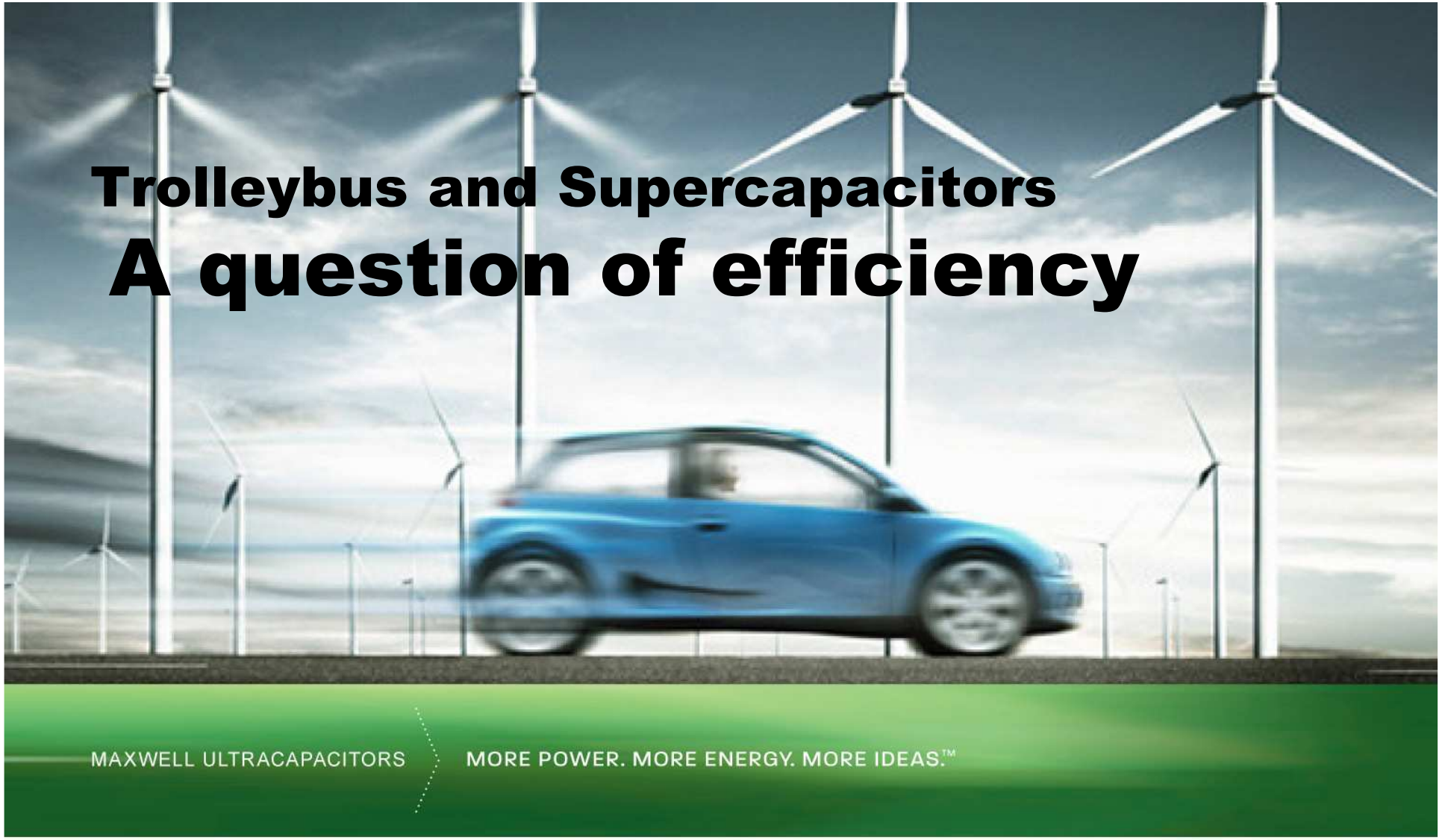
Trolleybus and Supercapacitors
A question of efficiency



Promoting electric public transport

Trolley

Maxwell TECHNOLOGIES

History

2010 First application in automotive sector

2007 Production in China

2005 Maxwell becomes supplier of proprietary Electrode

2005 Automated production in Rossens

2004 Maxwell produces own, proprietary Electrode

2003 Fusion of Maxwell and Montena

Market launch of first products 2001

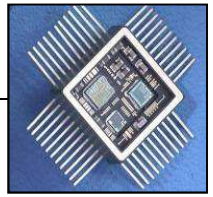
Start development of Ultracaps 1997

- 1995 Market launch of first products
- 1992 Start development of Ultracaps
- 1965 Foundation of Maxwell Laboratories

Foundation of Condensateurs Fribourg 1903

Company Products

Maxwell Technologies Inc., San Diego



Microelectronics

Ultracapacitors

Maxwell Technologies SA, Rossens

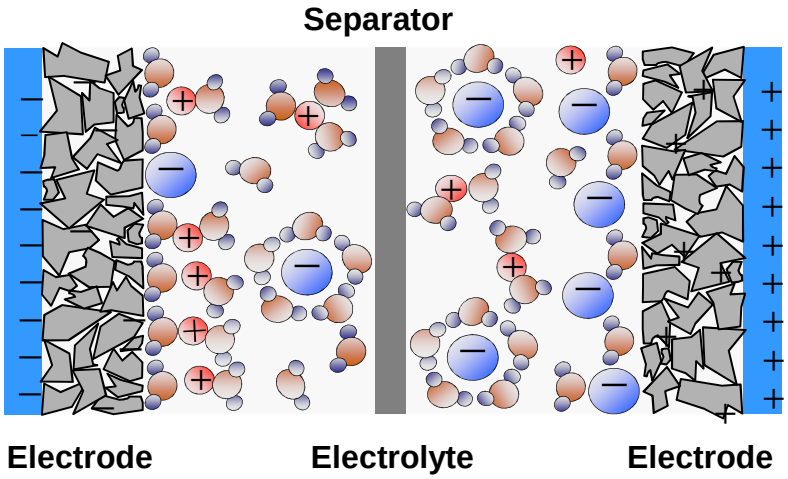
High Voltage

Ultracapacitors

What is a supercapacitor?

Ultracapacitor technology

Grind / Activation /Coating / Rolling / kneading / Pasting



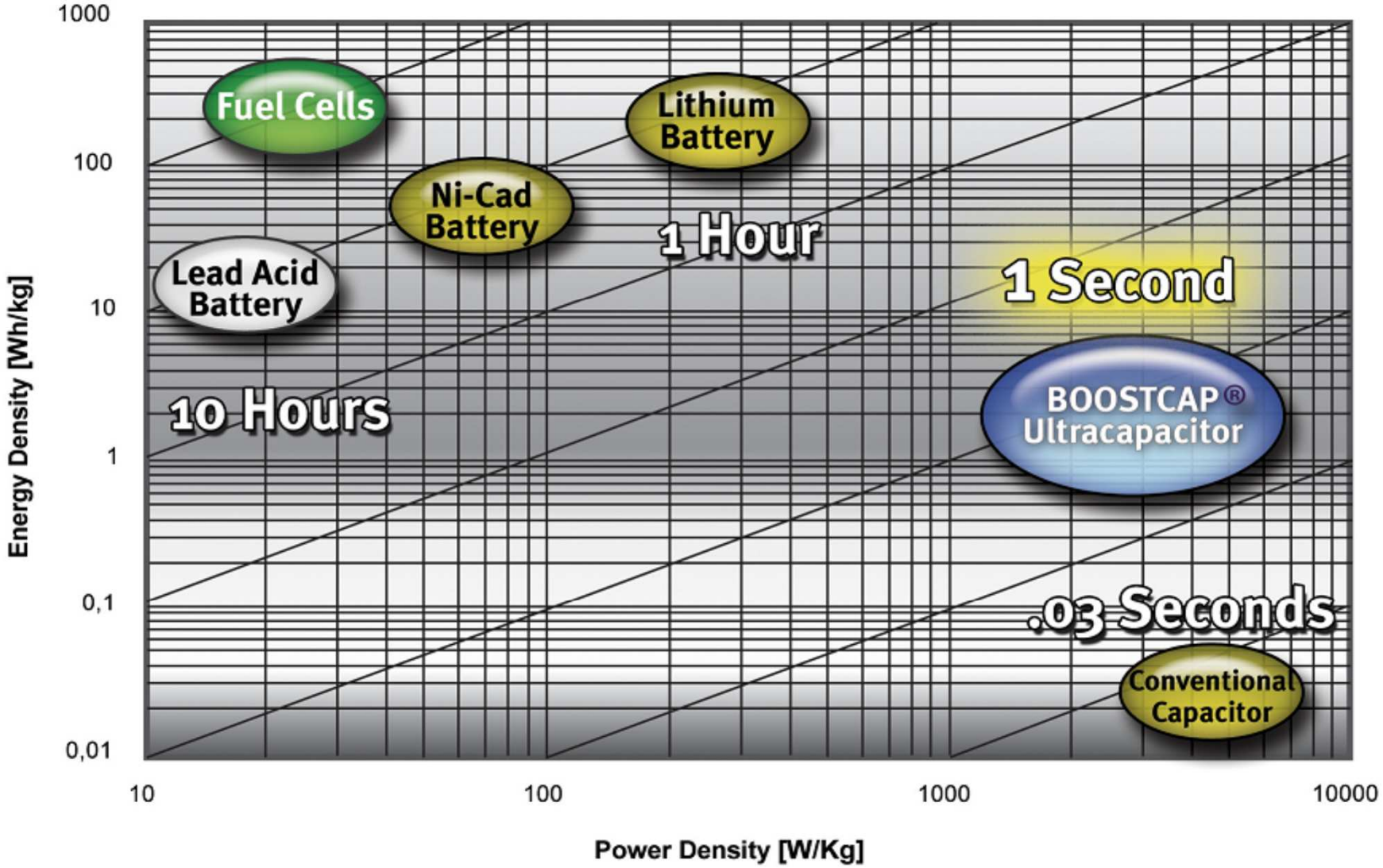
$$\text{Capacitance} \sim \frac{\text{Surface area}}{\text{Thickness}}$$

Thickness of Helmholz layer ~ 1nm

Carbon powder surface area
up to 3,000m^2/g

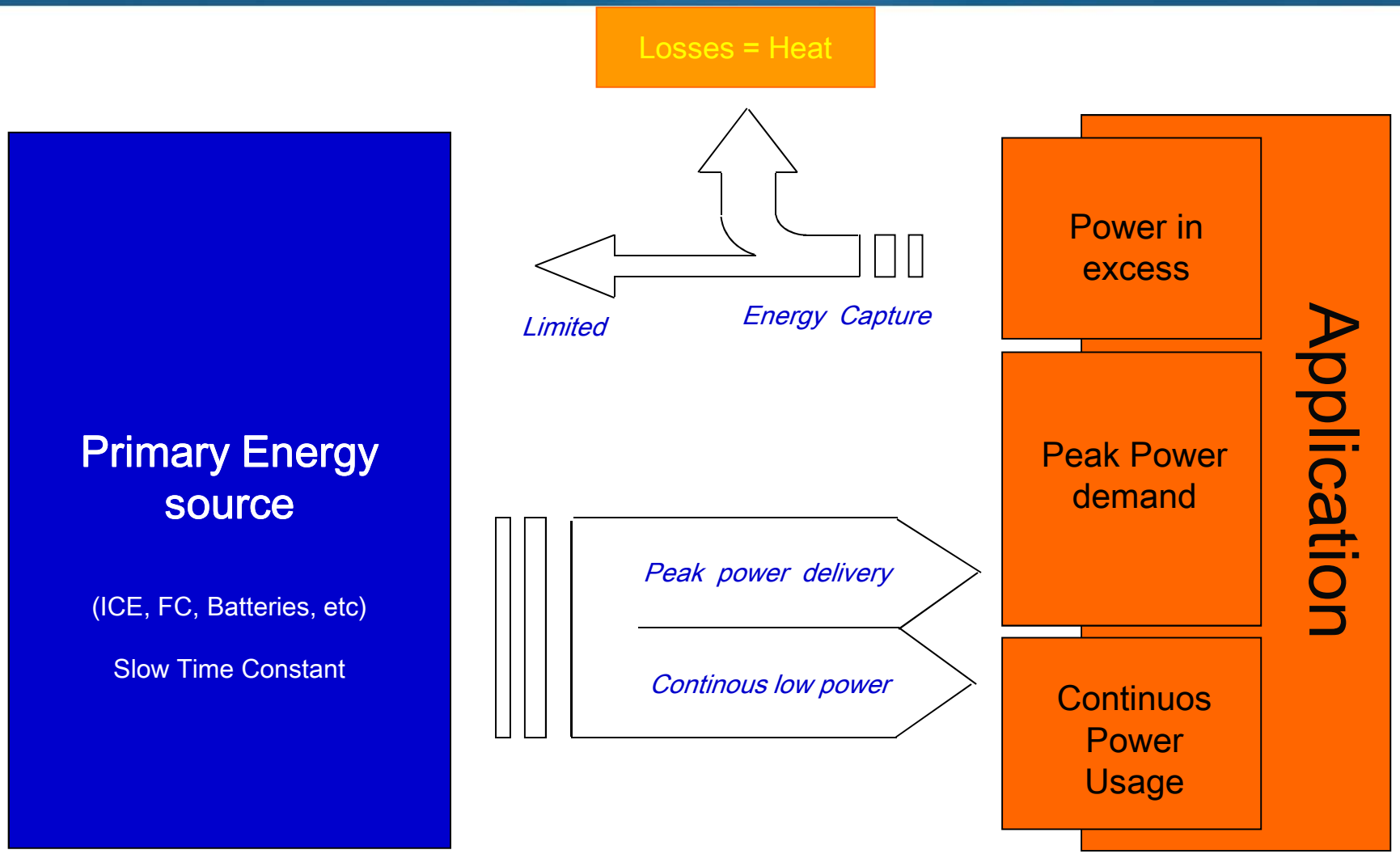
Capacitors up to 3,000F

Ultracapacitor vs. Battery

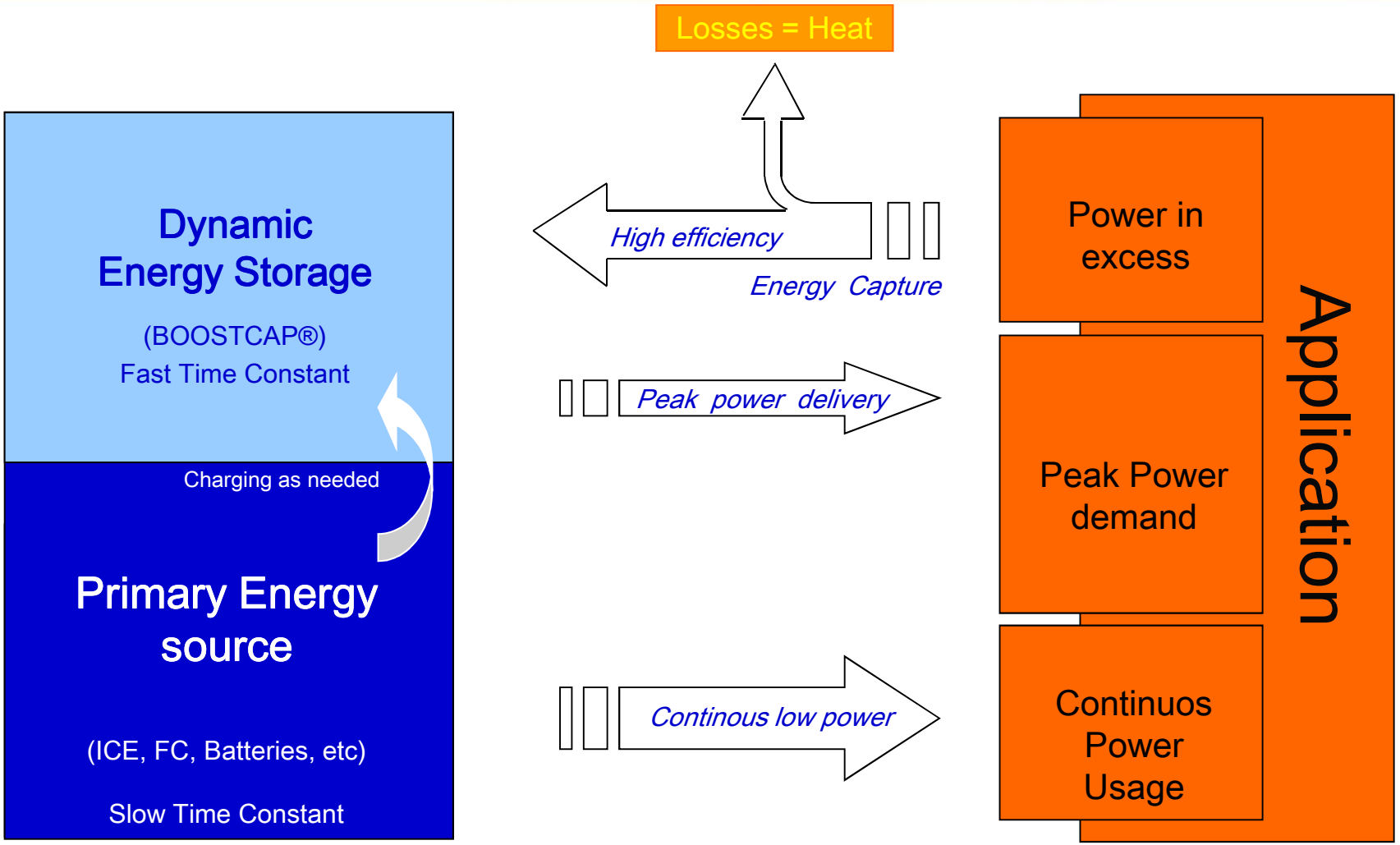


Why using supercapacitors?

Application Model (without BOOSTCAP®)



Application Model (with BOOSTCAP®)



Energy vs. Power: illustration

Locomotive Diesel Engine Cranking

Battery compartment with lead batteries.

Total weight more than 300 kg

Battery compartment with Uc's module

Total weight less than 30 kg

Our product range…

Standard Cells & Modules

PC/HC Line
2F to 150F

BC Line
310F and 350F

K2 Line 650F to 3000F

BC based 16 V Module

K2 based
16V Modules

K2 based
48V Modules

K2 based Wind Mills
75V Modules

K2 based
125V Heavy Transportation Module

… and their applications

Applications

Hybrid Bus

LRV

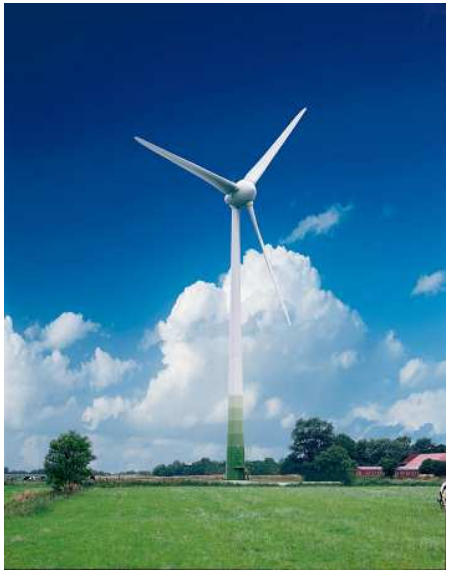
Diesel starter

Door opening assistance

Applications

Straddle carrier

Windmills



UPS Systems

A.M.R.

Trolleybus

A common history

Von Siemens (1882)

Von Helmholtz (1879)

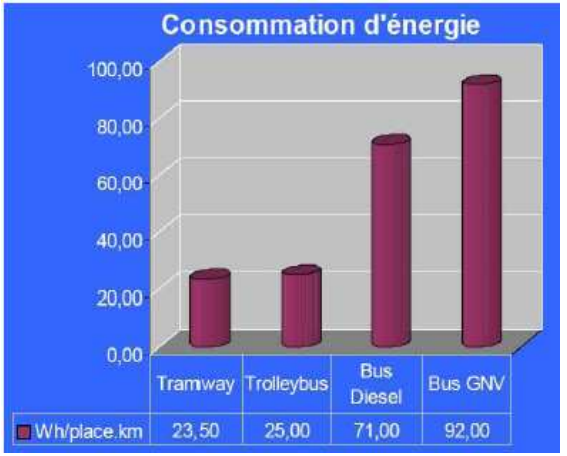
Van Hool / Vossloh Kiepe / Maxwell (2008)

Trolleybus challenges

Trolleybus efficiency is not to prove, but end-users still face challenges

- Control of energy flux within a delimited electrical network
  => Grid stabilisation

- Mitigation of visual impact and autonomous vehicle
  =>Overhead line free run



Source: EDF

Grid stabilisation

Recuperating 80% of the kinetic energy of a 15 tons bus running at 20km/h (average city bus speed), represents the energy and power necessary to lift a piano of 200kg to the top of a 30 floor building within a few seconds!

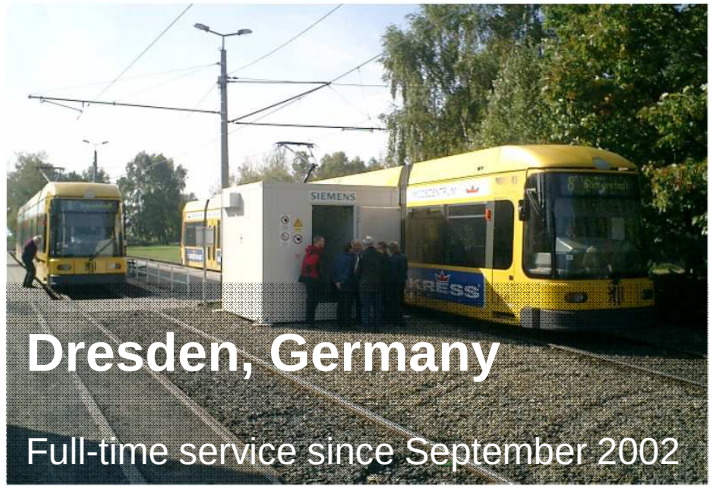
Peaks due to absorption or restitution of the kinetic energy introduce instability in the voltage grid.

To reduce or avoid those, the energy must be transferred rapidly. It can be either burnt (looses) or recuperated and reused in energy storage.

SITRAS® Installation Examples

Substation solution from Siemens (Sitras, in function since 2003) for trams shows following reductions:

- Energy consumption up to 30%
- Peak power demand up to 50%

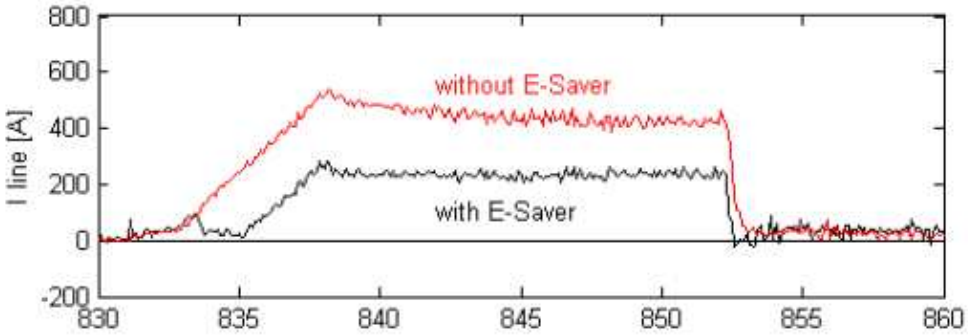


Other advantages

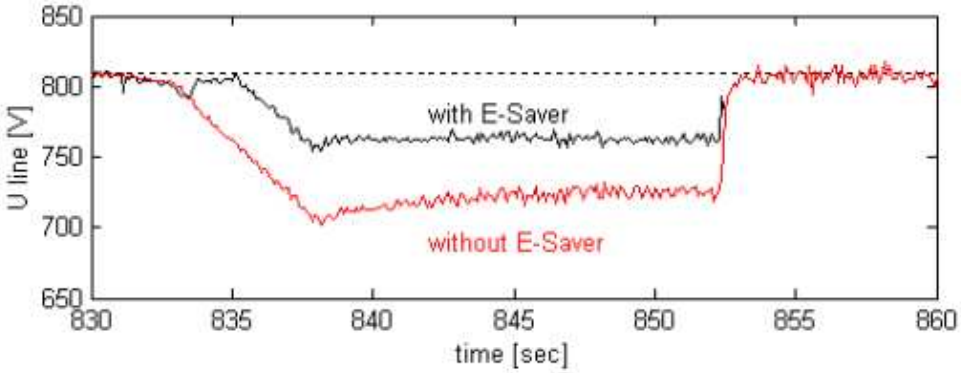
- More trains in the same network
- Less sub-station (factor 1.7)

MVV Light Rail Vehicle with MITRAC

Drastic reduction of line power demand possible



Drastic reduction of line voltage drop



Advantages: On new lines, less substations
On existing lines, more vehicles

Source: Bombardier Transportation

Overhead lines free run

- mitigation of overhead lines and switches visual impact
- temporary re-routing

Example: the HESS 24m vehicle can ride up to **500m** on supercaps, without prior optimization of range of mode!

HTM125 Features and Benefits

More than one million charge/discharge cycles

- Long life of the module that reduces down time and total cost of ownership

IP65 compliance, high grade components

- Dust and splash proof, resistance to harsh conditions
- Designed and tested for SAE J1455, J2380, EN61373, ISO16750

Uncompromised safety

- Designed and tested for **4000VAC** isolation voltage
- Junction box preventing accidental contact with power elements

Today applications…

AUTROLIS, retrofit powered by Institute Elektrotechniki Warsaw

Film…

Application in Europe

VEHICLES	TOTAL PLACES	LENGTH [m]	TARE WEIGHT [kg]	TARE ENERGY CONSUMPTION [kWh/km]	FULL LOAD ENERGY CONSUMPTION [kWh/km]
SOCIMI 8820 (901-970)	100	1			
SOCIMI 8843 (100-132)	156	1			
BREDABUS F04 (200-232)	152	1			
CAM Busotto (300-308)	134	1			
Irisbus Cristalis (400-409)	132	18	20.400	3,98	5,73
Van Hool AG300T (with Supercapacitors)	152	18	19.700	2,64	4,02

VAN HOOL powered by Vossloh Kiepe for the city of Mailand, Italy

ATM
AZIENDA TRASPORTI MILANESI S.p.A.

Application in Europe

SOLARIS trolleybus powered by Cegelec for the city of Eberswalde, Germany

BREDAMENARINIBUS trolleybus powered by Skoda Electric for the city of Roma, Italy

… and tomorrow!

Tomorrow: the BoostBus

=> Run on supercaps
=> Range of ~2km
=> Recharge at station
=> Recharge time of 10-15sec
=> no dangerous material
=> High demand, little offer

Heuliez by PVI for Veolia (project WATT)

Děkuji!