



AGENCE D'ETUDES ET DE PROMOTION DE L'ISÈRE

# Grenoble isère-france

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AEPI

## New energy technology Micro energy sources for mobile devices

Grenoble-Isère boasts assets of national and European standing in new energy technology. It has **500 jobs in research**, distributed between CEA, CNRS and local universities. Some **900 students** are enrolled on higher education courses at INPG, UJF and UPMF. Jobs in industry total about **10,000 jobs**, in firms such as Air Liquide and Axane, Alstom, Atos Origin, Photowatt, Schneider Electric, MGE UPS SYSTEMS, Sogreah and Gaz Electricité de Grenoble. There are also a large number of subcontractors involved in metal-working, information technology and software, instrumentation and mechanical engineering. All in all the area is ideally placed for new energy technology to become one of the most promising growth sectors in the years to come.

Embedded micro energy sources stand at the crossroads between technology advances in micro and nanotechnology and electrochemistry for energy materials. Researchers in Grenoble are developing micro energy sources, by taking advantage of their microelectronics know-how, applying to fuel cells the same fabrication techniques as for printed circuits and using materials more commonly associated with microelectronics, in particular for thin-film deposition.

Increasingly small portable electronic devices demand correspondingly small power supplies delivering greater reliability, more power and longer life. The priority markets are consumer devices, primarily cellphones and notebook PCs, but targets also include applications in defence, healthcare and security.

Micro energy sources for mobile devices are a highly specialized field with potential for massive growth, benefiting from Grenoble-Isère's internationally recognized assets in micro and nanotechnology.





# Grenoble-Isère and Europe

G R E N O B L E - I S È R E - F R A N C E



**Grenoble-Isère offers direct access to the major centres of industry. Grenoble-Isère has invested in communications infrastructures that secure connections of exceptional quality.**

- 200 km: 9 million inhabitants
- 400 km: 43 million inhabitants
- 600 km: 88 million inhabitants
- 1,000 km: 180 million inhabitants
- 1,400 km: 450 million inhabitants



# Introduction

G R E N O B L E - I S È R E - F R A N C E

A wide range of technologies are being deployed to cope with the problems associated with greenhouse gas emissions, dwindling reserves of fossil fuels and energy dependence. Grenoble-Isère, with its exceptional scientific and industrial heritage, has several key assets – from hydroelectric to nuclear power, and power management and transmission – for developing new technologies for applications in housing and business, industry and transport.

Rooted in a highly diversified scientific and industrial fabric of international standing, new energy technology in Grenoble-Isère can draw on long established know-how and skills in electrical engineering, physics, materials science, electrochemistry, hydroelectric power, chemistry, microelectronics and computer science.

Since the end of the 19th century the economic and technological development of Grenoble-Isère has been based on the growing importance of energy technology, initially based on hydroelectric and then nuclear power.

In 1869 Aristide Bergès, the first Frenchman to harness hydroelectric power, started using the energy produced by mountain streams. His discoveries led to the development of a wide range of activities related to electricity production: turbines, penstocks, cables, electrical equipments, etc., marking a major turning point in the region's industry. After the second world war France's Atomic Energy Commission (CEA) took over a former army artillery range on the outskirts of Grenoble. It built first one then two nuclear reactors, providing the basis for experimental work carried out by the physicist Louis Néel, who specialized in magnetic bodies.

The two activities – hydroelectric and nuclear power – led to the acquisition of a wide range of specialist know-how in Grenoble-Isère's universities, research centres and firms.



## EnRRDIS

The Rhône-Alpes Drôme, Isère, Savoie Renewable Energies (EnRRDIS) centre of excellence focuses on all aspects of the development of new energy technologies. Certified in 2005, it has a nationwide reach, covering five specialist fields related to energy: solar power, hydraulic power, biomass, hydrogen and fuel cells, and electricity networks. It addresses the transformation of renewable energy sources into power vectors and their use in construction and transportation. Rhône-Alpes has all the necessary skills – in industry, research and training – to specialize in renewable energy. Several companies from Grenoble-Isère are part of the cluster EnRRDIS, among which there are Air Liquide, Alstom, Atos Origin, Gaz Electricité de Grenoble, Invensil, MGE UPS SYSTEMS, Photowatt, Schneider Electric, Sogreah and Thales. The Grenoble universities and their research laboratories along with CEA and CNRS are deeply involved.



## Main players in research

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### CEA/Liten

The CEA Laboratory for New Energy technology and Nanomaterials (Liten) accounts for almost 300 people, mainly located in Grenoble. It has two departments:

- The New Energy Technology Department (DTEN) studies materials, from high-temperature materials to components (bipolar plates in fuel cells, innovative membranes, etc.). It is also developing several miniature energy sources (micro fuel cells and batteries, thermoelectricity).
- The New Energy Systems Department (DSEN) studies components and their assembly to form complete systems (hydrogen, fuel cells, photovoltaic devices and energy in building).

CEA Grenoble is exploring three main lines of research into new energy technology: transport, housing and business premises, energy sources for mobile devices.

### STMicroelectronics

The world's fifth largest semiconductor manufacturer, in 2005, STMicroelectronics operates two facilities in Grenoble-Isère with more than 5,000 jobs, including 2,000 in R&D. The Crolles centre develops and produces advanced system-on-chip (SoC) technologies, as well as circuit development platforms and tools for the rest of the group. Grenoble is home to the headquarters of the most important divisions in consumer applications: cell phones, imagers, digital decoders, etc., and to the divisions designing software tools and processor cores. R&D work in the Grenoble-Isère divisions is carried out in close collaboration with laboratories at the CEA and Grenoble universities.

### Lepmi

The Electrochemistry and Physical Chemistry of Materials and Interfaces Laboratory (Lepmi) is a mixed basic research unit (UMRF) affiliated to CNRS, UJF and INPG. It comprises 130 people including 50 researchers and faculty members, working on the storage and electrochemical conversion of energy, materials and nanomaterials of electrochemical interest, and how best to characterize and model them.

### Micro fuel cells

■ **CEA/Liten.** Micro fuel cells are not just miniature versions of conventional fuel cells. They represent a genuine technology breakthrough based on the use of thin-film processes, or in other words the application of microelectronics techniques to electrochemistry. In simple terms miniature electrical generators are implanted on a silicon substrate. Ultimately the corresponding storage device, using hydrogen contained in a hydride, will take the form of a disposable recharge.



Micro fuel cells have power outputs ranging from 1 watt to 10 watts. A single recharge provides about 10 hours' autonomy, two or three times better than for a conventional lithium battery. For wireless terminals, which use a great deal of

energy, hybrid systems powered by micro fuel cells and lithium batteries will be required.

An industrial consortium involving a chip manufacturer for the silicon core, a manufacturer of disposable objects for the hydrogen cartridge and a cellphone manufacturer is being set up. This exceptional consortium consists of specialists in fuel cell cores and recharges. The partnership, the only one of its kind in the world, brings together about 30 people. Preparation for industrial production of micro fuel cells will be complete within two or three years.



■ **STMicroelectronics**, of which the Grenoble centre is tasked with developing microprocessors for wireless terminals, energy microsystems and firmware, is working closely with CEA on micro fuel cells. The centre has been working on miniature power supplies for mobile devices for the last 15 years and has contributed to research by Liten leading to development of micro fuel cells. In all 10 people are doing R&D work for this technology. Grenoble is home to STMicroelectronics' only business unit dedicated specifically to energy management for wireless terminals and optimization of power consumption for consumer wireless multimedia devices. It is also involved in a wide range of projects with other local players such as France Telecom, Sun, Xerox and the National Institute of Applied Computer Research (Inria).



■ The Electrochemistry and Physical Chemistry of Materials and Interfaces Laboratory (**Lepmi**) is studying two types of micro fuel cell: devices that run on liquid methanol; and others that work with cartridges containing hydrogen stored in the form of metallic hydrides (magnesium nanocomposites).

## Batteries for mobile devices

Annual battery production worldwide currently stands at about 1.5bn units to cater for the growing demand created by the spread of cordless consumer electronic devices such as cameras, phones and notebook PCs. Nickel-cadmium batteries still dominate the market but lithium and lithium-ion alternatives are proving increasingly promising.



### ■ Microbatteries

Drawing on its skills in the various fields involved – energy, electrochemistry, materials, microelectronics – CEA-Liten is working on the development of lithium-ion micro-batteries to power tomorrow's communications devices. More specifically it is researching very thin-film micro energy sources suitable for powering smart cards, RF ID tags that communicate with their environment, and microdrones. Such lithium-ion micro-batteries could be integrated in a wide range of media, including textile fibres or paper.

To realize this technology CEA has set up a consortium with HEF, a company based in Saint Etienne specializing in surface processing. CEA is also working with Leclanché, a battery specialist. A pilot pre-production unit is being set up in Rhône-Alpes. Other partnerships are underway with STMicroelectronics facilities, in Crolles and Le Rousset, and other equipment manufacturers.

In 2003 HEF, based in Saint Etienne, and CEA-DTEN, in Grenoble, set up a joint research centre to produce rechargeable micro power sources and integrate them in mobile devices. In view of the size of the market for smart cards, work focused mainly on integrating a microbattery in a smart card. Integrating the power source with the device would enhance security. It would also cut fabrication costs, thanks to the use of microelectronics processes, and reduce weight and volume.

### ■ Minibatteries

Lepmi has been researching lithium mini-batteries for a long time. They remain extremely promising, particularly lithium-ion batteries, which use a solid polymer electrolyte that delivers performance twice as good as the nickel-cadmium equivalent. Lepmi is developing new materials for lithium-ion batteries, widely used in mobile devices. The aim is to avoid any variation in volume and allow rapid recharges, so that batteries last longer and charge more quickly. Other research topics include polymer electrolytes, aqueous or gelified electrolytes, membranes and in particular ways of thinning the layer of platinum currently used.

Some 35 people work on energy storage at CEA-Liten. This field covers photovoltaic power, fuel cells and micro energy sources. Work at CEA-Liten focuses on:

- lithium-ion mainly, one of the prime objectives being to replace, in the foreseeable future, the lead batteries used in electrical vehicles and in association with photovoltaic units. Tomorrow's low-cost lithium-ion batteries would cater for demands for high intrinsic security and increased capacity and/or power.
- the architecture, materials and components of quick-charging batteries for applications in smart cards, electrical vehicles and hybrid batteries.



### ■ Thermoelectric components

The thermoelectric effect is used in cooling systems and energy sources. In the first case it overcomes heat problems. In the second the electrons produced by the temperature differential provide a way of recovering electrical energy. Work on this technology, which has existed since the beginning of the 20th century, started at CEA in 2003 for microelectronics applications.

Components can also be cooled. They thus gain in autonomy and are lighter and more reliable. They can also be combined with micro-batteries. Partnerships involving STMicroelectronics and US chip manufacturers are working on this topic.

All these technologies link up with basic research being carried out on nanocomponents, carbon nanotubes, nanowires, etc., in partnership with Leti-CEA for applications in micro and nanotechnology and micro energy sources.



## Companies

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### STMicroelectronics

STMicroelectronics, one of the world's top five manufacturers of semiconductors, is a world leader for the development and production of silicon-based solutions for a wide range of applications such as low-power portable multimedia terminals, 3D graphics platforms, consumer digital systems, and network processors for broadband communications infrastructures. It has a total workforce of 48,000 people, working in 16 advanced research units, 39 design and applications centres, 16 production facilities and 88 sales offices. It is represented in 31 countries. STMicroelectronics operates two centres in Grenoble-Isère accounting for almost

5,000 jobs: the Grenoble site dedicated to product design; and the Crolles site for R&D and fabrication activities. The Crolles 2 Alliance facility, jointly developed by STMicroelectronics, Freescale (semiconductor division of Motorola) and Philips, aims to consolidate the three firm's dominant position in CMOS technology for the next three generations of chip on 300mm wafers. Some \$1.4bn is being invested in the Alliance initiative.



In the field of micro energy sources research at STMicroelectronics is focusing on production of an integrated microbattery demonstrator for use with a secure smart card.

### Paxitech

Paxitech is a CEA spin-off, incorporated in September 2003. It specializes in deposition on membranes (active components) for mobile fuel cells used in laptop computers and CD drives. Its trade focuses on fuel cell cores and side-by-side architectures, as opposed to stacks. Paxitech is also developing suction fuel cells. These low-cost consumer devices are small, flat and light. They consist of layers of electrical conductors and plastic diffusers. They can be integrated in embedded devices used at sea or in the mountains and fitted with a hydrogen reservoir.



# Training in new energy technology

G R E N O B L E - I S È R E - F R A N C E

Grenoble-Isère universities are well known for the excellence of their science courses, which attract many foreign students. A total of 60,000 students are enrolled at Université Joseph Fourier (UJF), specializing in science, technology and medicine, the National Polytechnical Institute of Grenoble (INPG), Université Pierre Mendès-France (UPMF) specializing in human and social science, Université Stendhal, languages and literature, the Grenoble School of Management and many other public and private schools of higher education.

These universities are key players in Grenoble's economic development, rooted in the region's scientific and industrial life since the discovery of hydroelectric power. The first public course in industrial electricity was taught in Grenoble in 1892, laying the academic foundations for the first INPG school, the Institute of Electrotechnology.



■ INPG, with a total of some 5,000 students, has four schools working in fields related to energy technology – Ensieg for electricity, Enseeg for electrochemistry, ENSHMG for hydraulics and mechanics, and ENSPG for physics. It aims to build on the synergy existing between these schools to develop an energy competency centre, drawing on the other schools in the group and partnerships with higher education establishments elsewhere in the Grenoble area.



- Grenoble's Graduate School of Electrical Engineering (Ensieg) trains future engineers in the control of energy, signals and systems, for jobs in energy and information technology, and production systems. It has a total intake of 525 students.
- Grenoble's National Graduate School of Electrochemistry and Electrometallurgy (Enseeg) trains specialists in materials science and engineering, surfaces and interfaces, electrochemistry and process engineering for jobs involving applied physics and chemistry. It has a total intake of 330 students.
- Grenoble's National Graduate School of Hydraulics and Mechanics (ENSHMG) has a total intake of 450 students, divided into two departments: fluids and mechanical engineering; and hydraulics and the environment.
- Grenoble's National Graduate School of Physics (ENSPG) trains engineers in fields related to materials, biotechnology, energy management and nuclear power, optics and microelectronics, instrumentation and sensors. It has a total intake of 400 students.

■ Université Joseph Fourier (UJF), with 18,000 students, covers all the main scientific fields: mathematics, computer science and information technology, physical and engineering science, chemistry, life science and medicine, science of the Earth and the universe, human and social science. For courses focussing on energy UJF generally joins forces with INPG.

■ Université Pierre Mendès-France (UPMF), which specializes in human and social science, teaches a total of 19,000 students. Its Economics, Strategy and Enterprise research unit offers two specific courses on energy and energy policies, addressing the key issues facing the world today.



The following table details all the energy-related courses taught by vocational secondary schools, INPG, UJF and UPMF. Here it includes:

- All forms of energy: fossil fuels, nuclear, hydraulic and photovoltaic power, fuel cells, etc.,
- Materials for energy production,
- Energy transmission and distribution, and the associated information systems,
- Energy policy.

## 1. Initial training

School/ Component	Option/course	Degree	Number of students	Training target occupation
<b>Lycée Technique R. Deschaux Grenoble</b>	Fluids, energy, environment specializing in climatic engineering	BTS	24 students	Training target occupation.
<b>Lycée Galilée Vienne</b>	Electrical engineering specializing in intelligent housing	BTS	25 students	Intelligent housing technicians.
<b>UJF/IUT1</b>	Thermal engineering and energy	DUT	130 students	Thermal engineering technicians
<b>UJF/IUT1</b>	Thermal engineering and energy management	Professional Bachelor's	36 students	Sales engineers for climate control, heating, renewable energy, etc.
<b>UJF/IUT1</b>	Electricity and electronics specializing in electrical distribution and automation systems	Professional Bachelor's	28 students	Electrical distribution and system automation specialists
<b>UJF/IUP</b>	Electrical engineering and industrial computing specializing in power electronics and high-frequency circuits	Technology engineer	80 students	Electrical engineering and electronics specialists
<b>UJF/INPG/ INSTN/ UCB Lyon1</b>	Engineering, traceability, sustainable development specializing in drainage and dismantling nuclear facilities	Professional Master's	13 students	Nuclear power industry engineers
<b>Lycée Technique R. Deschaux UJF/ENSPG/ INSTN/UCB Lyon1</b>	Engineering, traceability, sustainable development specializing in scientific and technological management of radioactive waste	Professional Master's	15 students	Nuclear power industry engineers
<b>UJF/INPG</b>	Engineering, traceability, sustainable development specializing in acoustics and industrial heat engineering	Professional Master's	Opening in 2005	Heating, acoustics, structural engineering specialists
<b>ENSIEG/UJF</b>	Electrical engineering, electronics, automation and signal processing specializing in design of electrical energy systems	Professional Master's	15 students	Electrical network study and design

School/ Component	Option/course	Degree	Number of students	Training target occupation
<b>INPG/UJF</b>	Physics and engineering specializing in modelling and simulating industrial physical systems	Professional Master's	13 students	R&D engineers, specialists in digital modelling techniques and methods
<b>UPMF</b>	International economics and strategy specializing in: corporate governance for international development (incl. energy policy and the political economics of energy)	Professional Master's	15 students 15 degrees per year	Experts in decision aids and appraisal for national and international, public and private organizations
<b>ENSIEG</b>	Electrical energy <ul style="list-style-type: none"> <li>•Production, transmission, distribution of electrical energy</li> <li>•Power electronics</li> <li>•Decentralized production and energy storage</li> <li>•Designing, producing and managing electrical engineering</li> <li>•Control and diagnosis of electrical systems</li> </ul>	Engineer*	270 students 90 degrees per year Opening in 2005	Engineers in design, control and management of electrical systems, from components to complete networks and including conversion
<b>ENSIEG ENSHMG ENSEEG ENSPG</b>	New energy technology <ul style="list-style-type: none"> <li>•Organization of energy systems and procurement</li> <li>•Dependability and management of energy computer systems</li> <li>•Energy marketing management</li> </ul>	Engineer*	180 students 60 degrees per year	Engineers in design, control and management of hybrid energy systems in the energy international market
<b>ENSHMG</b>	Energy engineering and processes	Engineer*	60 students 30 degrees per year	Engineers working in design of complex mechanical systems involving fluids and their industrial application.
<b>ENSPG</b>	Electrical engineering and nuclear power	Engineer*	66 students 33 degrees per year	Current needs of nuclear power industry
<b>INPG/UJF</b>	Mechanical and energy engineering specializing in physical energy management	Research Master's	17 students 17 degrees per year	Specialists in materials for energy and heat transfer

\* Engineering degrees may be obtained as part of initial training or via continuous training.

School/ Component	Option/course	Degree	Number of students	Training target occupation
<b>INPG/UJF</b>	Mechanical and energy engineering specializing in fluid mechanics and transfer	Research Master's	15 students 15 degrees per year	Specialists in energy transfer at interfaces
<b>INPG/UJF</b>	Electrical technology, electronics, automation and signal processing specializing in electrical engineering	Research Master's	20 students 20 degrees per year	Specialists in electrical engineering and energy management
<b>INPG/UJF</b>	Materials and process engineering specializing in materials science and engineering, process engineering, electrochemistry	Research Master's	50 students 50 degrees per year	Specialists in: materials for energy saving, electrochemical reactions
<b>UPMF</b>	International economics and strategy specializing in economics and international policy (option: sustainable development)	Research Master's	15 students 15 degrees per year	Project and development managers in international public and private organizations

### TOTAL Training courses in new energy technology:

**4 engineering courses**, including one started in 2005

**5 research master's degree courses**, covering seven specializations

**6 professional master's degree courses**, including one started in 2005

**1 technology engineering course**

**2 professional bachelor's degree courses**

**1 DUT technician's course**

**2 BTS technician's courses**

**900**  
students

**700**  
degrees per year

**20**  
theses presented per year

## 2. INPG continuous training department

MIDEP Electrical engineering option	Continuous training degree, grade 2	Project managers for electrical energy production and distribution systems
FORMATECH Electrical engineering option	Continuous training degree, grade 2	Technical managers in energy, from components to electrical networks
Specialist course Specialization in hydraulic machines		
Specialist course Choosing electrical equipment in an industrial context		
Specialist course Introduction to nuclear power		





## A dynamic area

G R E N O B L E - I S È R E - F R A N C E



Lyon - St Exupéry airport



### Grenoble-Isère: a quality environment

■ A region of manageable size, with 1.1 million inhabitants and 467,900 salaried jobs, located at the heart of Rhône-Alpes.

■ Population of 9 million consumers living within a 200 km radius.

■ Fully-developed transportation network: highways, TGV, international airports.

■ Fabric of industrial companies with organizations of all sizes working together, numerous foreign firms, a wide range of activities.

■ Renowned higher education, especially in sciences. 4 universities, 60,000 students.

■ Exceptional concentration of public and private research centres. First research area after Paris region. 19,000 researchers.

■ 4 international research centres: EMBL, ESRF, ILL, Iram.

■ 9 national research organizations: CEA, CEN, Cemagref, CNRS, CRSSA, Inra, Inria, Inserm.

■ International stature:  
- 400 companies with foreign capital creating 41,000 jobs,  
- accommodations for foreign newcomers: international schools, clubs and companies specialized in helping foreign managers and their families adjust to their new lives here.

■ Exceptional environment: at the heart of the Alps (34 ski resorts, at less than 1 hour's drive away), near Switzerland and Italy, 250 km from the French Riviera. A lifestyle that combines the pleasures of the urban and cultural life of Grenoble, Lyon and Geneva with sports and outdoor recreational activities.

■ Facilities for setting-up new companies, adapted to all types of projects. Grenoble-Isère can offer a wide range of solutions, with more than 1,500 hectares of fully-equipped sites, and industrial and office space of all sizes, available for rent or for sale.

**All these advantages contribute to the reputation of Grenoble-Isère, and have led numerous national and international companies and research centres, to locate here.**



■ Industry leaders:

**Agri-food industry:** Aoste, Danone, Sodiall (Candia/Yoplait)

**Medical and pharmaceutical activities:** BD, bioMérieux, Patheon, Roche Diagnostics, SkyePharma

**Chemicals:** Arkema, Rhodia

**Electrical construction:** Arnould FAE, MGE UPS SYSTEMS, Schneider Electric

**Energy:** Alstom, EDF, Gaz Electricité de Grenoble, Sogreah

**Sports and leisure equipment:** Petzl, Rossignol/Quiksilver

**Mechanical engineering:** A.Raymond, Caterpillar, Poma, Valeo

**Paper manufacturing:** Ahlsrom, ArjoWiggins, Matussièrre et Forest

**Information and communication technologies:** Atmel, Atos Origin, Bull, CapGemini, Freescale, HP, Philips, Photowatt, Radiall, Silicomp, Soitec, STMicroelectronics, Thales

**Textile:** Hexcel, Mermet, Porcher

**Metalwork:** Alcan, Ascométal, Federal Mogul

# Grenoble-Isère: well connected to European countries



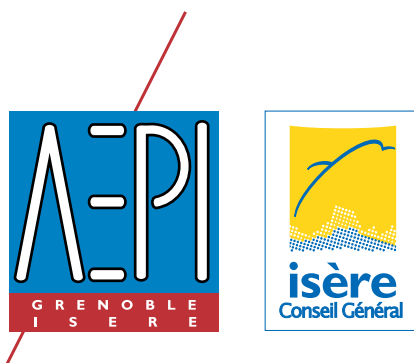
# The Isère economic development agency, AEPI

- An instrument serving the department and its various components,
- An interface between local, regional, national and international economic players,
- A resource centre for industrial, scientific and institutional players in the Grenoble-Isère economy.

**AEPI is funded entirely  
by the Isère Departmental Council.**

Missions serving the interests of the community:

- Development of key technologies,
- Economic promotion of Grenoble-Isère,
- Prospection of companies in France and abroad,
- Reception and location of firms in Grenoble-Isère,
- Economic studies and information.



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