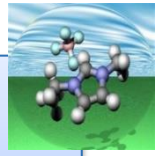
What does acetonitrile become in case of high temperature?

In the combustion of acetonitrile, **HCN is formed by pyrolysis reactions** and is consumed by oxidation reactions. The distribution of products, such as HCN, NO, N_2O, N_2, CO, and CO_2, depends on the acetonitrile/oxygen ratio. Because most fires tend to be oxygen deficient, there is a potential for HCN release from the combustion of CH3CN. The temperature and residence time control the extent of decomposition of acetonitrile and efficiency of HCN formation.

Hydrogen Cyanide (HCN) : extremely poisonous, almond-like odor

SAFECAP™:

SAFE AND PERFORMANT ELECTROLYTE

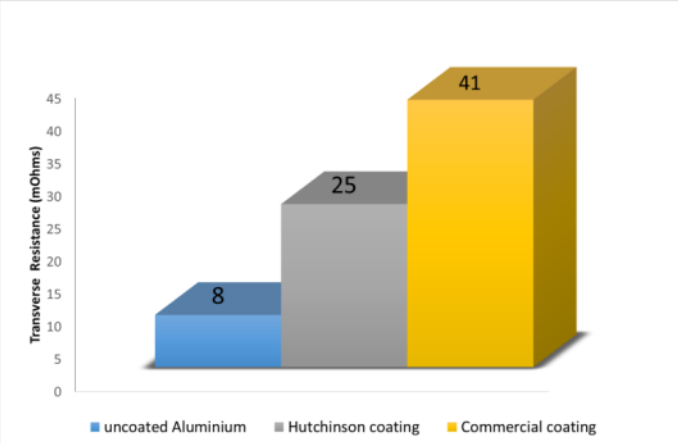


IONIC LIQUID

- Extremely low Vapor Pressure
- Higher Unom
- Higher SPECIFIC ENERGY
- Non toxic
- Not flammable
- Higher boiling point
- Greater SAFETY
- Extended operating temperature

HUTCHINSON SAFECAP: The technology

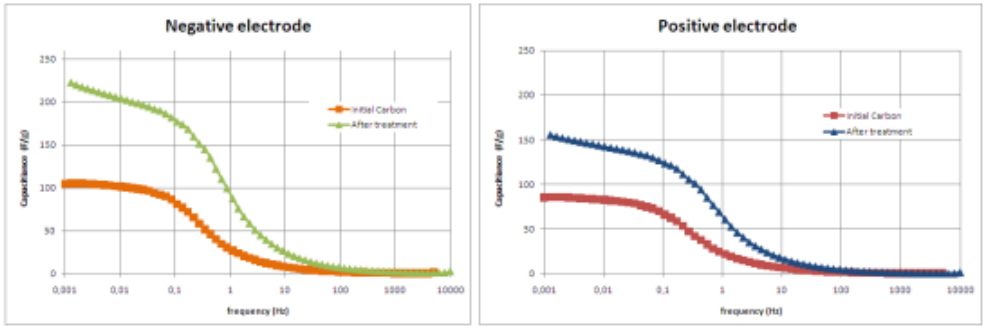
- Development of:
  - **Corrosion protective coating** to protect Al current collectors (1 patent, 2 pending)
    - Good interface with current collector (reduced ESR)
    - Good adhesion to current collector and active material



  - **Tuned electrode formulation** (1 patent filed)
    - Adapted to our carbon – water based (green process)

HUTCHINSON SAFECAP: The technology

- Development of:
  - **Specific carbon** (2 patents)
    - Tuned porosity, control of the pores size distribution , well adapted to the electrolyte (both Aqueous & Ils)
    - Pseudocapacitive behavior (+100% C after treatment on C^- and C^+)



EIS spectra in aqueous electrolyte

ILs SAFECAP: Performances tensions *vs* températures

	Regular supercap	HUT3,2 en dvp	HUT2,9	HUT2,5
C range (F)	150	135	145 F → 291 F	145 F → 291 F
Rated voltage (V)	**2,7** / 2,3	3,2	**2,9**	2,5
Operating T°C	-40°C /65°C / **70 °C**	-40°C / 120°C	-30°C / 65°C	-30 °C / **90°C**
ESR (DC mOhms)	14 mohms	3,8 mOhms		
E available (Wh)	152 mWh	192 mWh	340 mWh	126 mWh
Specific Energy (Wh/kg)	4,7	5,3	**8,7 → 10**	**6,5 → 7,3**
Specific Energy (Wh/L)	4,6	4,6	9,0 → 9,5	6,7 → 7,1
Specific Power (kW/kg)	4,1 kW/kg	5 kW/kg		
Dimensions	30 x 23 x 4,8 mm		80 x 146 x 4,5 mm	

T°C max = 70°C

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Peformances SafeCap ILs:

CYCLING & CALENDAR AGEING

AIRBUS DEFENCE & SPACE

Reminder:
Vop= 3,2V
0,9.Vop = 2,88V

Ref:> 10 000 h

Calendar test type	Number of hours	Capacity loss	ESR raise
0.5.Vop at Tamb	4000	25%	150%
0.9.Vop at Tamb	2000	45%	150%
Vop at Tamb	2000	75%	400%
0.75.Vop at 60°C	2000	40%	150%
0.75.Vop at 80°C	1000	67%	400%

On going

Ref:> 300 000 C

Cycling test type	Number of cycles	Capacity loss	ESR raise
100 % energy at Vop	1 million	44%	300%
75 % energy at Vop	4 million	60%	450%
75 % energy at Vop	1 million	40%	170%
75 % energy at 0.9.Vop	1 million	20%	75%

Improve the sealing parameters (on going)

- ✓ Feasibility is proven
- ✓ Specific energy is increased compared to aqueous (x4)

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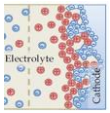
Advantages of SAFECAP™ vs. competitors

CONCEPT: Combining high potential and high capacity

Energy: $E = \frac{1}{2} C.U^2$

- Use of Ionic Liquids (ILs) as electrolyte (High ESW)
- Tuned carbon porosity to best fit to ions size



SAFETY, TOXICITY

- **Non toxic** system (no solvent)
- **Safe** system (not flammable, even non volatile with ILs)

Acetonitrile = Deleterious substance, irritant, toxic, and flammable

PERFORMANCES

- Extended **temperature range [-40 - 120°C]**
- **Higher specific energy**
- Cycle life and calendar ageing

HUT develops the **whole value chain** from carbon synthesis to cell, even module assembly

- Capacitance can be adapted to customers specifications
- Dedicated module packaging with lightweight materials based on HUT knowhow

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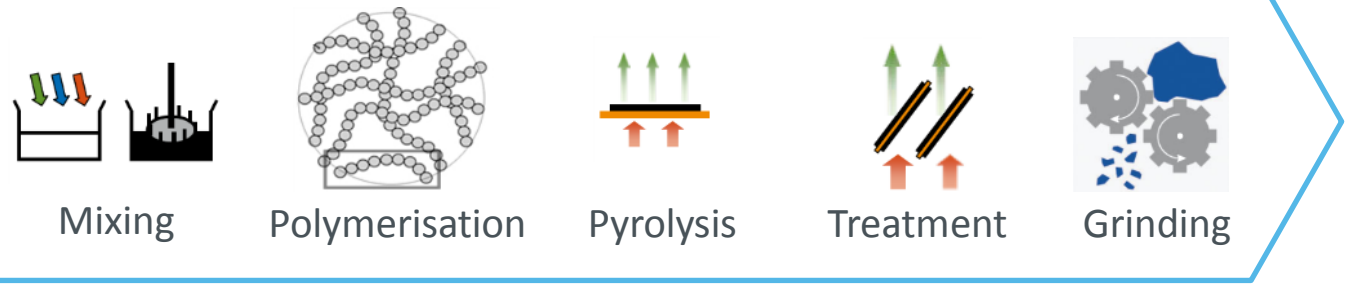
HUTCHINSON SAFECAP: Pilot Line

- Development of:
  - **Specific carbon** (2 patents)
    - Tuned porosity, control of the pores size distribution , well adapted to the electrolyte

Carbon Production



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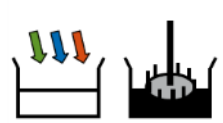
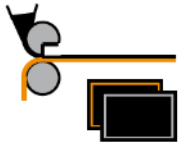
HUTCHINSON SAFECAP: Pilote Line

- Formulation designed to allow both low (power oriented) and very high (energy oriented) thicknesses

Electrode Coating

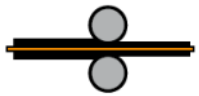


Mixing/Grinding

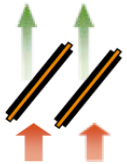


Coating

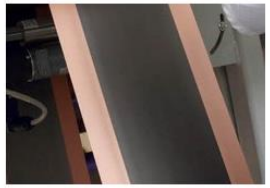
Drying



Calendering



Thermal treatment



Coating thickness : 50-200 µm

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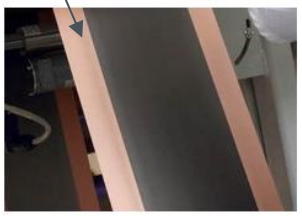
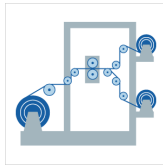
SAFECAP: Design

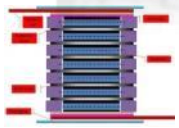
Cu, Al



Coating thickness : 50-200 µm

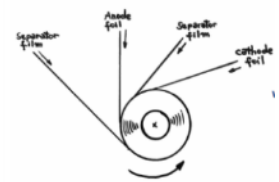
Scap Assembly





Cutting/stacking

Prismatic & pouch cell



rolling

Jelly roll cell (in development)

Pilot line capacity :

- **50 000 jelly roll cells / year**
- **200 000 pouch cells / year**

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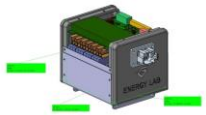
APPLICATIONS (1/2)

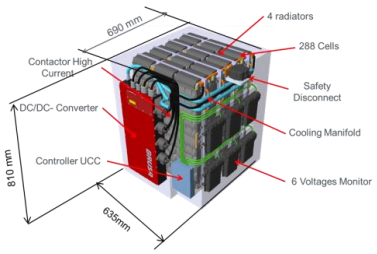
Electric bike



- Dual Energy Storage (Battery + Scap) :
  - Improve power for climbing and starting the bike.
  - Increase lifetime of the battery, or could allow to downsize the battery with the same lifetime
- 100% Scap Energy storage for 3-wheelers:
  - Allow fast charge of the energy storage system (in few minutes)
  - Maintenance free
  - 8Wh pack (1km autonomy)

Hybrid Truck

- Hutchinson was involved in a FP7 project (CONVENIENT)
- Dual Energy Storage system
  - 500Wh pack (60kW for 30s – 650V)
  - Definition of the electronic part (UCC + DC/DC)
  - Increase breaking energy recovery
  - Increase lifetime of the battery



Hybrid Truck pack during testing

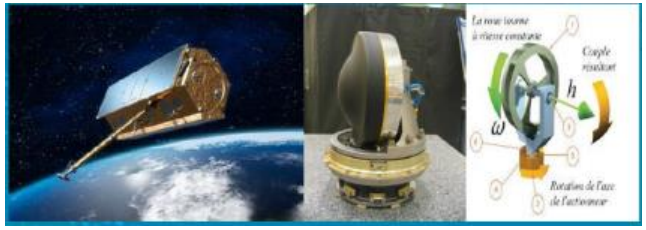
For such a pack, the amount of electrolyte would be **roughly 30L!**

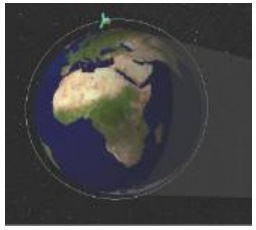
SAFETY?

APPLICATIONS (2/2)

SATELLITES /LAUNCHERS

- Pulse and/or High power application in aerospace (Telecommunication and Observation satellites)
  - Power filtering for actuators : 2 000 000 cycles
  - Radar : 400 000 to 1 100 000 cycles
  - Power bus filtering : continuously





Actuators for satellites
radar
Network voltage stabilization

- Increase electrification in launchers, increase power demand
  - Need of supercapacitors for
    - pyrotechnics applications (40Wh – 1,5kW)
    - Thrust vector applications (>100Wh - >10kW)

Conclusion

- New technology developed based on ionic liquid electrolyte for improved **SAFETY** and **ENERGY**

- Hutchinson has the capacity to **adapt each subcomponent** to provide the **optimal product** for specific applications

- **Pouch cells design is validated (> millions cycles)**
  - Specific for **small packs**
  - For Niche markets : **aerospace, sensors, consumer goods …**

Thank You
FOR YOUR ATTENTION

We make it ***possible***

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