R&D ON ENERGY AT THE UPC

2023

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

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01 THE UPC

The Universitat Politècnica de Catalunya (UPC) is a public institution of research and higher education in the fields of engineering, architecture, sciences and technology, and one of the leading technical universities in Europe.

The UPC participates in the innovation system of Catalonia with projects and contracts for research, development, valorization of knowledge and commercialization of technology.

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RESEARCH, DEVELOPMENT AND INNOVATION ACTIVITY AT THE UPC 2022

141
Research groups

15
TECNIO Research centers

305
PhD theses

78,1 M€
Projects income

1.011
Ongoing research, development and innovation projects

2.526
Magazine articles

1.422
Contracts

13
Registered patents

6
New UPC spin-offs

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02 ENERGY

Energy is the ability to perform work, that is to say, the intervention of energy is necessary to do anything that involves a change, such as a movement, a temperature variation, a transmission of some, etc.

In the field of research, development and innovation (R+D+I), there are several areas and disciplines related to the field of energy.

MANIFESTATIONS AND ENERGY SOURCES

KINETIC ENERGY

Kinetic energy is the ability to do work associated with the movement of bodies.

THERMAL ENERGY

Thermal energy is the manifestation of kinetic energy, the sum of the microscopic contributions of the particles that make up a substance, related to the temperature of the substance.

POTENTIAL ENERGY

The **potential energy** accumulated in certain circumstances according to the specific configuration of a body with respect to a system of bodies. So, bodies have the capacity to do work, even if they are not in motion and without taking into account the amount of thermal energy they possess due to the agitation of their molecules.

ENERGY SOURCES

There are several sources of energy: **wind** (when it comes from the wind), hydraulic (when it comes from water), **solar thermal** (when the heat from the sun's rays is used) and **solar photovoltaic** (when the sunlight into electricity). We also have other non-renewable energy sources such as oil, natural gas and coal and uranium (nuclear energy). A separate case is electrical energy, and its accumulation and storage.

Basic concepts (Termcat)

Renewable energy

"Energy that is obtained from inexhaustible or renewable sources. For example, wind energy, solar thermal energy, photovoltaic solar energy and biomass energy are considered renewable energies."

Nonrenewable energy

"Energy that is obtained from exhaustible or non-renewable sources. For example, fossil fuels, because their formation process lasts millions of years; nuclear fuels, because they are limited, and agrofuels, because they compete with food, require a high volume of fertilizers and pesticides, and are produced in monocultures."

Energy efficiency

"The degree to which an optimal relationship is achieved between the resources used in energy management and the results obtained."

Electrification

"Transformation of an activity or a sector so that its main source of energy is electricity, as an alternative to burning fossil fuels."

Energy transition

"Progressive abandonment of energy that comes from fossil fuels in favor of energy that comes from renewable energy sources."

03

RESEARCH AND INNOVATION

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Since 2010, the Universitat Politècnica de Catalunya (UPC) has been the main partner of one of the first knowledge and innovation communities funded by the European Commission: EIT InnoEnergy.

One of the tools derived from these projects was the systematic collection of information on the energy research capacity of the UPC's different centers and collectives.

The result of this effort is this document, which briefly and synthetically summarizes a first approximation of the University's Energy Research Map.

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Activity examples I

Modeling and control of complex systems, as well as in its application to problems related to the network and automotive systems.

Research into architecture from an environmental point of view, considering the environmental parameters that affect human comfort and perception, as well as the impact that construction can have on cities and the environment.

Analysis and design of structures with the development of conceptual and numerical models and the performance of tests to evaluate the safety, functionality and durability of structures under static loads, seismic and environmental actions.

Obtaining useful nuclear data to improve **knowledge of the nuclear fuel cycle** during the operation of nuclear power plants and in the transmutation of radioactive waste, preserving nuclear safety.

Consolidation and improvement of skills in the field of **nuclear power plant simulation** to independently analyze possible scenarios in the power plants.

Network monitoring and traffic analysis, digital identity and electronic signature, energy efficient networks and nano-communications.

Activity examples II

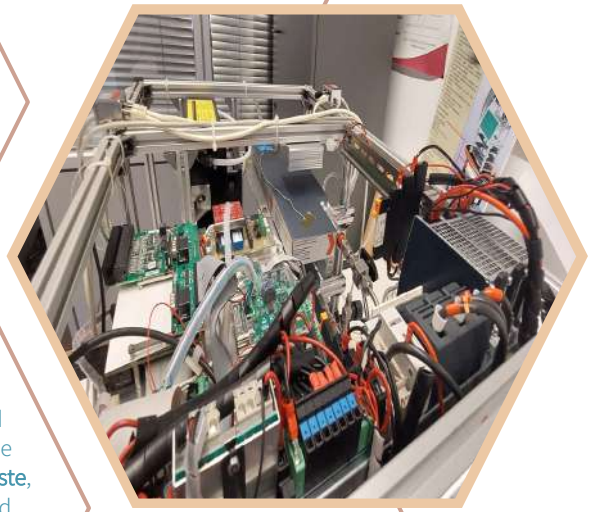
Study of the excitations generated by a fluid and the structural response to determine the vibrational behaviors and deformations in hydraulic turbomachines.

Design, obtaining and **characterization of new ferroelectric materials** based on low environmental impact oxides for energy harvesting and storage.

Creation of **new structures of electric machines** fed through power converters for energy saving in electric drives.

Obtaining models and multi-criteria tools for the design of **isolated electrification systems** with renewable energies, thus ensuring that the solutions obtained are efficient and sustainable over time.

Development of sustainable and innovative biotechnologies for the **treatment of water and organic waste**, which eliminate conventional and emerging pollutants and which can produce bioenergy.



Development of **thermal systems** that allow sustainable growth, minimizing the consumption and impact of conventional energies.

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UPC RESEARCH GROUPS IN ENERGY

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UPC RESEARCH GROUPS IN ENERGY

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SPECIFIC UPC RESEARCH CENTERS

AGROTECH - Specific Center for Research in Agricultural Technology

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CatMech - Advanced Center of Mechanical Technologies

[illegible]

CD6 – Sensors, Instrumentation and Systems Development Center

[illegible]

CEBIM – Molecular Biotechnology Center

[illegible]

SPECIFIC UPC RESEARCH CENTERS

CER-H2 – Specific Hydrogen Research Center

CPSV – Policy Center of Soil and Valuations

CRAL – Center for Research and Services for Local Administration

CREMIT – Motors and Installations Research Center

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SPECIFIC UPC RESEARCH CENTERS

CS2AC – Supervision, Security and Automatic Control

[illegible]

LIM – Maritime Engineering Laboratory

[illegible]

PERC-UPC – Power Electronics Research Center

[illegible]

SSR-UPC – Smart Sutainable Resources

[illegible]

04

UPC EXCELLENCE PROJECTS

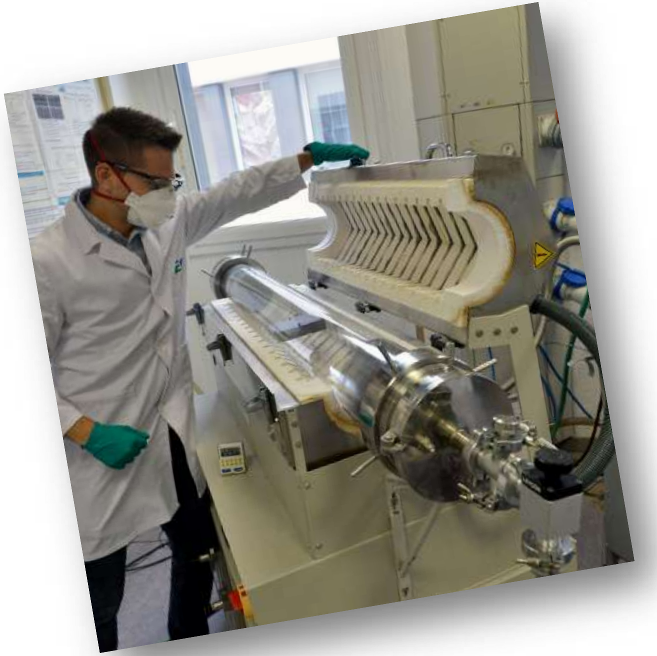
In this document, projects of excellence are considered those in which:

- The scientific process is rigorous and meets high quality standards.
- They are strategic and tractors.
- They acquire a commitment to social challenges and have a great scientific and socio-economic impact.
- They have an impact on the territory.
- They have different entities participating in the quadruple helix, which makes the projects multidisciplinary.

UPC excellence projects are financed by various programs, such as the State Plan or Horizon Europe.

FLEX4FACT - Industrial Cluster FLEXibility platform for sustainable FACTories to reduce CO_2 emissions and to enable the Energy Transition

UPC research group involved: CITCEA-UPC - Center for Technological Innovation in Static Converters and Drives



SENSATE - Low-dimensional semiconductors for optically tunable solar collectors

UPC research group involved: Department of Electronic Engineering

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Image courtesy of EF Solare Italia

SYMBIOSYST - Low-dimensional semiconductors for optically tunable solar collectors

UPC research group involved: Department of Agricultural Engineering and Biotechnology

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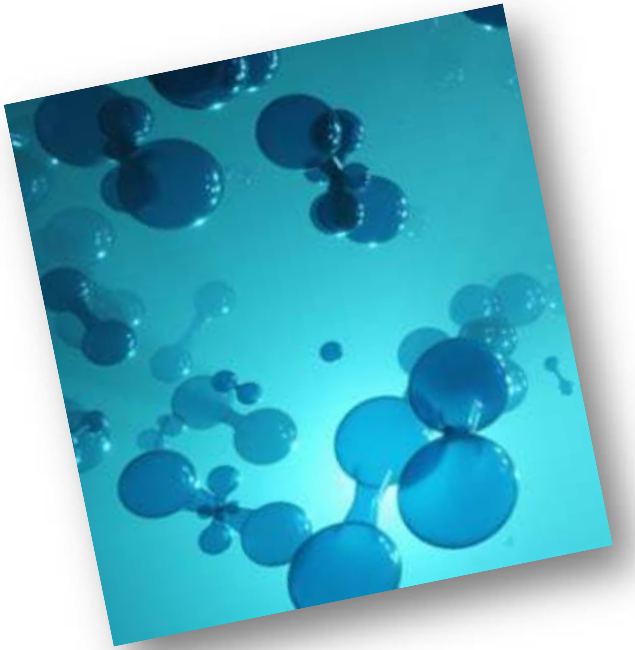

HYNTERCAT - Hydrogen energy technologies driven by interface engineering of amorphous/crystalline catalysts

The reasoning behind the HYNTERCAT project considers that, typically, the unique properties desired for a particular catalyst cannot be achieved by a well-defined ordered material alone, but requires a clever combination of crystalline and amorphous phases in a catalytic composite . In this project we will fabricate a new generation of catalysts for hydrogen production and purification reactions based on a controlled interface engineering approach of amorphous and crystalline phases aimed at creating unprecedented active sites with unique properties. Compared with the most studied crystalline materials, amorphous catalysts have the uniqueness of atomic-scale structural flexibility and abundance of defects, which are two important aspects in catalysis design.

UPC research group involved: INTE – Institute of Energy Techniques

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ADOreD - Accelerating the deployment of offshore wind using DC technology

This PhD consortium, ADOreD, will recruit and train 15 researchers collaborating with 19 academic and industrial organizations. It aims to address the academic and technical challenges in the areas of transmission of offshore wind energy to the AC grid by using AC/DC technologies based on power electronics. In doing so, it will equip researchers, through their doctoral studies, with the essential knowledge and skills to face a rapid energy transition in their future careers. The project covers 3 key aspects of research: offshore wind (including wind turbines, wind energy harvesting and wind farm design and control); DC technologies (including AC/DC converters, HVDC control and DC network operation and protection); and AC network (including stability and control of converter-dominated AC networks under different control modes.

UPC research group involved: CITCEA-UPC - Center for Technological Innovation in Static Converters and Drives

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MECATEN - Mechanochemical preparation of catalysts for energy applications: methane activation and hydrogen production

In this subproject, catalysts based on metals supported on inorganic oxides will be prepared using mechanochemical methods and their capacity to transform the methane molecule (natural gas) and for the photocatalytic production of hydrogen as an energy vector will be studied. We will study in detail the preparation of Pd-CeO2 catalysts as well as Pd-M-CeO2 bimetallic systems to achieve robust catalysts in natural gas transformation, and TiO2-supported transition metal catalysts for photocatalytic hydrogen production. Among other variables to be considered, supports of different morphology will be used to study the effect of the exposed crystallographic planes on the mechanochemical synthesis and on the catalytic behavior of the resulting materials, as well as preformed metallic nanoparticles with known properties.

UPC research group involved: INTE – Institute of Energy Techniques

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iPLUG - Distributed multiport converters for the integration of renewable energy, storage and load systems while improving the performance and resiliency of modern distributed networks

iPLUG proposes the development of new power electronics solutions based on multiport converters in order to improve the integration of multiple renewable sources, energy storage systems and loads. The proposed converters, installed in various optimal locations, can facilitate a massive integration of renewables by avoiding grid congestion and enabling the provision of functionality to both end users and the distribution network.

UPC research group involved: CITCEA-UPC - Center for Technological Innovation in Static Converters and Drives

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FusionCat – Fusion in Catalunya

It is an alliance to establish an active nuclear fusion community in Catalonia that includes leading research institutions, universities and industrial partners.

It consists of 11 original R&D projects, organized into 3 focused work packages based on recognized complementary fields of expertise. It aims to establish the transfer of technology from partners to industry in order to develop industrial skills in Catalonia for the realization of fusion energy.

UPC research groups involved:
Heat Transfer Technology Center (CTTC)
Nanoengineering of materials applied to energy (NEMEN)
Advanced Nuclear Technologies (ANT)

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Moyón, L. [et al.]. Early detection of main bearing damage in wind turbines. "Renewable energy and power quality journal", Setembre 2022, vol. 20, p. 773-777. https://futur.upc.edu/34202481 The article presents the application of a new algorithm to treat the data emitted by wind turbines and detect main bearing failures, which are an important concern to increase their reliability and availability.

Díaz-González, F. [et al.]. A hybrid energy storage solution based on supercapacitors and batteries for the grid integration of utility scale photovoltaic plants. "Journal of energy storage", 1 Juliol 2022, vol. 51, p. 104446:1-104446:16.
https://futur.upc.edu/34195856
This paper presents a 2-level controller that manages a hybrid energy storage solution (HESS) for grid integration of photovoltaic (PV) plants in distribution networks.

Coronas, S.; de la Hoz, J.; Alonso, À.; Martín, H. 23 Years of Development of the Solar Power Generation Sector in Spain: A Comprehensive Review of the Period 1998–2020 from a Regulatory Perspective. “Energies”, 2022, 15, 1593.
https://futur.upc.edu/32838751
The article provides a 23-year review of the evolution of the solar energy sector in Spain, highlighting both its boom and bust phases, driven by government policies and regulatory changes. It underlines the importance of support mechanisms and provides information for other countries pursuing renewable energy development.

Marti, J. [et al.]. Nucleation of helium in liquid lithium at 843 K and high pressures. "Materials", 13 Abril 2022, vol. 15, núm. 8, p. 2866:1-2866:18.
https://futur.upc.edu/33083794
This study investigates the behavior of lithium and helium mixtures under fusion reactor conditions, emphasizing the formation of helium droplets, a critical factor for reproductive mantle performance.

05 FORMACIÓ

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  ≝ ¤MŁÆaëŁ̈ŕŁ¤L̲ĖŘM¬ÕM¦ ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤L̲ Æéőŕ̈ŁĥëŁaŁÆĥL̲ĖŘMŸÕ ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤L̲ Æéőŕ̈ŁĥëŁaŁÆĥL̲ĖŘMŸÕ ˜ ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤Là²¤ĜMë² ÉĥL̲ Æéőŕ̈ŁĥëŁaŁÆĥL̲ĖŘMM ; ; Ł̈L̲ MŸÕ ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤Lí ² Æ¤ĥL̲Õëŕ̈ĥ¤ëĥMë² ¤Ĝ̲L̲ Ÿĥëőª ˆŵÑŕĥMıÕÉĥëŕ² vŵ ² ŁŕŁ¤MM ² Æ¤ĥL̲Õëŕ̈ĥ¤ëĥMáí ² Æ¤ĥL̲ Ÿĥëőª ˆŵÑŕĥMıĖŘMŸÕM==¬; rŒM ; ; Łt ŁM¬ÕM g ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤L̲ ĥÆ¦ MÉ² ëĥLŸĥëőª ˆŵÑŕĥML M¤Ñŕ¤ĥĥÆ¤ÑĖŘMÕMs Ÿŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LM¤uæÆ¦ ¤T¸ĥ¤L²MLM¤Ñŕ¤ĥĥÆ¤ÑŁ̲
  ŘMŸÕM==¬; Łt ŁM ; ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤L̲=ŭuŵMLM¤Ñŕ¤ĥĥÆ¤ÑĖŘMŸÕM==¬; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤Lí ŕ¤ĥÆ³ vŁ≈ĥM aÆéĥMLM¤Ñŕ¤ĥĥÆ¤Ñ²¤Ĝ̲L̲
  ≈ĥëŕ¤ëŵ¤ÑĖŘM¬ÕM ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤L̲ ÑÆ¦ ¤ ¸T¸ŕëLÕëŕ̈ĥ¤ëĥML̲M¤Ñŕ¤ĥĥÆ¤ÑL̲
  ŘMM ; ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤L; ˜ŕ ˆŵÑŕĥ² vÕ¬MÆĥT MLM¤Ñŕ¤ĥĥÆ¤ÑL̲
  ŘMM ; ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LŸĥvŵë ¸T¸T a¤ŕë² ŁŕŁ¤MŸĥëőª ˆŵÑŕĥML
  ²¤ĜLÕĥÆaŭëĥMLM¤Ñŕ¤ĥĥÆ¤ÑĖŘMŸÕMŸ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LMŵëŁÆ¦ ¤ëŁŸĥvŵë ¸T¸T a¤ŕë² ŁŕŁ¤ML
  M¤Ñŕ¤ĥĥÆ¤ÑĖŘMŸÕMŸ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤L̲ aŁŁT̈ ŁŭuĥŁLM¤Ñŕ¤ĥĥÆ¤ÑĖŘM¬ÕM ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤Ls¤ĜaMÆĖ² vÆDĥMÑ¤Ł² ¤Ĝ¬Æ¦ĜaëŁÆ
  Dĥuĥŵ ÉT¸ĥ¤LÆM¤Ñŕ¤ĥĥÆ¤ÑĖŘM¬ÕM g ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤Ls¤ĜaMÆĖ² vÆDĥMÑ¤Ł² ¤Ĝ¬Æ¦ĜaëŁÆ
  Dĥuĥŵ ÉT¸ĥ¤LÆM¤Ñŕ¤ĥĥÆ¤ÑĖŘMÕMs Ÿŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LM¤ĥÆ¤ÑaLM¤Ñŕ¤ĥĥÆ¤ÑĖŘMM Mŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤Lí ² ŁĥÆ² vÆM¤Ñŕ¤ĥĥÆ¤ÑĖŘMM Mŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LMŵëŁÆë² vÆM¤Ñŕ¤ĥĥÆ¤ÑĖŘM¬ÕM g ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LMŵëŁÆë² vÆM¤Ñŕ¤ĥĥÆ¤ÑĖŘMM Mŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LMŵëŁÆë² vÆM¤Ñŕ¤ĥĥÆ¤ÑĖŘMÕMs Ÿŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤LÕ¬MÆĥT M²¤Ĝî ² u² vÆŸĥëőª ˆŵÑaL
  M¤Ñŕ¤ĥĥÆ¤ÑĖŘî ; ŕ
- ; ² ëőĥŵ Æ$MD ĥÑŊĥĥŀ̈¤Lî ² aLë² vÆ²¤Ĝí ² ÆŁT ĥLŸÆ¤M5 ÆŁL̲
  ŘRî ; ŕ

í ÕŸM≈s̩ÕL̲DMg≈MMÕL̲Ó‡¬=L̲s

- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ Ĵđéőřl̂Ĥěl̂HĴĥĻĖMŸÕ ; ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ Ĵđéőřl̂Ĥěl̂HĴĥĻĖMŸÕ ˜ ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ Ĝu²¤ěĥĜL̲= ¤MLĴąěĽřĮ¤Ľ¤L; aňŴĜř¤ŇĻĖM¬ÕM; ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ D²ŇŏMM²¤ĜL̲¤LĤĴuĥ¤ĽřĮ¤LŸĥěőř¤řTaĥMĽ¤L; aňŴĜř¤ŇĻĖM¬ÕM; ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ Ĝu²¤ěĥĜL̲ÕL̲HĜřĥMĽ¤L̲Ĵđéőřl̂Ĥěl̂HĴĥĻÒ; ²Ĵđéĥŵ¤²LĖŕ ; Ĵđéőřl̂ĖMŸÕ ; ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ ; aňŴĜř¤ŇĻí ²¤²ŇĥŢ ĥ¤LĻĖM¬ÕM; ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ ÕaMĽ²Ľř¤²ēvĥL̲s¤LĤĴuĥ¤ĽřĮ¤Ľ¤LĻĤĥL; aňŴLM¤uřĴ¤Ţ ĥ¤LĻĖŕ sÕí ĥ=ŕĻĖMŸÕ ˜ ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ à²¤ĜMé²ĖĥL̲ Ĵđéőřl̂Ĥěl̂HĴĥĻĖŕ ; à²¤Ĝ Ĵđéőŕ ĻĖMM ; ; Ļ; ĻMŸÕ ; ŕ
- MĴ¦MŢaMĺ¸a¤ĜaMŢ²MLĤĴ$MĜĥŇĴĥĥĽř¤ ≐ ²MĽ²M²¤ĜĹí ²Ĵđ¤ĥLM¤ŇŕĥĥĴđ¤ŇĻ²¤ĜĹí ²¤²ŇĥŢ ĥ¤LĻĖŕ í M ŕĻĖMŸÕM==¬; ŕ
- MĴ¦MŢaMĺ¸a¤ĜaMŢ²MLĤĴ$MĜĥŇĴĥĥĽř¤ f˜ŵ ĜL̲≈ŕMúĺí ²¤²ŇĥŢ ĥ¤LĻĖMŸÕM==¬; ŕ
- MĴ¦MŢaMĺ¸a¤ĜaMŢ²MLĤĴ$MĜĥŇĴĥĥĽř¤ n ѧĜĴ¸ŕ¤ĥ ĴŢ²LĖŕM²¤ĜL̲ ²LĤĴĺí ²¤²ŇĥŢ ĥ¤LĻĖMaĴ¸ Γa²ĥŕĻĖMŸÕM==¬; ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ í ŕ¤ŕ¤ŇĻM¤ŇŕĥĥĴđ¤ŇĻĖM¬ÕM ŕ
- ‡¤ňuĥĴMLHLí ²MLĤĴ$MĽ¤ ü ěĥ²¤ ŇĴ¦Бőѧl²¤ĜĹí ²Ĵđ¤ĥLM¤uřĴ¤Ţ ĥ¤LĻí ²¤²ŇĥŢ ĥ¤LĻĖMŸÕM==¬; ŕ
- í ²MLĤĴ$MĜĥŇĴĥĥĽř¤ ‡Ĵđ²¤Lí ˇ ēňvĻĖMĻĖMŸÕ ; rĻMŸÕM==¬; rĻMŸÕMŸ; rĻMŸÕMs; Ļ; Ļf s; ŕ
- í ²MLĤĴ$MĜĥŇĴĥĥĽř¤ Γa²ěavĻĖMĴĥĻĖMM ; ; ŕ
- í ²MLĤĴ$MĜĥŇĴĥĥĽř¤ ŇĴ¤ Ţ řěĻM¤ŇŕĥĥĴđ¤ŇĻĖMM ; ; ŕ
- MĴ¦MŢaMĺ¸a¤ĜaMŢ²MLĤĴ$MĜĥŇĴĥĥĽř¤ Dѧ¤²Ţ řěM̲ŗ¸≈ĥ¤ĥш²ēvĥMÒě²MĥĜL̲¬ ш ĥĴĻÕѧMLĤŢ MĻĖMŸÕMs; ŕ

í ÕŸM≈s̨ÕLDMg≈MMÕL Ő‡¬=Lss

- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ aĽŰŢ˜ LŕŭĥŰLM¤ÑŕĥĥŰ¤ÑLĖMŸÕMs; ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ M¤ĥŰŰÑ¤LM¤ÑŕĥĥŰ¤ÑŕŵűĥĜŰŰŰŰĥĥLs¤¤ M¤ĥŰŰÑ¤LŠŰŰ¸ŰŰ¾Ţ irLĖMŸÕMs; ir
  Ÿőŕ™M¿ ²MÛÎ⁄$MŻM£²ŰŰŰ¸ŗLŠŰĥĥLĥĜaë²LŕŰ¤²vŰŠŰŰ¸ŰŷëLŰ¤¤ M¤ĥŰŰÑ¤ ɯŕŠŰŰLŠŰĥĥLŋ ŵŵɯŕ¤ÑŰŻ¤LÛŰŰ¤²LŕŰ¤²v¿ ²MÛÎ⁄$MŰ
  ŠŰŰ¸ŰŰ¾Ţ MMM¤ɯŕŰŰ¸¤ Ţ řë²v¿¬²LŠŰɯ¿²ʁM¿n ŰŰÕaM£Űŕŏŕŏŕ¤²ēvŵLM¤ĥŰŰÑ¤LÕ¤MÛÎŢ MŰŕÕMŠaM=Ÿr ő≈ĥ¤ĥɯ²ēvŵLM¤ĥŰŰÑ¤LŰ≈M Mr őM¤ĥŰŰÑ¤L
  ŋ ŰŰÕŢ²ŰŰŰ¬ŕŰŰĥMőÕŢ²ŰŰLMŵĥëLŰŰë²v¿ ĥLŰŰ¸ ŰŰ¿M£¤ĜŰÕ¤MÛÎŢ MŰŕÕMŕ ÕMr
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ aĽŰŢ²LŕëŰÕ¤MÛÎŢ M£¤ĜŰs¤ĜaMŰŰ²v¿MŵĥëLŰŰ¤řëMŰĖMÕMs Ÿr
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ =őĥŢřë²v¿M¤ÑŕĥĥŰ¤ÑŰĖMM; Mr
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ MŵĥëLŰŰëL¬ ɯĥŰŰÕ¤MÛÎŢ M£¤ĜŰDŰŰŰĥMŰĖMŸÕMs; ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ î aëvĥ²ŰŰM¤ÑŕĥĥŰ¤ÑŕŵűĥĜŰŰŰŰĥĥLs¤¤ M¤ĥŰŰÑ¤LŠŰŰ¸ŰŰ¾Ţ irLĖMŸÕMs; ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ Ÿőŕ̂ŰŰŢ²v¿M¤ÑŕĥĥŰ¤ÑŰĖMŸÕMs; ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ î ²u²v£²¤ĜŰü ëĥ²¤ŰM¤ÑŕĥĥŰ¤ÑŰĖRî ; ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ í ²¤²ÑĥŢĥ¤ŰŰ¾¤ĜŰü ЕĥŰ¾Ł£ŰŰ¤L ɲí ²ŰŰŰŢĥŰM¤ĥŰŰÑ¤Lf²ëŕvŰŰŰŰĥMŰĖRî ; ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ Õëŕ™ĥ¤ëĥL²¤ĜŰŸĥëő¤ ˇŵÑ¤LɲÕaM£Űŕŏŕŏŕ¤²ēvŵLHŰĖRŠÕ‡¬=ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ M¤ɯŕŰŰ¸¤Ţ ĥ¤ŰŰ£MvM¤ÑŕĥĥŰ¤ÑŰĖMŸÕMv==¬; ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ î ²LŰŰ¾¸v¿≈ĥMaŰëĥMŰM¤ÑŕĥĥŰ¤ÑŰĖMv¬ÕMí ir
- í ²MÛÎ⁄$MÛĜĥÑŰĥĥÛ¤ ÕaM£Űŕŏŕŏŕ¤²ēvŵLs¤LŰŰŰĥ¤ŰŰ¸¤Lŕŏŕŏŕ¤LŰŰĥL; aŕvŵLM¤ɯŕŰŰ¸¤Ţ ĥ¤LŰŕ sÕí ĥ=irLĖMŸÕÕ ˜ ir

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‡ ¬=ÒÕ=n ü ü à

- í ² MÛĤД ŋ¬ĥД ² ¤ĥ¤LЏŸД ¤¤Ň¤ ÕŢ ² ДЏMĦĥДŇĦMĦĥ¤ĥш² ēvĥ M¤ĥДŇĦĥM² ¤Ĝ DĦŇĦLĦ² ĽĦ ¤
- ¬ MLŇД Ĝa² LĤ ¤ DĦŇĦ²ЏwM¤ĥДŇĦ
- ¬ MLŇД Ĝa² LĤ ¤ M¤ĥДŇĦ Mē ¤ Ţ ĦēM
- ¬ MLŇД Ĝa² LĤ ¤ ≈ĥ¤ĥш² ēvĥ M¤ĥДŇĦ ¤ ДęőĦLĤëLЏД
- ¬ MLŇД Ĝa² LĤ ¤ ≈ĥ¤ĥш² ēvĥ M¤ĥДŇĦĥM² ¤Ĝ MĥëLДę í ˇ ēĦvLЏ
- ¬ĥДŢ ² ¤ĥ¤LЏŸД ¤¤Ň ≟ aДMĥ ¤ MĥëLДgĦę² ĽĦ ¤ ² ¤Ĝ≈² Ħwш² я M¤ĥДŇĦ
- ¬ĥДŢ ² ¤ĥ¤LЏŸД ¤¤Ň ≟ aДMĥ ¤ î ² LЏДĥĜę² MĥĜÕ vaĽĦ ¤ ŋ ДЏĤĥ M¤ĥДŇĦ ŸД ¤MĽĦ ¤

≈MÕM ≈=nL̲ î DL̲
ŝ î ü ˜ Ÿsü î L̲
Õ‡ ¬¬ü ≈ŸL̲
ÕM≈˜ s=M

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