

# MEMS Energy Harvesting Devices, Technologies and Markets

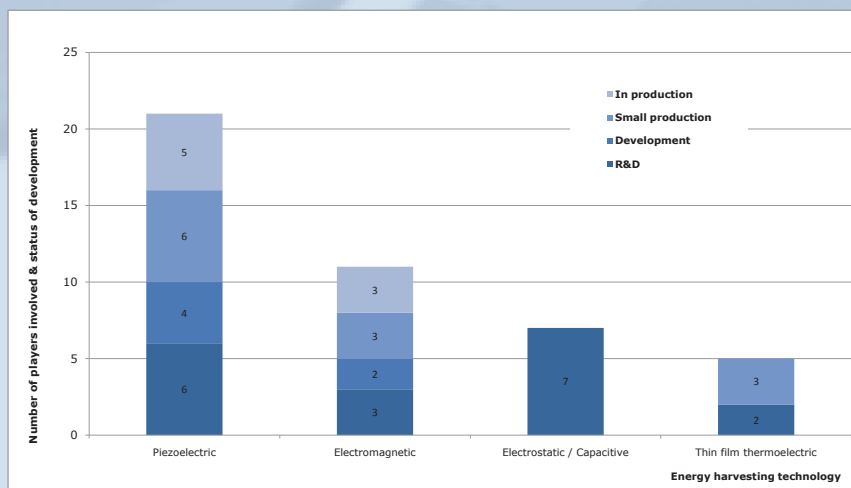
*Market driver analysis for challenges that go beyond energy density!*

## OBJECTIVES OF THE REPORT

**This report focuses on MEMS energy harvesting devices from both technology and market points of view.**

Special attention has been given to the market drivers for adopting MEMS energy harvesting devices in different market segments, factoring the progress of competing technologies and cost constraints.

It appears that the numerous opportunities for energy harvesting devices must be analyzed carefully, taking into account all aspects of the final application from power consumption profiles to lifetime and size constraints. Applications screened cover automotive, medical, industrial machine monitoring and process control, home automation and defense. The main developments in MEMS energy harvesting



*Number of developments for the main energy harvesting technologies (2009)*

devices are described and compared to fuel cells and micro-batteries. The report also describes the challenges facing the current players and the current market trends and business models.

## MAIN CHALLENGES

**Within an environmentally conscious world, MEMS Energy harvesting devices promise in principle a cleaner and almost perpetual solution to powering small systems avoiding the use and waste of polluting batteries.**

Ever optimistic market projections are predicting billions of dollars in revenue for ubiquitous sensor networks in the next five to ten years and derive from these numbers large energy harvesting sales and volumes.

And indeed, MEMS energy harvesting devices have been a hot topic in MEMS R&D for some years with spectacular developments driven by DARPA programs within the Hi-MEMS cyborg insects.

The reality is that beyond the technological buzz, commercial applications are slowly starting to get to market for industrial applications and home automation appliances. This is driving the first volumes for energy harvesting applications, but

not necessarily at the micro scale. Hot market segments in 2007 and 2008 such as tire pressure monitoring systems where batteries are currently the dominant solution have driven enormous efforts but the market dynamics have not made it possible to accept a premium price for alternative solutions.

We have focused our efforts in this report into a fine analysis of the market drivers for using MEMS energy harvesting devices, in comparison to micro batteries, micro fuel cells, or even solar cells. Different application fields from medical to home automation, industrial process control, machine monitoring or automotive have been analyzed in this report.

The challenges facing this technology were examined in a broad view, from a technology but also from a whole product point of view. There are needs for better power density but also for less power consuming electronics and wireless communications!

## MARKET METRICS

**Market acceptance of MEMS energy harvesting devices is a function of several parameters that are studied in the report.**

These parameters include, but are not limited to: size, cost, amount of power generated versus amount of power needed by the system and projected lifetime for the energy harvesting device compared to the system parts lifetime.

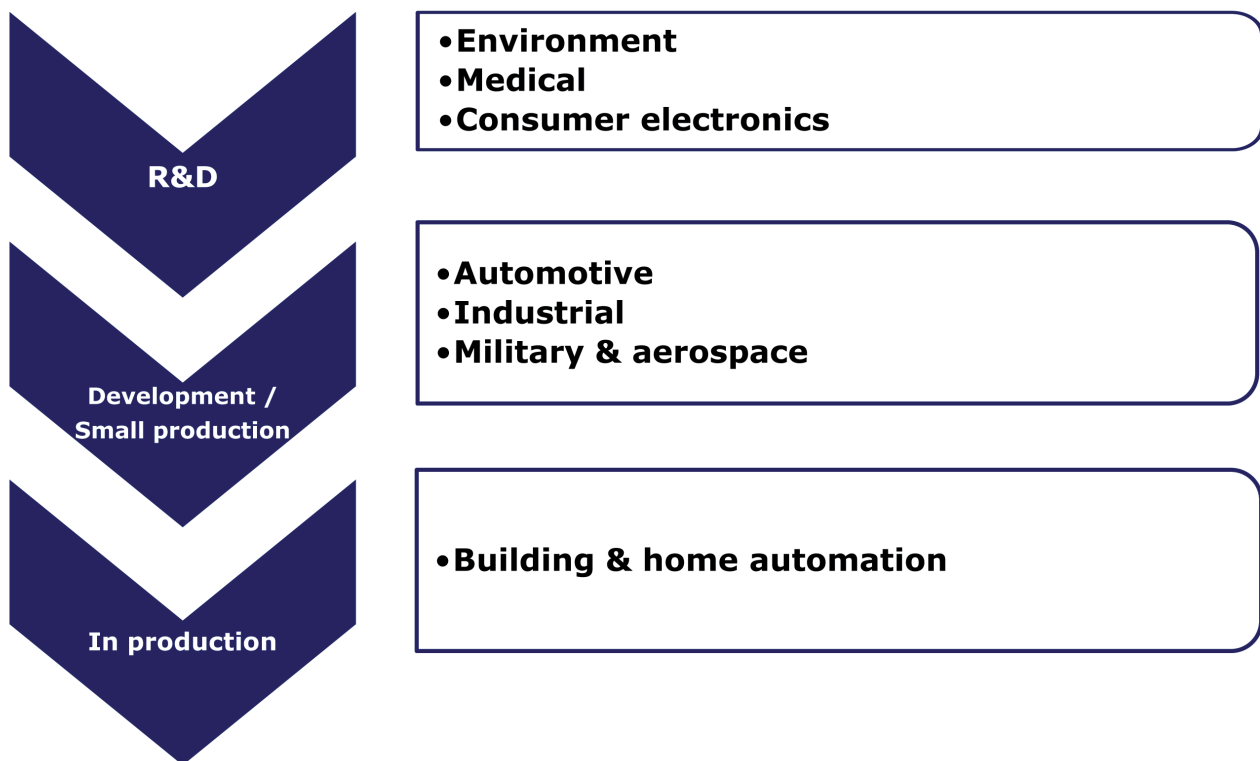
A major factor to be taken into account is whether there is enough power harvested for a particular application from a particular environment, and

whether the scavenged power needs to be stored. As piezoelectric MEMS energy harvesting devices can currently power sensor nodes requiring 60 uW according to the latest developments, a companion energy storage device would be necessary for most applications.

Commercial success will come from a full understanding of all aspects of the system to be powered and of the data receiver nodes.

Challenges include ultra low power electronics and wireless data transmissions rates and standards.

### STATUS OF ENERGY HARVESTING DEVICES\* IN THE DIFFERENT APPLICATION FIELDS, 2009



\* Only vibration and thin film thermal energy harvesting technologies are considered; Photovoltaic is not taken into account

## REPORT HIGHLIGHT

- 21 applications evaluated
- Global overview across 7 fields : automotive, industrial, building & home automation, environment monitoring, military & aerospace, medical, consumer electronics
- 14 company profiles
- 180 + slides
- Analysis of piezoelectric, capacitive, electromagnetic vibration energy harvesting and thin film thermal energy harvesting
- Review of the latest developments in energy storage devices (microbatteries...), wireless communication technologies and wireless sensor networks

## COMPANY PROFILES

### Main players and status

AdaptivEnergy, EnOcean, Holst Centre, Lumedyne Technologies, MEMS@MIT, Micropelt, Microstrain, Morgan Electro Ceramics, Piezo TAG, PMG Perpetuum, Thermo Life, TPL Micropower, Transense Technology, Visityre.

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- **Conclusion**

## BIO



**Ridha HAMZA** joined Yole Développement in April 2007, as Project Manager MEMS devices and Technologies.

He has been involved since 1998 in MEMS EDA developments with various companies. He earned a Master of Science in Electrical Engineering.



**Laurent Robin** works at Yole Développement on marketing & technology analysis in the fields of MEMS and advanced packaging.

He earned a master degree of marketing and technology management and a science master degree in physics, with a specialisation in micro-technologies.

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Our commitment is to facilitate market access for innovative technology, devices, equipment and materials in the disruptive semiconductor businesses. Founded in 1998, Yole Développement is involved in the following fields, with strong leadership worldwide:

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- Nanomaterials
- Photovoltaic
- Microfluidics
- 3D IC/TSV & Advanced Packaging

Our services and publications:

- Market research
- Technology analysis
- Strategy consulting
- M&A support and due diligence
- Magazine Publication Micronews (print version and on line services)
- Exclusive newsletters in MEMS, 3D IC, photovoltaic, compound semiconductors and microfluidics
- Market reports & Database

Yole Développement is the world leader in the analysis of disruptive semiconductor applications and markets. Each day, Yole Développement's team of 20 market analysts is in contact with industrial companies, R&D institutes and investors worldwide in order to help them understand the market and technology trends. In its analysis, Yole Développement takes into account the complete value chain including materials, equipment suppliers, device & system manufacturers and end users.



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1. Scope  
1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. ANY ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY OBJECTED TO BY THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

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2.1 Products are sent by email to the Buyer:

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2.5 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer's risk.

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3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

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4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

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