Internet of Energy
for Electric Mobility

Dr. Ovidiu Vermesan, Chief Scientist, SINTEF
26 October 2011, Scandic Marina Congress Center, Helsinki, Finland
Presentation Outline

- Introduction
- Objectives
- Technological Challenges
- Partners
- Summary
Future Vehicle

From mechanics to mechatronics

Mechanical Craft → Computer on Wheels

Source: Rinaldo Rinolfi – Fiat Powertrain Technologies
Source: FIAT Group Automobiles
Source: Duracar

ARTEMIS Joint Undertaking

Internet of Energy
Emission of CO₂ g/km

- Electrification of cars and bikes
- Board Net Architecture
- Low Power/ Power on Demand

Source: Infineon
Energy and Propulsion Alternatives

**Energy Resources**
- Oil
- Coal
- Natural Gas
- Biomass
- Other Renewable Energy (Hydro, Solar, Wind)

**Energy Carriers**
- Liquid Fuels
- Gas Fuels
- Electricity
- Hydrogen

**Propulsion Systems**
- Conventional ICE (Gasoline / Diesel)
- Gas ICE
- ICE Hybrid
- Plug-In Hybrid ICE
- Electric Vehicle
- Fuel-Cell Electric

Source: GM
Future Smart Grid

- From centralised to distributed

Source: Rinaldo Rinolfi – Fiat Powertrain Technologies
ARTEMIS Joint Undertaking

Source: IBM
Factors influencing charging profile

The decision how to charge optimally is taken within the vehicle.
Future Batteries

Watt hours/kg (cell level) | Technology

- Li-ion
- Li-metal
- Li-metal
- NaNiCl₂ (Zébra)
- NiMH
- NiCad
- Lead

Energy density

<table>
<thead>
<tr>
<th>Year</th>
<th>Li-ion</th>
<th>Li-metal</th>
<th>NaNiCl₂ (Zébra)</th>
<th>NiMH</th>
<th>NiCad</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1980</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1990</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Increasing expected lifetime, decreasing cost and weight
Enabling Technologies

- Security
- Privacy
- Future
- Internet
- Knowledge
- Aggregation
- Standards
- Power
- Electronics
- Communication
- Cloud
- Computing
- Discovery
- Services
- Nanoelectronics
- Embedded
- Systems
- Software
- System
- Integration
Synergies among European Programs

- ENIAC – E³Car
- ARTEMIS - IoE
- ARTEMIS - POLLUX
- ENIAC - MotorBrain

- Nanoelectronics
- Power Modules
- Electric Mobility
- Architecture
- Embedded Systems
- Internet - Grid
- Embedded Systems
- Motor Drives
IoE - ENIAC E$^3$Car - ARTEMIS POLLUX

“Creativity is the power to connect the seemingly unconnected.”
Implement real-time interface between the power network/grid and the Internet.

Develop reference designs and embedded systems architectures for high-efficiency smart network systems.

Managing key topics:
- Demand response
- Modelling/simulation
- Usage monitoring
- Real-time energy balance and billing

Creation of value-added services using both wired and wireless devices with access to the Internet.

Develop hardware, software, and middleware for seamless, secure connectivity and interoperability.

Connecting the Internet with the energy grids with application in the area of Electric Mobility.

Electric Vehicles

Renewable Energy

Communication

Charging Stations
Why Internet of Energy?

Nanoelectronics and Embedded Systems for Electric Mobility

Ubiquitous Charging
Embedded Systems
Communication Smart Grid
Energy Storage Systems

Security, Privacy, Safety, Dependability
IoE Architecture Fundamental Layers

IoE

Information Technology

Communication

Power and Energy System

Information Technology

Communication

Power and Energy System

70%
IoE - Overview

- **User**
  - Added green power sources
  - Plug-in hybrid electric cars
  - Real-time and green pricing signals
  - Smart thermostats, appliances and in-home control devices

- **Generation**
  - Smart meter

- **Transmission**
  - On phone
  - On computer

- **Electric Power Management System**
  - Smart Power Grid
    - Adaptive wireless
    - Internet of Energy
    - Future Internet
    - Web centric remote control
    - Optimized Energy Storage
    - Current Power Grid Communication Network

- **On Board**
  - Controller
  - Transformer

- **Information**
  - On computer
  - On phone
  - On Board

**ARTEMIS Joint Undertaking**
# IoE Applications

## Electric Vehicles
- **Automotive**
  - Network energy management
- **Automotive**
  - Bidirectional fast charger
- **Automative**
  - Communicator ecosystem

## IoE Infrastructure
- **IoE Infrastructure**
  - Fast charging station
- **IoE Infrastructure**
  - Energy storage station

## Smart Buildings
- **Smart Buildings**
  - Building energy gateway

## Embedded Systems

## IoE Architecture
- **IoE Architecture Renewables /Solar / Wind**
  - Smart grid architecture
- **ICT Platform**
  - Energy station platform
- **Internet**
  - Security privacy dependability

## NFC Communication
- **NFC Communication**
  - NFC identification station

## PLC/Wireless Communication
- **PLC/Wireless Communication**
  - Power line communication
  - Smart metering
ARTEMIS IoE Project Partners

- 10 European countries
- 45 Million € budget
- 42 partners

![Projects and Partners Logos]

<table>
<thead>
<tr>
<th>SINTEF</th>
<th>infineon</th>
<th>SIEMENS</th>
<th>EWE</th>
<th>Lantiq</th>
<th>Technische Universität Braunschweig</th>
<th>CentroSolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PURE Watson</td>
<td>THINK</td>
<td>STI</td>
<td>CRP</td>
<td>CentrO Ricerche FIAT</td>
<td>Enel</td>
<td>INTEGRAre</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NXP</td>
<td>Technolution</td>
<td>QinetiQ</td>
<td>Infineon</td>
<td>University Of Sheffield</td>
<td>The University Of Sheffield</td>
<td>Acciona Infrastructures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Royal Holloway University of London</td>
<td>GreenPower rect</td>
<td>Indra</td>
<td>tecnalia</td>
<td>Cia</td>
<td>aicid</td>
<td>Acciona Infrastructures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantiq</td>
<td>cellstrom</td>
<td>CISC</td>
<td>TECHNIKON</td>
<td>EPYON</td>
<td>Nokia Siemens Networks</td>
<td>EB</td>
</tr>
<tr>
<td>Austria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ON Semiconductors</td>
<td>triphase</td>
<td>VTT</td>
<td>EMTELE</td>
<td>Nokia Siemens Networks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Norway | Germany | Italy | Netherlands | UK | Spain | Austria | Czech Republic | Belgium | Finland
# IoE Project Targets

## IoE Devices Connected to the Smart Grid

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Potential Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Mobility (+3 Millions Evs)</td>
<td>+ 25% by infrastructure, seamless use, integration</td>
</tr>
<tr>
<td>Renewable Energy to Grid</td>
<td>+ 10% by need balance</td>
</tr>
<tr>
<td>Power Generation to Grid</td>
<td>+ 10% by control and flexibility of energy sources</td>
</tr>
<tr>
<td>Storage to Grid (Load/Generation)</td>
<td>+ 5% by grid reserve balancing</td>
</tr>
<tr>
<td>Household to Grid (Load)</td>
<td>+ 5% by demand control and cut peak energy</td>
</tr>
</tbody>
</table>

## IoE Total Potential

Weighted Mean Value **+20%**
Summary

Internet of Energy is the answer to a number of the energy challenges related to electric mobility.
Thank you for your attention!

Dr. Ovidiu Vermesan, Ovidiu.Vermesan@sintef.no