NANOfutures Initiative Overview

Donato Zangani
25th November 2009
ECTP Conference - Panel on Energy Efficient Buildings
Donato Zangani graduated in Civil Engineering at the University of Genova, Italy, and after his degree joined D’Appolonia, a leading Italian Engineering company with more than 300 professionals. D’Appolonia provides integrated engineering services to industries, governmental bodies, public administrations, and research organizations in the sectors of infrastructures, security, transport, environment, energy, oil and gas, and innovation. He subsequently completed a PhD at Newcastle University on Composite materials modelling. He has been involved in a broad range of innovation activities with companies across Europe and developed expertise in coordination of several international research projects and networks. He is responsible for Technology Transfer and Financing Innovation aspects within NANOfutures.
The NANOfutures platform would become a European multi-sectorial, cross-ETP, integrating platform with the objective of connecting and establishing cooperation and representation of all relevant Technology Platforms that require nanotechnologies in their industrial sector and products.

NANOfutures and its operative branch NANOfutures association will act as a “Nano-Hub” by linking JTIs, associations, ETPs with expert groups in a collaborative environment.

NANOfutures’ Networking
NANOfutures Integrating Role

- NANOfutures at its base will be open to industry, SMEs, NGOs, financial institutions, research institutions, universities and the civil society with an involvement from Member States at national and regional level.
- It will be an environment where all these different entities would be able to interact and come out with a shared vision on nanotechnology futures.
- NANOfutures collaborates with the ETPs on the basis of a Memorandum of Understanding.
NANOfutures Approach

NANOfutures will identify the key nodes in strategic nano-activities and develop strategies to address nanotechnology challenges with an inter-sectorial approach.

This will be achieved by a close interaction between horizontal working groups, which will address cross-sectorial horizontal issues, and sectorial group representatives (i.e., ETP representatives).

NANOfutures horizontal working groups include:

<table>
<thead>
<tr>
<th>RESEARCH / TECHNOLOGY</th>
<th>TECHNOLOGY TRANSFER</th>
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<tbody>
<tr>
<td>INDUSTRIALIZATION/ nano- MANUFACTURING</td>
<td>NETWORKING</td>
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<tr>
<td>COMMUNICATION</td>
<td>SKILLS AND EDUCATION</td>
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<tr>
<td>NANOSAFETY</td>
<td>CONSUMER POLICIES</td>
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<td>INDUSTRIAL NANOSAFETY STRATEGY GROUP</td>
<td>REGULATION</td>
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<tr>
<td>STANDARDIZATION</td>
<td>INNOVATION FINANCING</td>
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</tbody>
</table>
NANOfuture Approach

**ETP needs** (e.g. ECTP, SUSCHEM, MANUFUTURE, PHOTONICS 21, EUMAT, FTC, MINAM etc.)

**Horizontal Working Groups**
(e.g. NANO SAFETY, STANDARDISATION, REGULATION etc.)

**KEY NODES:**
Nanotechnology nodes related to several sectors and different horizontal issues.
(e.g. analytical tools, related to standardisation, research and technology, safety issues and to different industry sectors such as Textile, Chemicals and Materials, Energy, Health and Biomed etc.)
ETPs interested in NANOfutures

- 10 ETPs signed or are going to sign the Memorandum of Understanding, in order to formalise their support to NANOfutures.

<table>
<thead>
<tr>
<th>ETP</th>
<th>Name</th>
<th>Mail</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Going-to-be-signed</td>
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During the last NANOfutures Meeting, November 6th 2009, it was agreed that NANOfutures Steering Committee (SC) will be formed by:

- **Chair**: to be elected at first steering committee (pro-tempore Prof. Matteazzi from NBM Nanomaterialia, Italy);
- **Two co-chairs** to be elected at the first steering committee meeting;
- **ETP representatives**, officially appointed by the ETPs;
- **Horizontal working groups chairs**.

![NANOfutures Organization Diagram](image-url)
NANO\textit{futures} Organization

- Memorandum of Understanding signed or going to be signed by 10 ETPs;
- First Steering Committee: January 2010
- Participants to NANO\textit{futures} and to the working groups and other NANO\textit{futures} activities may be coming from the platforms and groups or on an individual basis as required.
Sinergies between NANOfutures and E2B

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Nanotechnology Products

- Nano iPod
- MacBook Air
- Cosmetics
- Automotive Applications
- Glass Photo / Self Cleaning
- Textile / Clothing
- CNT Bat
- Tennis Racquet lead Nano Titanium
- Catalysts
- Anti Odor / Anti Bacterial Insoles for Shoes
- Detection of Cancerous Cells
- Air Purification / NanoBreeze
- Odorless socks
- Chocolate Chewing Gum

Source: EAG Report on Future R&TD of NMP
Nanotechnology Applications for Construction and Housing

• Big improvements can be achieved by making all housings and buildings energy neutral. This will contribute considerably to the overall energy saving target of 20% in 2020. To realise this target, efficient insulating materials and coatings have to be developed, including phase changing materials to be applied in heat storage systems. Materials for high lumen and low power lighting (LED) will also reduce energy consumption.

• In 2020 about 20% of the total energy consumption in Europe will have to be supplied through solar and wind energy. To improve the efficiency of wind turbines, new materials with improved strength / weight performance are necessary to apply larger rotor blades, while new monitoring devices will ensure timely maintenance.

• Breakthroughs in materials innovation (nanotechnology, thin films and coatings) are required to produce cheaper photovoltaic cells with improved yields and significantly longer lifetimes.
## Nanotech Priorities in the Construction sector

<table>
<thead>
<tr>
<th>Key R&amp;D Targets</th>
<th>Material Advancements</th>
<th>Process Advancements</th>
<th>Applications &amp; Time Frame</th>
</tr>
</thead>
</table>
| Improved Life-Cycle Cost Management by:  
  - Shortened design time  
  - Shortened building time  
  - Reduced maintenance | Steel, glass, light metals, concrete, ceramics, polymers, laminates and combinations with the following properties:  
  - Accurate knowledge of material properties for performance based design methods  
  - Predictability of required maintenance  
  - Reduced maintenance requirements (self cleaning materials)  
  - Allowing in situ upgrade and repair  
  - Wear and tear proof coatings  
  - Smart release coatings | Innovations in  
  - Design Process (virtual prototyping, performance based design methods)  
  - Building Process (advanced prefab technologies, fast connection techniques, etc.)  
  - Contracting methods (e.g., Design Manufacturing Finance Maintain constructions)  
  - Professional Asset Management, incl. status dependent maintenance approaches | 10 % reduction of total building and maintenance costs (2008-2015) |
| Increased design lifetimes | Steel, glass, light metals, concrete, etc. with the following properties (surfaces and coatings):  
  - Improved and endurable esthetics  
  - Sustainable and long endurance  
  - Self-healing, self-cleaning, in-situ upgrade and repair | Contracting methods (e.g., Design Manufacturing Finance Maintain constructions)  
  - Professional Asset Management, incl. status dependent maintenance | |
| Building (verb) with:  
  - Reduced energy and waste materials  
  - Less disturbance  
  - Less emission | Recyclable components and re-use of materials, e.g., all steel constructions (100 % recyclability)  
  - Ecological substitutes for high energy / high emissions materials  
  - Smart materials for acoustic noise reduction | Innovations in:  
  - Logistics  
  - Acoustics (noise reduction)  
  - Innovations in recycling processes | Taking responsibility towards society (2010-2020)  
  - 5 % reduction of total building and maintenance costs (2010-2020) |
| Design for recyclability | Prefabricated steel components  
  - Joining techniques for prefabrication of various material combinations  
  - Materials for high strength, robust scaffolding  
  - Steel, glass, light metals, concrete, etc. which provide  
  - Low emission, low radiation, toxic free substitutes, e.g., design of steel / glass structures  
  - Breathing (semi-permeable walls)  
  - Fire immunity or resistance, e.g., fire resistant steel grades  
  - Robustness against earth quakes, e.g., ultra high strength flexible steels | Improved building processes  
  - Safe and fast construction site technologies  
  - Better safety procedures and safety awareness  
  - Risk based fire engineering | Less loss of life and less casualties (2010-2015)  
  - Reduced insurance costs (2010-2015)  
  - Complying with stricter regulations on safety and internal environment (health) environment  
  - Increase of high end market volume by 20 % |
| Improved safety in building construction areas | Healthy and safe buildings, i.e.:  
  - Low emission  
  - Low radiation  
  - Toxic free  
  - Right climate  
  - Fire resistant  
  - Seismic proof | | |
Nanotechnology Applications for Energy Storage, Conversion and efficient use

<table>
<thead>
<tr>
<th>Energy sources</th>
<th>Energy change</th>
<th>Energy distribution</th>
<th>Energy storage</th>
<th>Energy usage</th>
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</thead>
<tbody>
<tr>
<td>Regenerative</td>
<td>Gas turbines</td>
<td>Power Transmission</td>
<td>Electrical Energy</td>
<td>Thermal Insulation</td>
</tr>
<tr>
<td>Photovoltaics: nano-optimized cells (polymeric, dye, quantum dot, thin film, multiple junction), antireflective coatings</td>
<td>heat and corrosion protection of turbine blades (e.g. ceramic or intermetallic nano-coatings) for more efficient turbine power plants</td>
<td>High-Voltage transmission nanofillers for electrical isolation systems, Soft magnetic nanomaterials for efficient current transformation</td>
<td>Batteries: Optimized Li-Ion batteries by nanostructured electrodes and flexible, ceramic separator foils, application in mobile electronics, automobile, flexible load management in power grids (mid term)</td>
<td>Nanoporous foams and gels (water, polymer foams) for thermal insulation of buildings or in industrial processes</td>
</tr>
<tr>
<td>Wind Energy: nano-composites for lighter and stronger rotor blades, wear and corrosion protection nano-coatings for bearing and power trains etc.</td>
<td>Thermoelectrics</td>
<td>Supernovas: Optimized high temperature SC's based on nanoscale interface design for loss-less power transmission</td>
<td>Supercapacitors: nanomaterials for electrodics (carbon aerogels, CNT, metal-oxides) and electrolytes for higher energy densities</td>
<td>Air Conditioning</td>
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<tr>
<td>Geothermal: nano-coatings and -composites for wear resistant drilling equipment</td>
<td>Fuel Cells</td>
<td>CNT power lines: super conducting cables based on carbon nanotubes (long term)</td>
<td>Chemical Energy</td>
<td></td>
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<tr>
<td>Hydro-/Tidal Power: nano-coatings for corrosion protection</td>
<td>Nano-optimized membranes and electrodes for efficient fuel cells (PEM) for applications in automobiles/mobile electronics</td>
<td>Wireless power transmission</td>
<td>Hydrogen: nanoporous materials (organocatalysts, metal hydrides) for application in micro fuel cells for mobile electronics or in automobiles (long term)</td>
<td>Light and heat flux in buildings by electrochromic windows, micro mirror array or IR-reflectors</td>
</tr>
<tr>
<td>Biomass energy: yield optimization by nano-based precision farming (nanosensors, controlled release and storage of pesticides and nutrients)</td>
<td>Hydrogen Generation</td>
<td>Power transmission by laser, microwaves or electromagnetic resonance based on nano-optimized components (long term)</td>
<td>Fuel reforming/rfining: nano-catalysts for optimized fuel production (oil refining, desulfurization, coal liquefaction)</td>
<td>Lightweight Construction</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>Fuel cells and new processes for more efficient hydrogen generation (e.g. photocatalytic, electrolysis, biophotonic)</td>
<td>Smart Grids</td>
<td>Fuel tanks: gas light fuel tanks based on nano-composites for reduction of hydrogen fuel emissions</td>
<td>Light weight construction materials using nano-composites (carbon nanotubes, metal matrix composites, nano-coated light metals, ultra performance concrete, polymer-composites)</td>
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<td>Combustion Engines</td>
<td>Nanosensors (e.g. magneto-rheoactive) for intelligent and flexible grid management capable of managing highly decentralised power feeds</td>
<td>Thermal Energy</td>
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<td>wear and corrosion protection of engine components (nano-composites/coatings, nanoparticles as fuel additive, etc.)</td>
<td>Heat Transfer</td>
<td>Phase change materials: encapsulated PCM for air conditioning of buildings</td>
<td>Substitution of energy intensive processes based on nanotech process innovations (e.g. nanocalysts, self-assembling processes etc.)</td>
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<tr>
<td>Nuclear</td>
<td>Electrical Motors</td>
<td>Efficient heat in- and outflow based on nano-optimized heat exchangers and conductors (e.g. based on CNT composites) in industries and buildings</td>
<td>Adsorptive storage: nanoporous materials (e.g. zeolites) for reversible heat storage in buildings and heating nets</td>
<td>Lighting</td>
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<tr>
<td></td>
<td>nano-composites for radiation shielding and protection (personal equipment, container etc.), long term option for nuclear fusion reactors</td>
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<td></td>
<td>Energy efficient lighting systems (e.g. LED, OLED)</td>
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Source: VDI TZ
## Priorities in Energy & Power Systems

<table>
<thead>
<tr>
<th>Key R&amp;D Targets</th>
<th>Material Advancements</th>
<th>Process Advancements</th>
<th>Growth &amp; Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved and cheaper production for photovoltaic (solar) cells</td>
<td>Diffusion barriers on glass, metal and polymer substrates for thin film (Si and CIS) solar systems</td>
<td>Fundamental knowledge on Photovoltaics (Si, organic-Graetzel and thin film)</td>
<td>Cost effective storage of heat and air-conditioning of housings</td>
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<td>Systems to bridge the thermal</td>
<td>Knowledge on cell design, encapsulation and anti-reflection light trapping (on more general wavelength selective light management)</td>
<td>Storage of heat may result in 40% savings in heat usage, this could be combined with the pumping of heat or private micro turbines</td>
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<tr>
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<td>Expansion and other mechanical deformation difference between substrate (glass, steel, polymer and hybrid combinations) and Photovoltaic system</td>
<td>Mechanics of thin film multilayered and patterned structure, ageing and failure mechanisms</td>
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<td></td>
<td>Application of transparent thin conductive layers in combination with barrier layers</td>
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<td></td>
<td>Metal glass combinations</td>
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<td></td>
<td>New generation low cost coil to coil production processes, including internal patterning</td>
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<tr>
<td>Integrated systems for solar cells</td>
<td>Design integrated solutions for Photovoltaics on buildings and road structures</td>
<td>Knowledge on how to Integrate /transform to the electricity-grid</td>
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<tr>
<td></td>
<td>Develop accelerated testing procedures. Combined generation of electricity and heat with solar panels, efficient heat exchanges</td>
<td>Knowledge on construction market and systems</td>
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<td>Early involvement certification and classification companies</td>
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<tr>
<td>Saving 1 days energy as heat (until 100°C) in 1m² for €500</td>
<td>Developments should focus on: - Isolating materials - Phase Change Materials - Design of endo- and exo-thermic reactions - Highly efficient solar energy collectors and coatings for adsorbers</td>
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</tr>
</tbody>
</table>

Source: EAG Report on Future R&TD of NMP
Building industry - Technology Roadmap

**2009 (today)**
- Large area nanocoatings:
  - Passive glazes
  - Heat insulating windows

**2012**
- Large area nanocoatings:
  - Active glazes
  - Replication & screen printing
  - LED lightning

**2016**
- Large area nanotexturing:
  - Smart glazing
  - Large area ink jet printing
  - Sensor networks
  - Actuators
  - Home monitoring

**2020+**
- Nanotechnologies for energy harvesting
  - Full wireless sensor network for multiscale monitoring (Home, Buildings, Street, ecosystems, ...)

Source: MINAM
ENERGY - Technology Roadmap

2009 (today)

Thin film technologies:
- **Generation II PV cells** based on thin films (BIPV)
- **Thin film Li batteries.**
- Powering mobile systems

2012

Ceramic engineering:
- \(\mu\) PIM, nanomembranes
- Microreactors
- Thermoelectric Devices.
- \(\mu\) fuel cells
- Catalyst integrating Systems/
- **Dye and organic solar Cells**
  Polymer based nanocomposites engineering.
  Solar concentrator
  „Power“ batteries for hybrid vehicle

2016

Nanoobjects integration
In surface engineering
(Nanotubes, nanowires, nanodots:)
- **Generation III PV cells.**
- Up and down solar Conversion
- advanced thermoelectric Devices.
- Energy harvesting
  Heterogeneous assembling
- Polymer based fuel cells
- Solar concentrator
- „Power“ batteries for hybrid vehicle

2020+

Nanoobject integration in bulk materials & assembling.
- Hydrogen storage.
- High temperature electrolyser.
- **Solide Oxide Fuel Cells for stationary applications**

Integration of very high performance environmental Barriers
- High temperature turbine blades

Source: MINAM