



ELECTRILABS

 (Pty) Ltd

Sodium Nickel Batteries



- + 2006 FIAMM select the sodium-nickel technology as the storage system for 'mission critical' applications.
- + 2006-2009 FIAMM internal development of sodium technology with prototype validation and is ready for pilot line production. 2009: talks with MES-DEA start.
- + Jan 2010: FIAMM setup a new company **FZSO|NICK** in partnership with MES-DEA
- + May 2011: FIAMM buys 100% of FZ Sonick.
- + MES-DEA has been producing sodium-nickel batteries since 2000.
- + FZ Sonick is located in Switzerland (Stabio) in a 20,000 sq.mt. plant and 200 employees. Current mfg capacity is 85 MWh with a three-year plan to increase to 170 MWh, maximum capacity is 300 MWh.



FIAMM Sodium Nickel Batteries / Key Benefits

- + **Temperature Immunity:**
constant performances and lifetime over a wide temperature range -40 to +60°C in operation
- + **High performances under heavy cycling applications:** > 3.000 cycles at 80% DoD
- + **Advantageous total cost of ownership (TCO) over the years**
- + **Green Technology** (no lead and other harmful additives associated with i.e. NiCad)



FIAMM Sodium Nickel Batteries / Key Benefits

- + Installation & maintenance benefits:
 - + The module are **IP55**, possibility to save on cabinet design.
 - + Insensitive to the temperature (between **-40° to +60° C**), simplify air cooling solutions.
 - + Long shelf life without maintenance (**no self discharge**).
 - + Remote **monitoring included**.
 - + **Space saving**.
 - + **Reduced weight**:
 - Easier transportation
 - New installation design



FIAMM Sodium Nickel Batteries / Environment

+ Low environmental impact:

- **Zero ambient emissions**
- **Free of toxic materials**
- **100% recyclable** stainless steel, nickel, iron, salt, ceramic
- **Battery external temperature only a few degrees above environment.**



INMETCO®
AN Inco COMPANY

December 03, 1998

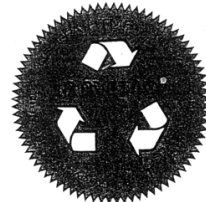
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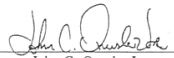
Certificate of Waste Material Recycling


Whereas, The International Metals Reclamation Company, Inc. (INMETCO) operates a hazardous/non-hazardous waste reclamation facility under the rules of the Pennsylvania Department of Environmental Resources and the U.S. EPA (ID No. PAD087561015).

Now, therefore, INMETCO does hereby issue this certificate to GEP mbH to evidence the consumption of Sodium Ni Chloride, Dry (Zebra), PAE8269796 on Sales Order Number 104722 received on 6/04/98.

Said Consumption has been completed on or about 11/30/98, in a manner consistent with acceptable engineering standards and in compliance with applicable rules and regulations set forth by the State of Pennsylvania and Federal authorities.




John C. Onuska Jr.
Manager, Environment Health and Safety


William J. Koshut
Plant Superintendent

Questions, corrections or comments on this document should be directed to INMETCO Marketing and Sales
P.O. Box 720 • 245 Portersville Road • Elwood City, PA 16117 • (Phone) 724-759-2900

FIAMM SoNick Battery / Safety Evaluation

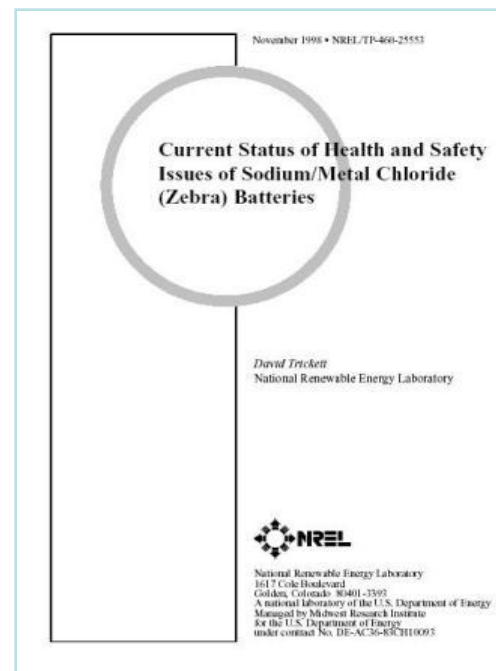
- + Sodium-Metal Chloride battery achieved **NEBS certification**.

Relevant tests passed:

- Temperature and heat dissipation
- Fire resistance
- Short circuiting
- Electro Magnetic Interference



- + a detailed evaluation of the Health and Safety Issues of the Sodium-Metal Chloride battery, performed by the National Renewable Energy Laboratory – US Department of Energy, is available.



FIAMM Sodium Nickel Batteries / Chemistry

+ Active materials

- discharged state: sodium chloride and metal powders (mainly nickel)
- charged state: sodium and metal chlorides



+ Operating temperature of the cell: 250°C to 350°C

+ Electrolyte: solid state β''alumina and molten state sodium tetra chloro aluminate (NaAlCl₄) catolyte

FIAMM Sodium Nickel Batteries / Chemistry



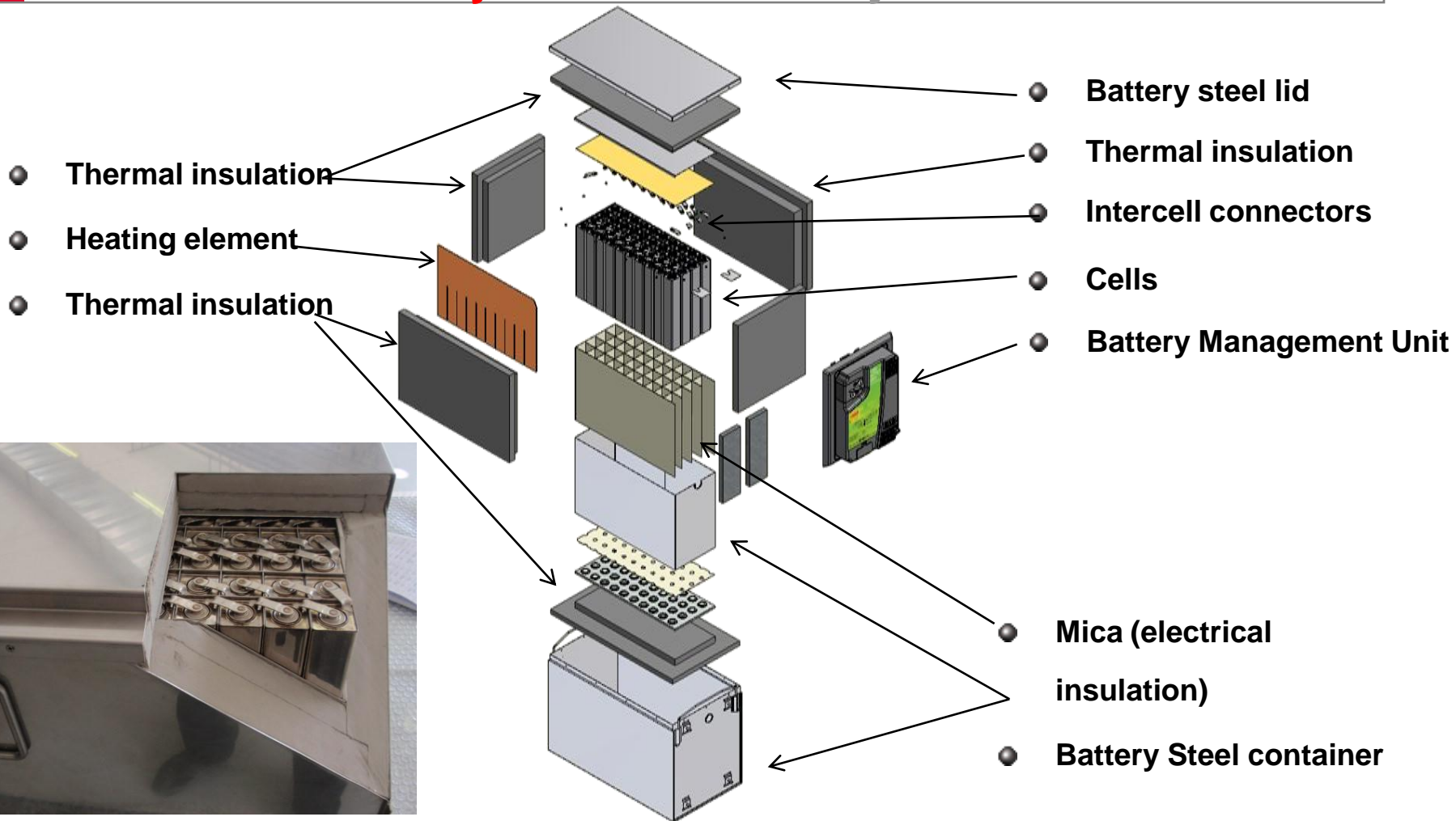
FIAMM Sodium Nickel Batteries / Cell characteristics

- + Voltage: 2.20-2.70 Volt (2.58 V on open circuit)
- + Capacity: 40 Ah
- + Dimensions: 36 x 36 x 220 H mm
- + Weight: 695 g
- + Specific Energy : 140 Wh/kg (Pb 25-35 Wh/kg)
- + Specific Energy : 280 Wh/l (Pb 70-100 Wh/l)



***Note:** the volumetric specific energy of the assembled battery is significantly lower,
due to the presence of the thermal insulation and the integrated battery management system*

FIAMM SoNick Battery / Inside the Battery

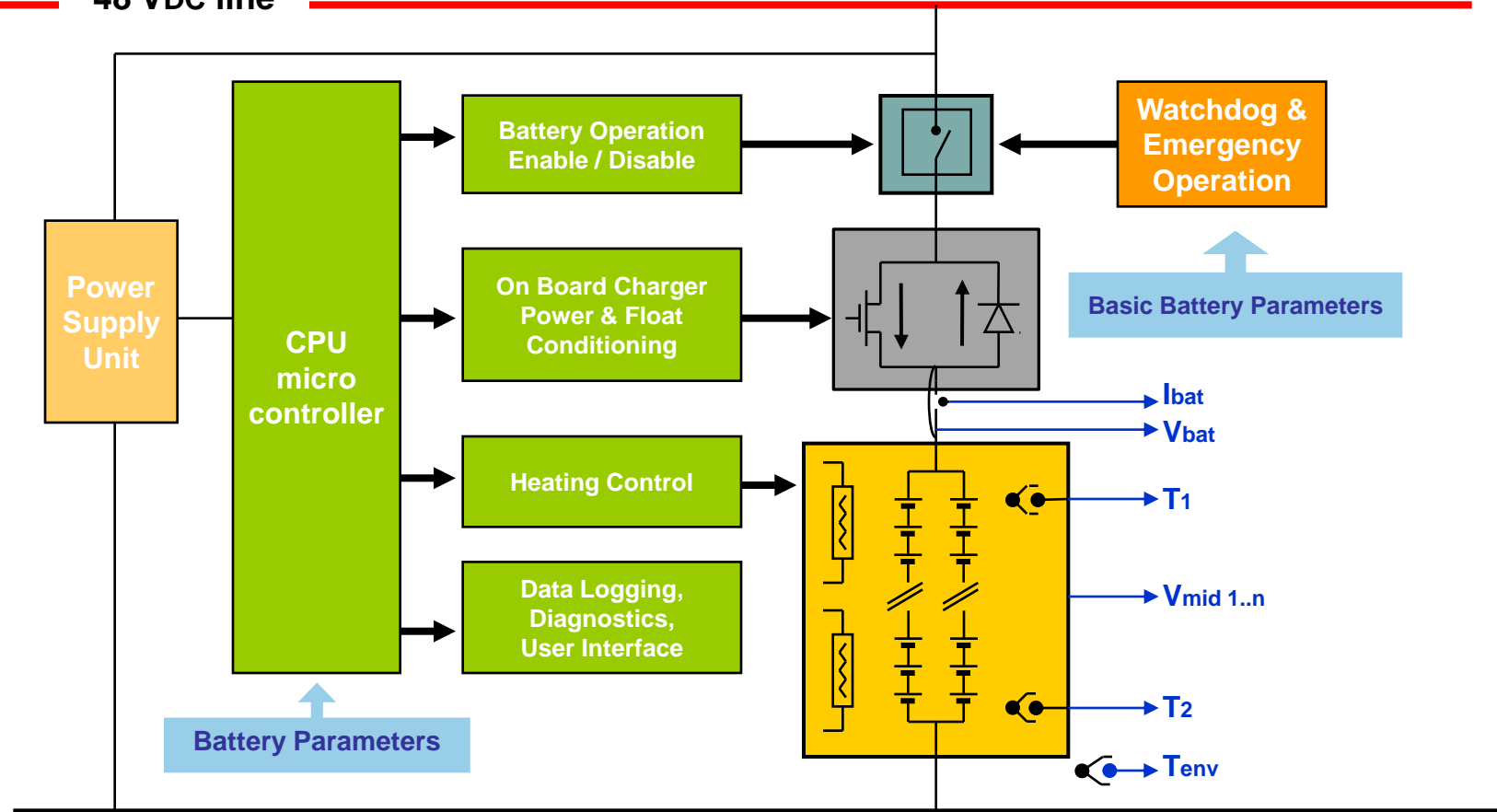


FIAMM Sodium Nickel Batteries / BMS

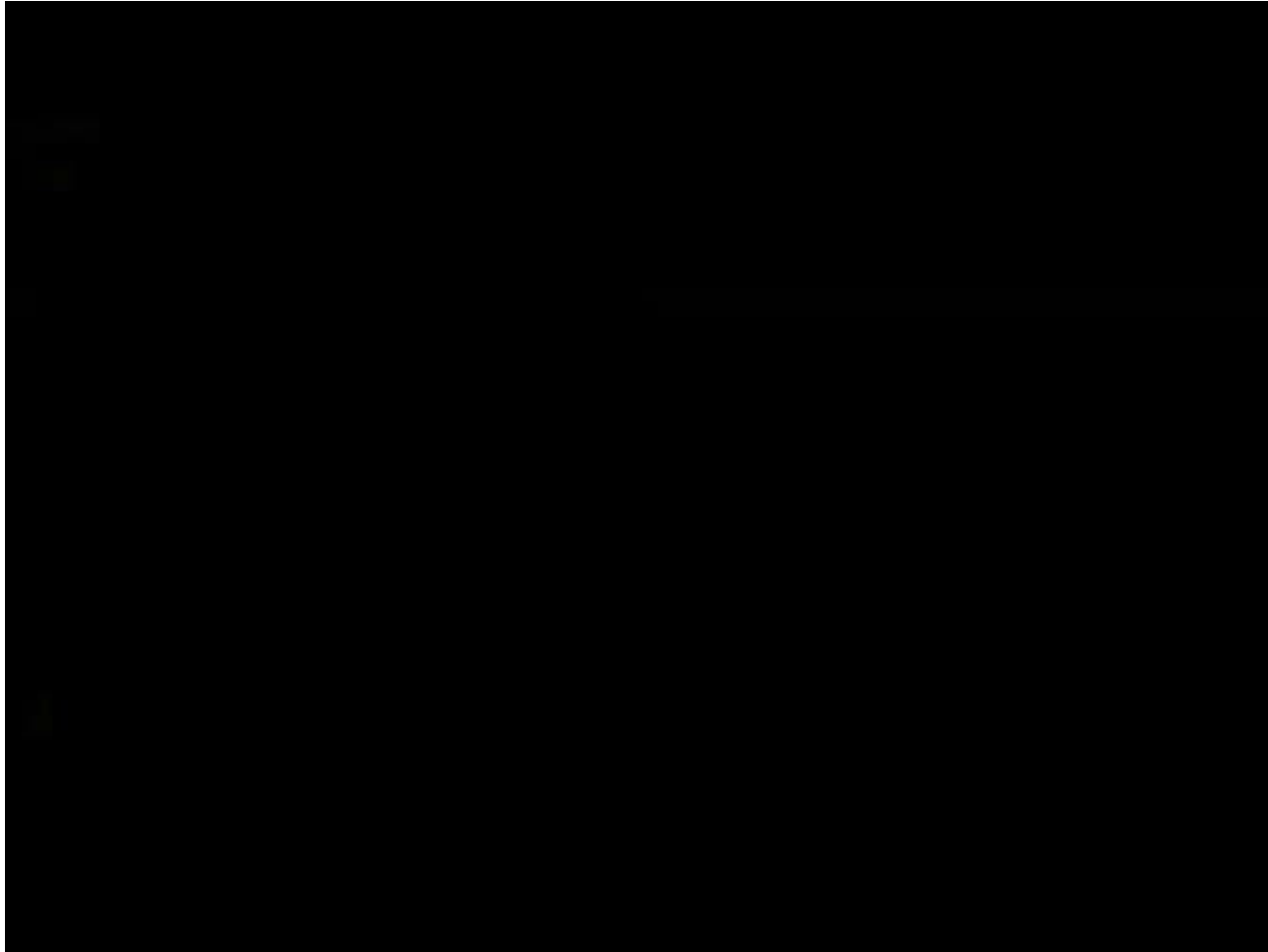
- + Integrated Battery Management System (BMS)**
for monitoring, diagnostics and logging - redundant watchdog
- + Battery operation enable/disable**
- + Battery heating management**
- + Conditioning of power on charge and on float**
- + Data acquisition and battery history logging**
- + Local or remote communication with user's interface**
- + Issue of warnings and alarms according to level of criticality**
- + In case of anomaly temporary emergency operation to ensure backup power and disconnection when time-out period is reached**

FIAMM Sodium Nickel Batteries / BMS for TLC appl's

48 VDC line



FIAMM Sonick— A modern plant which needs just simple raw materials



FIAMM SoNick Battery – Comparison vs NiCd

	NiCd	Sodium
Technology	Ni-Cd Battery	NaNiCl Battery
Charging Voltage	Temperature Compensated 55.9 Vdc @ 20C	Constant Voltage 55-60 Vdc
Charging Time	90 % charge in 5 hours	75 % charge in 5 hours
Service Life	> 15 years /	> 15 years / 2500 cycles @ 100% DOD
e.g. Physical Size (9,6 kWh)	1329 mm (L) x 847 mm (W) x 470 mm (H) (0.529 m2)	796 mm (L) x 507 mm (W) x 508 mm (H) (0,205 m2) 2,6 times smaller
e.g. Weight (9,6 kWh)	245 kg + battery box (~ 187kg) (Total 432 kg)	116 kg 3,7 times lighter

FIAMM SoNick Battery – Comparison vs NiCd

	NiCd		Sodium
Battery Monitoring	Current	LEM Sensor to human interface	Integrated into the Battery System and communicates with the human interface via CANbus
	Voltage	human interface	
	Temperature	Thermistor to APU	
Periodic Maintenance	Topping Up Cells with Distilled Water		Sealed Cell – maintenance not required
Memory Effect	Yes		No
Shelf/Storage Life	4 Years		Indefinite

FIAMM Sodium Nickel Batteries / 48TL80



+ Battery pack always includes the BMS

+ Nominal Voltage	48 VDC
+ Voltage Operating Range	40 to 54 VDC
+ Capacity	80 Ah
+ Energy	4 kWh
+ Max Discharge Current	50 Amps
+ Bus Voltage Range	53 – 60 VDC
+ Low Voltage Disconnect	40 VDC
+ Fuse	63 Amps
+ Communication Port	RS232 / RS485
+ Alarm Contact	230 VAC 2A
+ Front	260 mm (10.2 in)
+ Depth	550 mm (21.6 in)
+ Height	320 mm (12.6 in)
+ Weight	45 kg (100 lb)
+ Environ Temperature Range	- 40 to +60 °C (-40 to 140°F)
+ Internal Temperature	250 to 350 °C (482 to 662 °F)

FIAMM Sodium Nickel Batteries / 48TL120 – 160 - 200

- + **Nominal Voltage** 48 VDC
- + **Capacity** 120 / 160 / 200 Ah
- + **Energy** 5,8 / 7,7 / 9,6 kWh
- + **Optimal use** 1 ÷ 12h rate



+ **Main tech characteristics:**

- Operating Voltage Range 40 ÷ 54 VDC
- Heat dissipation 107 / 110 / 117 W
- Max Discharge Current 90 / 120 / 150 Amps
- Bus Voltage Range 53 ÷ 60 VDC
- Low Voltage Disconnect 40 VDC
- Fuse 200 Amps
- Communication Port RS485 or CAN / USB
- Alarm Contact 230 VAC 2A

- Front 496 mm (19.5 inc)
- Depth 558 mm (21.9 inc)
- Height 320 mm (12.6 inc)
- Weight 80 / 95 / 105 kg (177 / 210 / 243 lb)

- Env. Temperature Range - 20 ÷ +60 °C (-4 ÷ 140°F)
- IP rate IP 55

FIAMM Sodium Nickel Batteries / 24TL160

+ Nominal Voltage	24 VDC
+ Capacity	160 Ah
+ Energy	3,7 kWh
+ Optimal use	backup - 1 ÷ 12h rate

+ Main tech characteristics:

Operating Voltage Range	20 ÷ 27 VDC
Heat dissipation	70 W (est.)
Max Discharge Current	120 Amps
Bus Voltage Range	27 ÷ 30 VDC
Low Voltage Disconnect	19 VDC
Fuse	200 Amps
Communication Port	RS485 or CAN / USB
Alarm Contact	230 VAC 2A

Front	494 mm (19.5 inc)
Depth	370 mm (14.5 inc)
Height	320 mm (12.6 inc)
Weight	55 kg (121 lb)
Env. Temperature Range	- 25 ÷ +65 ° C (-13 ÷ 149°F)
IP rate	IP 55



FIAMM Sodium Nickel Batteries / 110UP80 / 220UP40

+ Nominal Voltage	110 / 220 VDC
+ Capacity	80 / 40 Ah
+ Energy	8,7 / 9 kWh
+ Optimal use	1 ÷ 12h rate

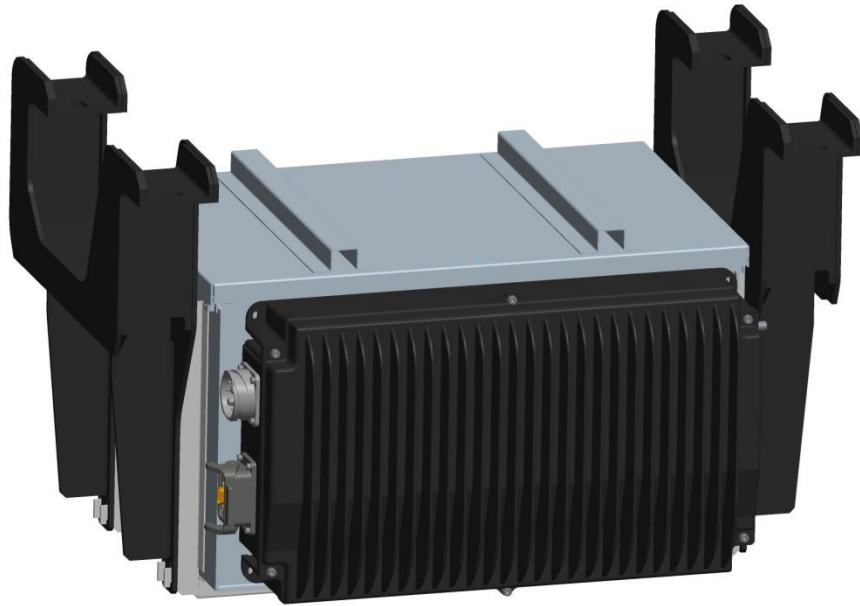
+ **Main tech characteristics:**

Voltage Operating Range	88 ÷ 135 / 177 ÷ 250 VDC
Heat dissipation	120 W
Max Discharge Current	120 / 60 Amps
Bus Voltage Range	120 ÷ 140 / 243 ÷ 250 VDC
Low Voltage Disconnect	88 / 117 VDC
Fuse	125 Amps
Communication Port	CAN Bus
Inputs	EPO , Load disconnect

Front	587 mm (23.1 in)
Depth	492 mm (19.3 in)
Height	338 mm (13.3 in)
Weight	98 / 100 kg (216 / 220 lb)
Env. Temperature Range	- 25 to +65 ° C (-13 to 150°F)
IP rate	IP65



FIAMM Sodium Nickel Batteries / 113V 80Ah



- + Nominal Voltage 113 VDC
- + Voltage Operating Range 135 to 88 VDC
- + Capacity 80 Ah
- + Energy 9 kWh
- + Max Discharge Current 120 Amps
- + Bus Voltage Range 140 to 120 VDC
- + Low Voltage Disconnect 80 VDC
- + Fuse 125 Amps
- + Communication Port CAN Bus
- + Front 616 mm (24.2 in)
- + Depth 526 mm (20.7 in)
- + Height 379 mm (14.9 in)
- + Weight 104 kg (230 lb)
- + Environ Temperature Range - 40 to +65 ° C
(-40 to 150°F)
- + Comply with: IEC 60571, 61571, 61991, 62236-3-1, 61508, EN 50126, 50128, 50129, NFPA 130

Dimensions and weight without mounting brackets

FIAMM Sodium Nickel Batteries / Approved by

TELECOM

- + **MTN** – RSA
- + **Eltek Valere** – USA
- + **Telefonica** – Spain
- + **OTE** – Greece
- + **Telecom Italia** – Italy
- + **T-Mobile** – US
- + **Cosmote** – Romania
- + **Elcos** – Italy
- + **Nokia Siemens** - Finland

Under Evaluation

- + **Ericsson** – Sweden
- + **Verizon** – US
- + **MTS** – Russia
- + **AT&T** - US

INDUSTRIAL

- + **INES** – France
- + **ABB** – Switzerland
- + **Posco** – Korea
- + **General Atomic** – USA
- + **Halton Hills Hydro** – Canada
- + **Fraunhofer Inst.** – Germany
- + **EDF** – France
- + **Terna** – Italy

RAILWAYS

- + **SNCF** – France
- + **Bombardier** – Canada
- + **PRASA** – South Africa
- + **OmniTRAX** – US
- + **Treni Italia** – Italy
- + **Scomi** - Malaysia

FIAMM Sodium Nickel Batteries / Bombardier Project

Brazil – Sao Paulo INNOVIA 300

Saudi Arabia – KAFD Riyadh INNOVIA 300

Canada – Skytrain Vancouver INNOVIA ART 300

Malaysia – Kuala Lumpur INNOVIA ART 300

Key Benefits:

- + Weight
- + Temperature range
- + Direct communication with the train
- + No maintenance
- + Extended life in harsh environment

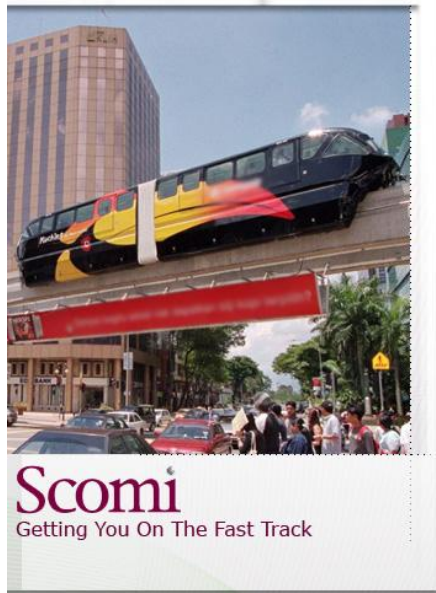


FIAMM Sodium Nickel Batteries / SCOMI Group

Malaysia – Kuala Lumpur mono-rail project

Key Benefits:

- + Weight
- + Temperature range
- + Direct communication with the train
- + No maintenance
- + Extended life in harsh environment



FIAMM Sodium Nickel Batteries / US Railways

OmniTRAX - US Railways – Signaling installations in Texas (US).

- Key factors:
 - + Temperature range
 - + Remote communication
 - + No maintenance
 - + Extended life in harsh environment
 - + Compact solution



FIAMM Sodium Nickel Batteries / Up and Running

South Africa - offgrid power for remote BTS in harsh environments

- photovoltaic sites with 48TL80 systems Onseepkans and Kalahari area
- Key factors:
 - + Immunity to extreme temperatures
 - + Long life under daily cycling
 - + Remote monitoring
 - + No maintenance



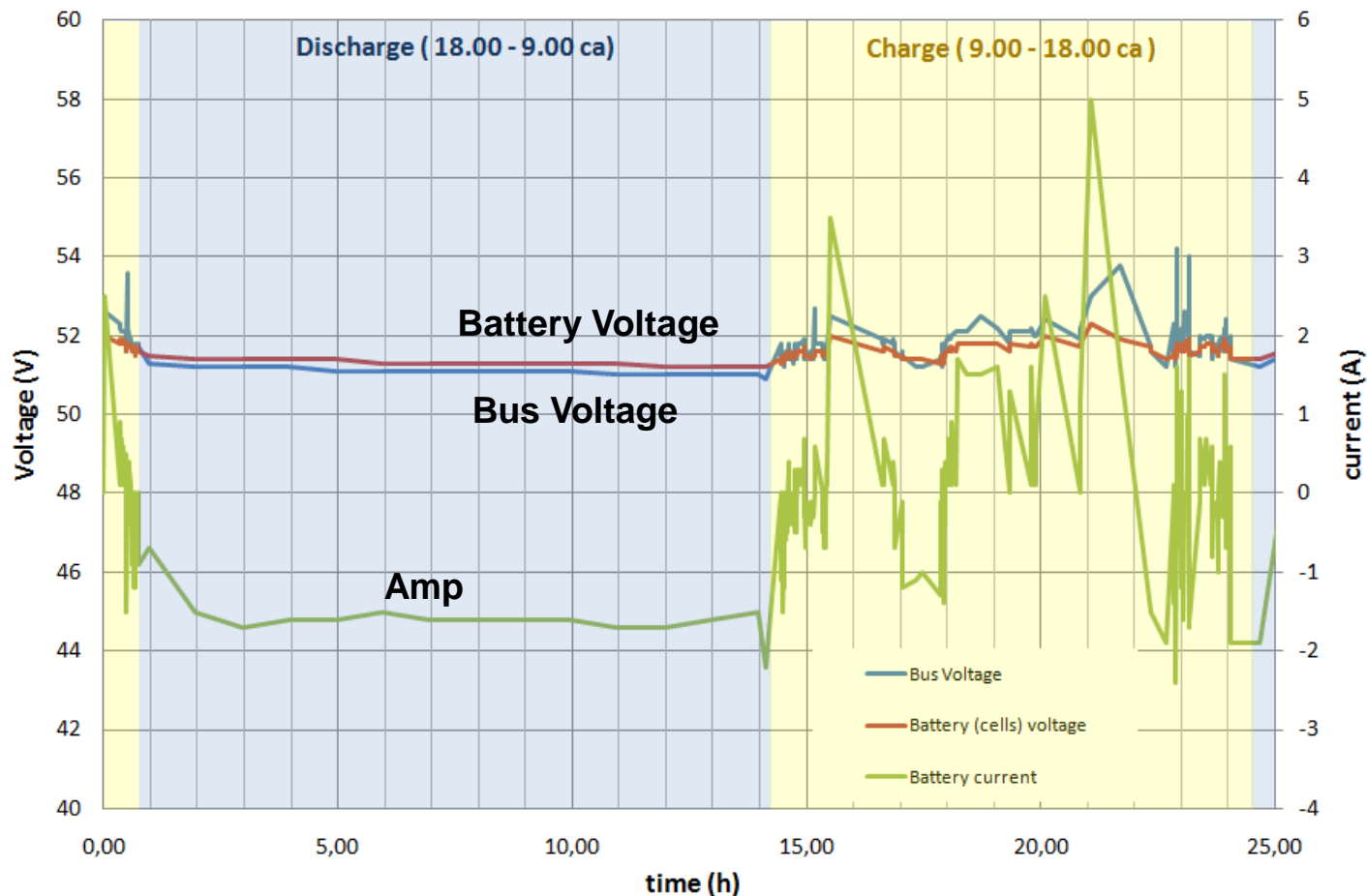
FIAMM Sodium Nickel Batteries / Up and Running

South Africa Installation



FIAMM Sodium Nickel Batteries / Up and Running

Noriseep - 24h acquisition - battery n°4



FIAMM Sodium Nickel Batteries / Up and Running

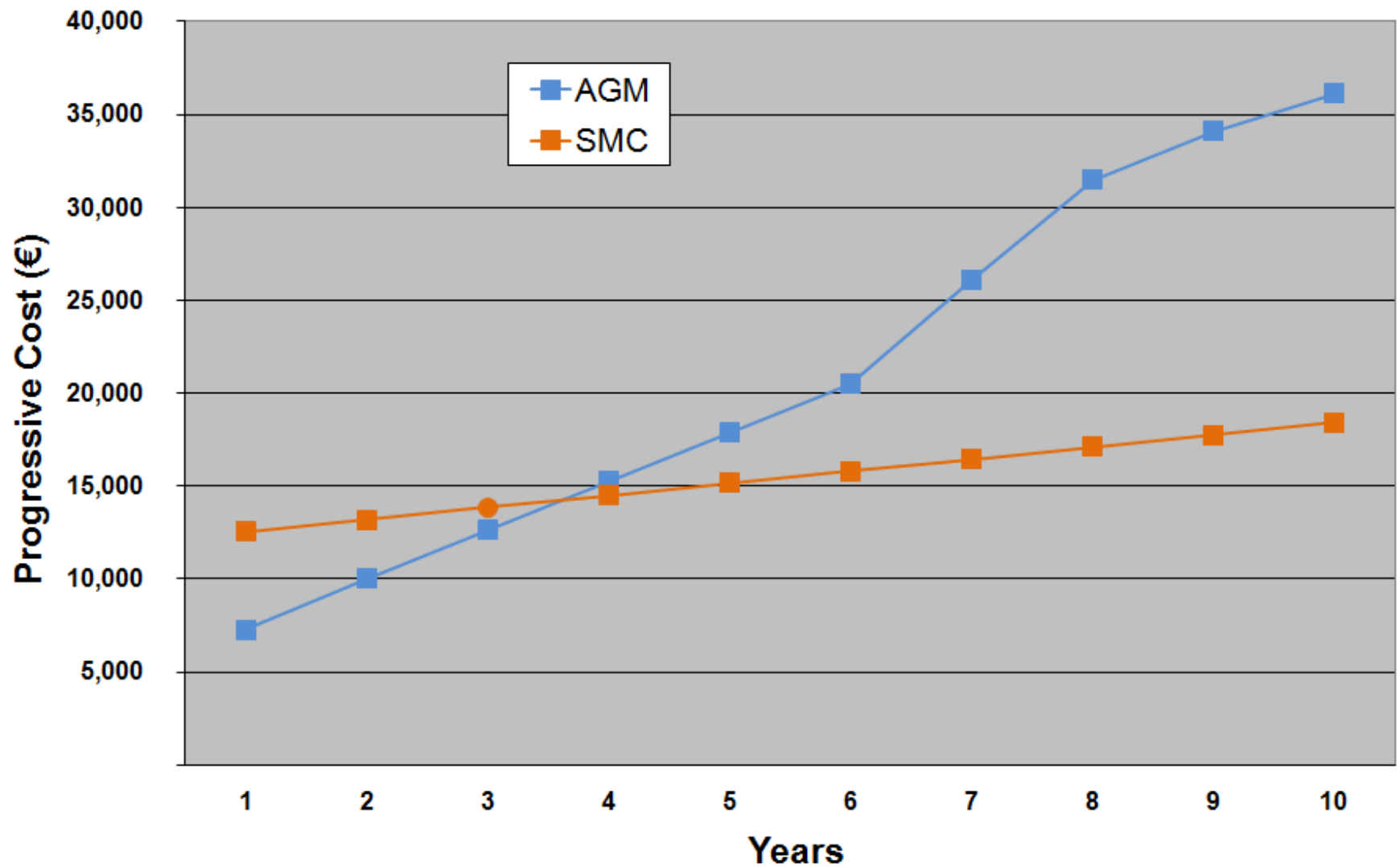
Central Italy - BTS in remote site

- Key factors:
 - + TCO: energy consumption & maintenance
 - + Extended life and reliability
 - + Remote monitoring



FIAMM Sodium Nickel Batteries /

TCO



FIAMM Sodium Nickel Batteries / Up and Running

Spain - BTS

- Key Factors:
 - + TCO: energy consumption & maintenance
 - + Extended life and reliability
 - + Competitive alternative for Peltier cabinet + AGM technology



FIAMM Sodium Nickel Batteries / Up and Running

Romania - BTS

- Key Factors:
 - + TCO: energy consumption & maintenance
 - + Extended life and reliability



FIAMM Sodium Nickel Batteries / Up and Running

Germany - BTS

- Key Factors:
 - + TCO: energy consumption & maintenance
 - + Extended life and reliability



FIAMM Sodium Nickel Batteries / Up and Running

Greece - Outdoor TLC cabinets

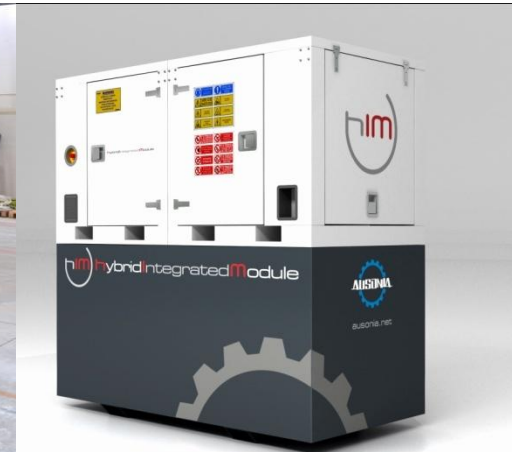
- Key factors:
 - + TCO: energy consumption & maintenance
 - + Extended life and reliability under high temp.
 - + Remote monitoring



FIAMM Sodium Nickel Batteries / Up and Running

Generator + Batteries

- Key Factors:
 - + Extended life and reliability
 - + Remote monitoring
 - + High cyclability



Hybrid applications + SMC batteries : Benefits



Fuel saving:

DG Continuous working ≈ 49 ℓ/day *

DG Hybrid application ≈ 22 ℓ/day

Annual saving
9850 €

Low maintenance:

Continuous working ≈ 30 services/y

Hybrid application ≈ 15 services/y

Annual saving
3000 €

Minor battery replacement:

Lead battery, Standby $\approx 3,5$ years life

SMC, hybrid ≈ 20 years life

Annual saving
500 €

Reduced CO₂ emission



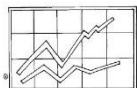
Battery temperature immunity



Battery weight considerably reduced

Total estimated saving*:

13350 €/y



Remote battery accurate monitoring

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Gruppo

* 10kW DG consumption: load 0-50% = 450g/kWh; load 50-100% = 330g/kWh

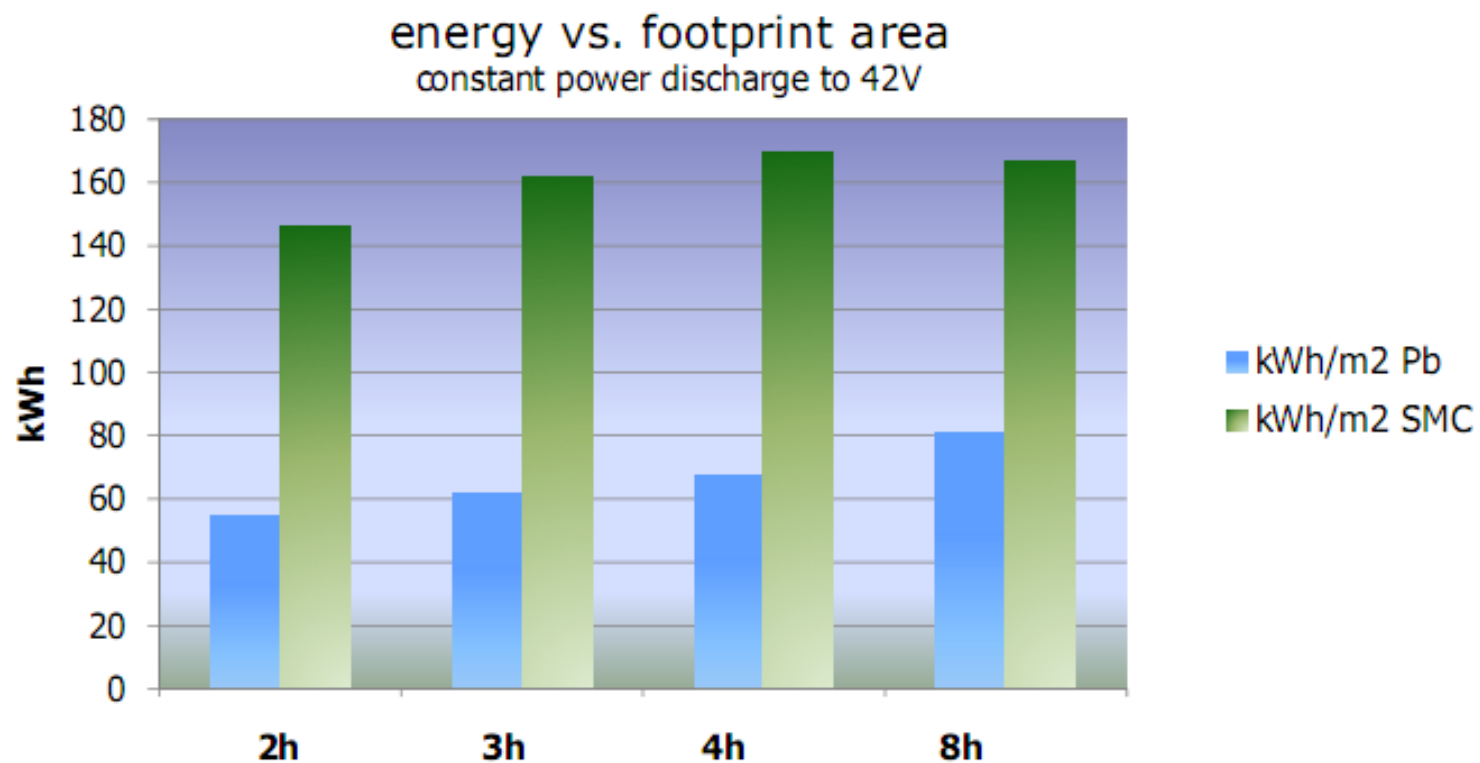
FIAMM Sodium Nickel Batteries

USA - TLC Central Office

- 48V 3200Ah rack system
- Key factors:
 - + Energy density
 - + No maintenance
 - + No air conditioning
- + Specific Energy: 79 Wh/kg (Pb 20 Wh/kg)
 - 4h rate



FIAMM Sodium Nickel Batteries



+ UN Conference on Sustainable Development *Rio De Janeiro: June 2012*





The Minister of Mines and Energy, Edison Lobao, expressed the interest of bringing the system Intelligent Energy Storage (IESS, its acronym in English) for different regions of the country, especially isolated communities that are not served by the integrated power transmission.



"I knew a similar system, developed by the University of Maranhao, but this one is well developed," praised Lobao. "I found a very significant advance. Let us insist on this system and maybe find a great way to be explored" he added.

SoNick Zebra Battery – Operational Experience and Reliability

10 year successful experience of Zebra Sonick Batteries in electric motion

	Some 350 <i>Think City</i> EV Cars across US and Europe
	More than 100 <i>Smart EV</i> fleet in London (Daymiller-Zytek)
	Hundreds of <i>Gulliver</i> buses in several European cities (80 in downtown Rome)
	<i>Electric Palio Weekend</i> manufacturing started at the Fiat Brazilian subsidiary
	<i>Europolis</i> (bus) and <i>Daily</i> (commercial van) in several cities in Europe
	Electrically Powered NATO Rescue Submarine System 8 x 17 kWh battery
	“GE battery of choice for hybrid motion”

SoNick Zebra Battery – Operational Experience and Reliability



THINK! EV



Sodium batteries: Zebra

The Zebra battery has high energy density, and provides long range performance, independent of ambient temperature. It is a “hot” battery, which means that the operating temperature is between 260 and 360 degrees. The battery is also made from environmentally friendly materials. This option is perfect for users who have a regular and frequent usage pattern. Active materials in the Zebra battery are sodium and nickel. The hot materials are contained in a vacuum insulated and sealed container. Thus, these batteries operate very efficiently in areas with very hot and very cold climate.

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Gruppo

In France with Venturi for “La Poste” 250 vehicles in 2010



Zebra Sonick Battery allowed a smart design of Berlingo First: it provides the same volume and payload as Citroën's petrol-based Berlingo

TECHNICAL SPECIFICATIONS

Batteries

Nickel sodium chloride “Zebra For Venturi”

Battery

Energy : 23,5 kWh

Mass : 201 kg

Air cooling

Life-span of batteries : over 1,000 cycles

Regeneration system via deceleration

Internal operating temperature : 270° C

Motor :

Asynchronous three-phase motor

Max power : 42 kW

Max torque : 180 Nm

Liquid cooling

Performance

Range on batteries : 100 Km (62 miles)

Top speed : 110 Km/h (68 mph)

Payload: 500 kg

Dimensions :

Length : 4137 mm

Width : 1960 mm

Height : 1819 mm

SoNick Zebra Battery – Operational Experience and Reliability



GULLIVER, more than 200+ buses across Europe



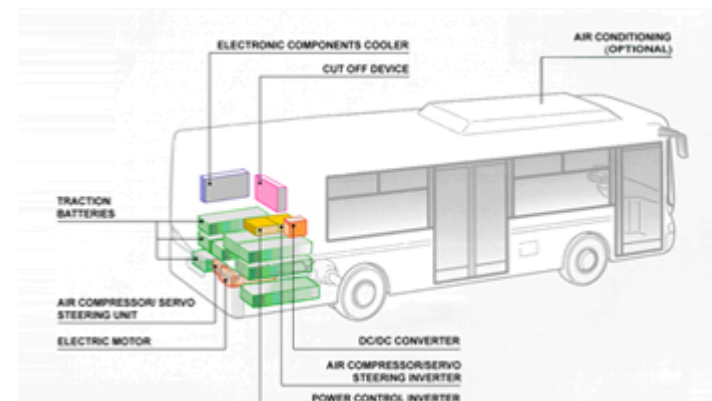
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Gruppo

SoNick Zebra Battery – Operational Experience and Reliability

IVECO  irisbus



Europolis, full electric bus for urban service

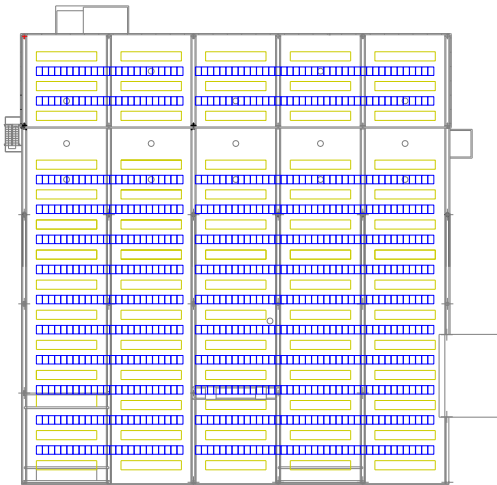
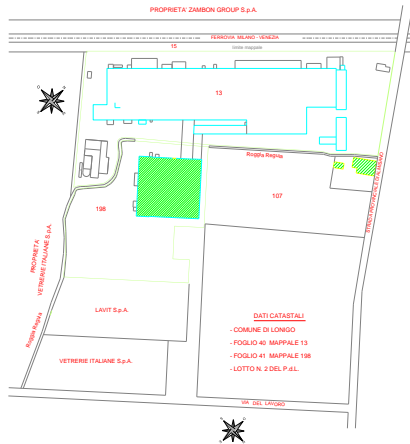
Range 120 km

Max Speed 60 km/h

Payload 48 passengers

FIAMM EXAMPLE OF GRID CONNECTED SOLAR SITE

FIAMM Group / Photovoltaic plant in Almisano factory, Italy



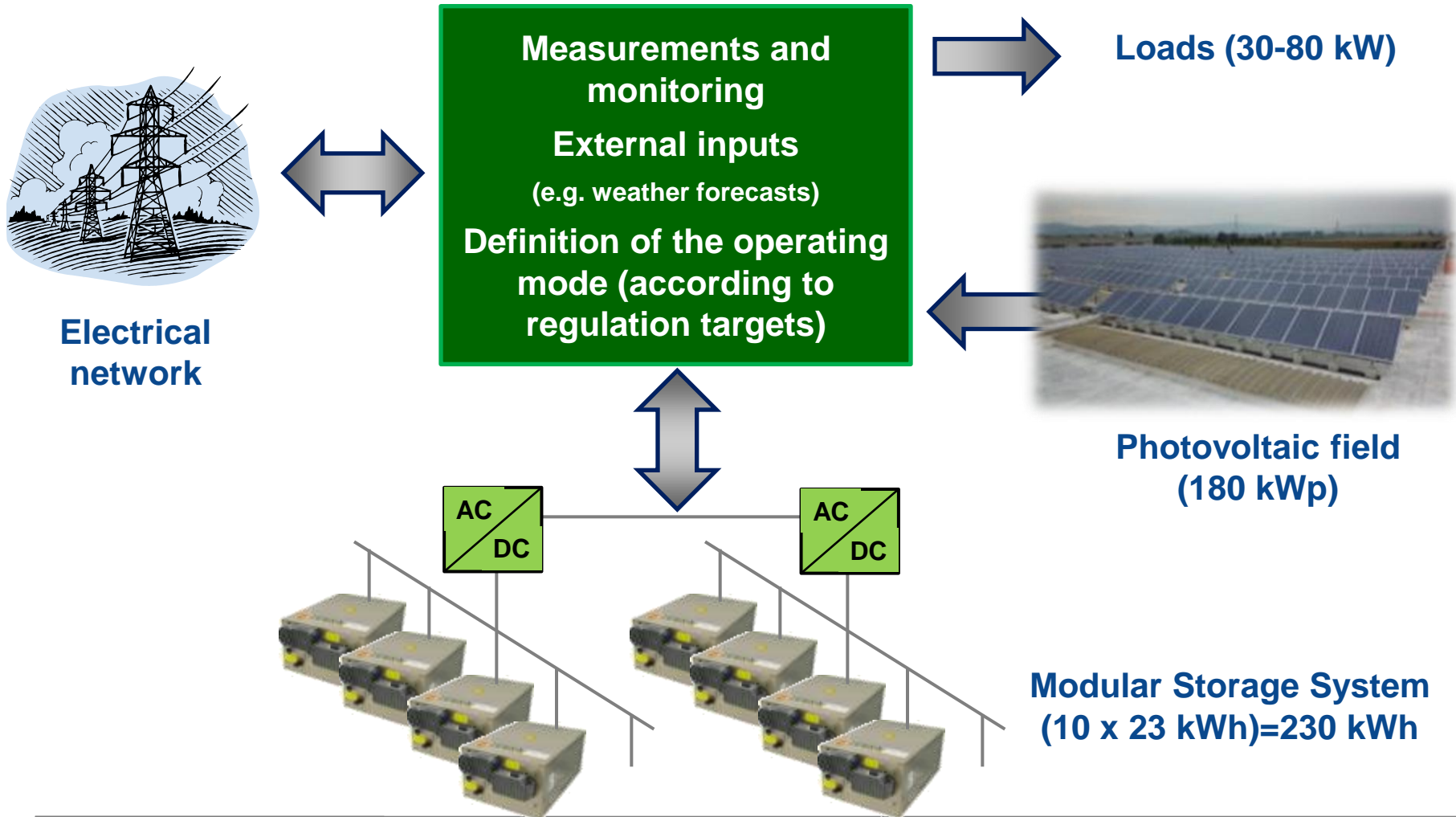
FIAMM LOGISTIC CENTER in Almisano, Italy:

- Electrical station: MV 20 kV
- Logistic Center Power LV 400 V – 400 kVA
- Power consumption: 30 kW (avg) → 80 kW (peak);
- Energy Consumption: 22 MWh/month;
- PV field generation: 180 kWp;
- PV energy generation [kWh/kWp day] :
1,21 (Dec) → 4,40 (Jul)
- Daily Average PV generation 2,85 kWh/kWp day
- Yearly Average PV generation : 1040 kWh/kWp year
- Average monthly PV generation
220 kWh/day (Dec) → 798 kWh/day (Jul)

FIAMM Group / Photovoltaic plant in Almisano factory, Italy



FIAMM Group / Almisano PV plant Block Diagram



Seven operating modes by design:

- **Operating mode 0: Storage off;**
- **Operating mode 1: Manual management with open loop power regulation (P,Q)**
- **Operating mode 2: Line VAR regulation**
- **Operating mode 3: Voltage regulation in connection node**
- **Operating mode 4: Storage Management with prediction of generation and loads;**
- **Operating mode 5: Storage Management with prediction of energy revenues (incentives)**
- **Operating mode 6: pure Island Operation PV Generation/Storage/Load**

FIAMM FZ Sonick Z37

▪ Type of module	Z37-ML3X-38
▪ No. of modules	10
▪ Capacity	38 Ah
▪ Nominal Energy	23,5 kWh
▪ Max DOD:	80% (17 kWh)
▪ Nominal >Voltage	620 VDC
▪ Continuous Power	10 kW
▪ Peak Power	30 kW 1 min
▪ Module weight	201 kg
▪ Specific Energy	120 Wh/kg
▪ Energy Density	183 Wh/l
▪ Specific Power:	170 W/kg
▪ Operating temperature	- 40 °C to + 60 °C
▪ Heat losses	105 W @ 270 °C
▪ Overall Dimensions	900 x 529 x 296 mm



FIAMM Group / Storage Station

