



R&D ON ENERGY AT THE UPC

2023



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

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UNIVERSITAT POLITÈCNICA
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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.



RESEARCH, DEVELOPMENT AND INNOVATION ACTIVITY AT THE UPC

2022



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.”

“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.”

Nonrenewable energy

Energy efficiency

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

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

Electrification

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



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.



Activity examples I

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

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

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.

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.

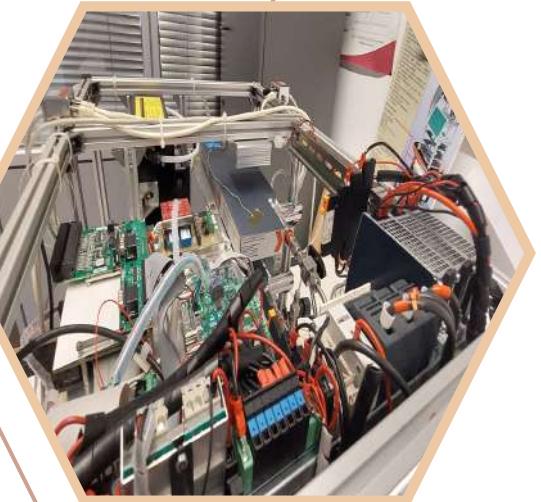
Creation of **new structures of electric machines** fed through power converters for energy saving in electric drives.

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

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.



UPC RESEARCH GROUPS IN ENERGY

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UPC RESEARCH GROUPS IN ENERGY

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g≈M¹ a n G o N l o G h i h D u N h
g≈M O D O a M E l o 2 e n t l u r o N
g≈M h i O s h h D M h e l D p e M
g≈s¹ D o M D e e s h m l h M i 2 D e o l 2 o G f a r s m E M
g≈t¹ D o h M i 2 D e o l 2 D e o M
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s M O ≈ Y l o s a s m l o p l 2 M D r M E o G i t h e a w D M o N o h i h D o N O
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s - l o s a h D² M o l i C h i h N l o G e D e h M M o N
s a e l f s

L

S o D o s M D t h o s s o p o h o M D r o G f a M d r e h M
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a M i I e a M s e o A i h e o 2 o r e v M p N o h i h D o N l a 2 e D s h d r
a M o M e I D a 2 e D s h d r l p o r v a h h M l p e s h M p N o h i h D o N
a s Y M l o D a 2 e D s h d r l p D U h e o o w N e o v s a s M l p l o D h e l M r o G l
l 2 M D r M

M

i = s I l s M o l e o D G f a M D r l p b b m e 2 M o M
i M e i Y l o i h e o 2 o r e v l p i 2 M D r M
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- u a l o l n t h t h d e l 2 M D r M E o G l y h e o o w N e o v l e t b h t h D M
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Q

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S

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T

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o e i i a 2 e o D o s a M M h o 2 e n t l h o G l i h s h o v M t p l D o h h M e h D l e o G l y h e o o w N e

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Y s i l o S l o D l D t h s d o M d s o C b D l v N M i e M

Y f ≈ M o l o D a h a t h e l l o G l i h s h o v M t p l D o h h M e h D l e o G l

h D M b e p l M p h i h h D o N

U

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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

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CD6 - Sensors, Instrumentation and Systems Development Center

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CEBIM - Molecular Biotechnology Center

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SPECIFIC UPC RESEARCH CENTERS

CER-H2 – Specific Hydrogen Research Center

Үөһиң Мөнө өлдүрт Мүшкә шәнді.
Дүйнән 2 дөңгөл ағыпшы үштің әннел
ЦРД мұндағы әмбебап шамхұрунан ғүл
өзінде Ніна шамеөштік үшін Мін
Т 2 үштің 2 үмбекең үйнеген дүшл
2 шамахынан шамхұрунан 2 үл
Мад бүрінші 2 үл шамхұрунан
1 қилем атахұда шамтін шамхұрунан
Бар 2 үл шамхұрунан
Шамеөштік үшін Міндең дүшл
Ніна шамхұрунан 2 үл шамхұрунан
Нія жаңа Ніна 2 үл шамхұрунан ғүл
2 бүнкән шамхұрунан 2 үл шамхұрунан
2 үл шамхұрунан 2 үл шамхұрунан

CPSV – Policy Center of Soil and Valuations

Үөһиң әмбебап шамхұрунан 2 үл шамхұрунан
Дүйнән 2 дөңгөл ағыпшы үштің әннел
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CRAL – Center for Research and Services for Local Administration

Үөһиң әмбебап шамхұрунан 2 үл шамхұрунан
Дүйнән 2 дөңгөл ағыпшы үштің әннел
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CREMIT – Motors and Installations Research Center

Фәр әл үшін 2 үл аблар үл 2 үл
әмбебап шамхұрунан 2 үл шамхұрунан
Мәндиң 2 үл шамхұрунан 2 үл шамхұрунан
Кеми 2 үл шамхұрунан 2 үл шамхұрунан
Ресми 2 үл шамхұрунан 2 үл шамхұрунан
Сирек 2 үл шамхұрунан 2 үл шамхұрунан
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SPECIFIC UPC RESEARCH CENTERS

CS2AC – Supervision, Security and Automatic Control

І аш¹ Міжнародний Центр дослідження та розробки в області надійності та безпеки систем автоматичного керування та захищеності (CS2AC) було створено в 2002 році на базі кафедри електротехніки та енергетики Університету Політехніки Каталонії (UPC). Центр є єдиним у Європі та Азії півдні та Південної Америки. Основні дослідження виконуються в галузі надійності та безпеки систем автоматичного керування та захищеності.

LIM – Maritime Engineering Laboratory

І Державний лабораторійний центр з морського та речевого флоту (LIM) було створено в 1998 році на базі кафедри морської механіки та енергетики Університету Політехніки Каталонії (UPC). Центр є єдиним у Європі та Азії півдні та Південної Америки, який проводить дослідження та розробку в галузі морського та речевого флоту та морської промисловості.

PERC-UPC – Power Electronics Research Center

І Охороняється міжнародними патентами та авторськими свідоцтвами. Центр є єдиним у Європі та Азії півдні та Південної Америки, який проводить дослідження та розробку в галузі морського та речевого флоту та морської промисловості.

SSR-UPC – Smart Sustainable Resources

І Центр досліджень та розробок з енергетики та енергетичних технологій (SSR-UPC) було створено в 2002 році на базі кафедри енергетики Університету Політехніки Каталонії (UPC). Центр є єдиним у Європі та Азії півдні та Південної Америки, який проводить дослідження та розробку в галузі морського та речевого флоту та морської промисловості.



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.



‡ $\gamma = \frac{IM}{M_a M} = \frac{M_e}{M_e}$
‐ $\approx \tilde{U} \tilde{M} = \tilde{Y} \tilde{\Omega}$



FLEX4FACT - Industrial Cluster FLEXibility platform for sustainable FACTories to reduce CO2 emissions and to enable the Energy Transition

Ӧхнүүц төлийн өндөрдүүлэгч нийт 17 МИШЛҮҮДҮҮДҮҮН БҮЛЭЭ ТУТЫН АЛДААНЫН САЛГЫНДАСАА
2025 онд БАСТИЛТЫН ГАИДҮҮЛЭХ САЛГЫН ДАВХААРУУЛЫГ САЛГЫНДАСАА
2050 онд БАСТИЛТЫН ГАИДҮҮЛЭХ САЛГЫН ДАВХААРУУЛЫГ САЛГЫНДАСАА
2060 онд БАСТИЛТЫН ГАИДҮҮЛЭХ САЛГЫН ДАВХААРУУЛЫГ САЛГЫНДАСАА

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



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$\nabla = \text{IM} = M \times M = M$
 $\approx \nabla \tilde{M} = \tilde{Y}$



SENSATE - Low-dimensional semiconductors for optically tunable solar collectors

ՕՄ Ծ ԱՐԵԴ Բ ՄԻՄԺԱՋ ՄՔ ԱՌԱՋԻՉԻ ՄՔ ՃԵ ՎԵՐԱԿԱՆՈՒՄ ՎԵ Տ ԵՎՑԻՇՈՎՆԱԼ
ԽՃ ՄՔ ԱՌԱՋԻՇՈՎՆԱԼ ՀՅԱ ՃԵ ՎԵՐԱԿԱՆՈՒՄ ՎԵ Տ ԵՎՑԻՇՈՎՆԱԼ ՄԱՏ Տ ԻՎԵԼ
ՄԻՆԻՋԵՎԱՆԻ ՎԵՐԱԿԱՆՈՒՄ ՎԵ Տ ԵՎՑԻՇՈՎՆԱԼ ԵՎ ԱՌԱՋԻՇՈՎՆԱԼ
ՄԻՆԻՋԵՎԱՆԻ ՎԵՐԱԿԱՆՈՒՄ ՎԵ Տ ԵՎՑԻՇՈՎՆԱԼ ԵՎ ԱՌԱՋԻՇՈՎՆԱԼ
ԽՃ ՄՔ ՎԵՐԱԿԱՆՈՒՄ ՎԵ Տ ԵՎՑԻՇՈՎՆԱԼ ԵՎ ԱՌԱՋԻՇՈՎՆԱԼ ԵՎ ԱՌԱՋԻՇՈՎՆԱԼ

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

SYMBIOSYST ხელშეწყობით განვითარებულ ტექნიკურ სისტემა და კონცენტრირებულ ფინანსურულ მიზანზე შემდგროვებულ დაგენერაციულ ციფრულ განვითარებულ სისტემებზე დაუცველ მიზანზე აღმოჩნდა. ეს სისტემა შემდგროვებულ ციფრულ განვითარებულ სისტემებზე მატებულ და განვითარებულ განვითარებულ სისტემებზე დაუცველ მიზანზე აღმოჩნდა.

SYMBIOSYST სისტემის მთავრებელ მიზანია კონცენტრირებულ სისტემებზე განვითარებულ ციფრულ განვითარებულ სისტემებზე დაუცველ მიზანზე აღმოჩნდა. ეს სისტემა შემდგროვებულ ციფრულ განვითარებულ სისტემებზე მატებულ და განვითარებულ განვითარებულ სისტემებზე დაუცველ მიზანზე აღმოჩნდა.

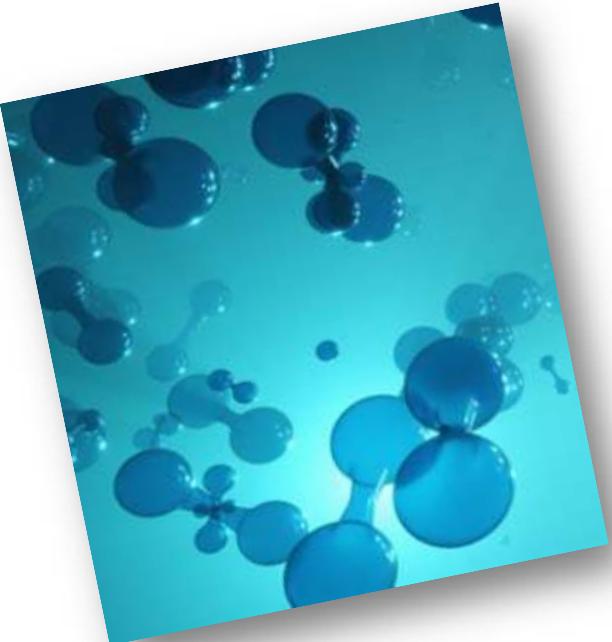
SYMBIOSYST სისტემის მთავრებელ მიზანია კონცენტრირებულ სისტემებზე განვითარებულ ციფრულ განვითარებულ სისტემებზე დაუცველ მიზანზე აღმოჩნდა. ეს სისტემა შემდგროვებულ ციფრულ განვითარებულ სისტემებზე მატებულ და განვითარებულ განვითარებულ სისტემებზე დაუცველ მიზანზე აღმოჩნდა.

SYMBIOSYST სისტემის მთავრებელ მიზანია კონცენტრირებულ სისტემებზე განვითარებულ ციფრულ განვითარებულ სისტემებზე დაუცველ მიზანზე აღმოჩნდა.

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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ADOréD - Accelerating the deployment of offshore wind using DC technology

This PhD consortium, ADOréD, 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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Õü í M‑† ; às= Ÿü † Õ

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



; =n Maü ≈ ŠOLD Mg ≈ MMOLÖ‡ - =

- 2 eõhw DMDhNthišal; aňðoNIMpÑøhñðaÑ2 oĜ
é oMIDeñt oLIM-OM ; i
- 2 eõhw DMDhNthišal DeõlõeñtLIMYÖ ; i
- 2 eõhw DMDhNthišal DeõlõeñtLIMYÖ ; i
- 2 eõhw DMDhNthišal ña2 oĜv2 BñL DeõlõeñtLIMM ; ; ill
MYÖ ; i
- 2 eõhw DMDhNthišalí 2 ñahIõeñpëhMp oĜ
Yhéoš w NñMñBñhëw w 2 M oM 2 ñahIõeñpëhMáí 2 ñahI
Yhéoš w NñMñLIMYÖM=-; ; M ; ; ï LIM-OM g i
- 2 eõhw DMDhNthišal ñð MB ëhLÜhéoš w NñM
MñÑøhñðaÑLIMÖVs Yr
- 2 eõhw DMDhNthišalIMwð ñT ñoLIMpÑøhñðaÑL
RMYÖM=-; ; ï LIMM ; ; i
- 2 eõhw DMDhNthišal=ñIMpÑøhñðaÑLIMYÖM=-; i
- 2 eõhw DMDhNthišal ñahÍ ñð ñM a ñhNMpÑøhñðaÑ2 oĜ
zheñepoLIM-OM ; i
- 2 eõhw DMDhNthišal ñð ñ T ñelõeñpëhMIMpÑøhñðaÑL
RMM ; ; i
- 2 eõhw DMDhNthišal ñ ñ NñeññOñMñt MIMpÑøhñðaÑL
RMM ; ; i

- 2 eõhw DMDhNthišal ñ hñð ñ T T a ñeñ ñ oMñLÜhéoš w NñM
2 oĜñð ñeññMIMpÑøhñðaÑLIMYÖM; i
- 2 eõhw DMDhNthišal ñMñelð ñeññtLIMYÖM; i
- 2 eõhw DMDhNthišal a ñT ñ hñð ñ oĜñð ñeññM
Dñshñw BT ñoMñpÑøhñðaÑLIM-OM g i
- 2 eõhw DMDhNthišal ñCaMIP ñDñMñp2 oĜñð ñeññM
Dñshñw BT ñoMñpÑøhñðaÑLIMÖVs Yr
- 2 eõhw DMDhNthišal ñMñelð ñ oMñpÑøhñðaÑLIMM M
- 2 eõhw DMDhNthišalí 2 ñLDP ñMñpÑøhñðaÑLIMM M
- 2 eõhw DMDhNthišal ñMñelð ñMñpÑøhñðaÑLIM-OM g i
- 2 eõhw DMDhNthišal ñMñelð ñMñpÑøhñðaÑLIMM M
- 2 eõhw DMDhNthišal ñMñelð ñMñpÑøhñðaÑLIMÖVs Yr
- 2 eõhw DMDhNthišal ñ ñ ñMñt M ñ oĜi 2 ñ ñ Yhéoš w NñL
MñÑøhñðaÑLIR; i
- 2 eõhw DMDhNthišalí 2 a ñeñ ñeññ oĜi 2 ñL ñT ñLÜð ñM ñL
R; i

Í ÖÜM̄S ŠÖLD M̄G ≈ M̄VÖLÖ‡ -ls

- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a Deörl̄h̄eñl̄d̄l̄l̄m̄ȳō ; ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a Deörl̄h̄eñl̄d̄l̄l̄m̄ȳō ~ ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a Ḡz̄ oéh̄Ḡz̄ oM̄d̄eñl̄ oš̄al̄ aňñøñl̄m̄-öM̄ ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a D̄z̄ N̄ ŠM̄r̄ oḠz̄ aññøñl̄h̄aññl̄ oL̄h̄eñḠaññM̄r̄l̄ aňñøñl̄m̄-öM̄ ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a Ḡz̄ oéh̄Ḡz̄ oḠh̄M̄r̄l̄ Deörl̄h̄eñl̄d̄l̄o : 2 d̄ñw̄ o2 l̄r̄ ; Deörl̄l̄m̄ȳō ; ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a : aňñøñl̄ 2 o2 N̄h̄t̄ h̄aññl̄m̄-öM̄ ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a ÕaM̄ȳo : eññl̄s̄aññl̄h̄aññl̄ oL̄s̄aññl̄h̄l̄ aňñM̄r̄s̄p̄ oT̄ h̄aññl̄s̄r̄ s̄o : h̄=i Deörl̄l̄m̄ȳō ~ ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a à2 oḠm̄ 2 bñL̄ Deörl̄h̄eñl̄d̄l̄r̄ ; à2 oḠ Deörl̄l̄m̄ ; ; l̄t̄ l̄m̄ȳō ; ī
- M̄z̄ M̄ aM̄i aḠaM̄T̄ 2 M̄d̄m̄Ḡh̄N̄h̄l̄r̄a Ě 2 M̄z̄M̄r̄ oḠí 2 Deñh̄l̄M̄aÑñh̄h̄d̄aÑñl̄ 2 oḠí 2 o2 N̄h̄t̄ h̄aññl̄s̄ í M̄ i Deörl̄l̄m̄ȳō=-; ī
- M̄z̄ M̄ aM̄i aḠaM̄T̄ 2 M̄d̄m̄Ḡh̄N̄h̄l̄r̄a f̄w̄ Ḡz̄M̄l̄ 2 o2 N̄h̄t̄ h̄aññl̄l̄m̄ȳō=-; ī
- M̄z̄ M̄ aM̄i aḠaM̄T̄ 2 M̄d̄m̄Ḡh̄N̄h̄l̄r̄a f̄ȳḠD̄ r̄o : T̄ 2 L̄s̄M̄r̄ oḠ- 2 L̄d̄l̄ 2 o2 N̄h̄t̄ h̄aññl̄s̄aññl̄ Ḡa2 h̄i Deörl̄l̄m̄ȳō=-; ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a í r̄oññl̄N̄b̄N̄h̄h̄d̄aÑñl̄m̄-öM̄ ī
- ‡ ošñh̄dm̄būí 2 M̄d̄m̄r̄a ü : eññl̄ 2 N̄z̄ B̄oññl̄ 2 oḠí 2 Deñh̄l̄M̄r̄s̄p̄ oT̄ h̄aññl̄ 2 o2 N̄h̄t̄ h̄aññl̄l̄m̄ȳō=-; ī
- í 2 M̄d̄m̄Ḡh̄N̄h̄l̄r̄a ‡ Deññl̄ 2 eññl̄ Deörl̄l̄m̄ȳō ; l̄m̄ȳō=-; l̄m̄ȳōM̄ȳ ; l̄m̄ȳōM̄s̄ l̄t̄ l̄f̄ s̄ ī
- í 2 M̄d̄m̄Ḡh̄N̄h̄l̄r̄a Ḡa2 eaññl̄d̄l̄l̄M̄ ; ; ī
- í 2 M̄d̄m̄Ḡh̄N̄h̄l̄r̄a N̄D̄ o : T̄ r̄eñM̄r̄N̄h̄h̄d̄aÑñl̄l̄M̄ ; ; ī
- M̄z̄ M̄ aM̄i aḠaM̄T̄ 2 M̄d̄m̄Ḡh̄N̄h̄l̄r̄a D̄ȳo : T̄ r̄eñM̄r̄l̄z̄h̄aññl̄s̄ 2 eññM̄o : M̄Ḡ- šh̄d̄OññM̄h̄t̄ l̄m̄ȳōM̄s̄ ī

Í ÓÝM₂ ŠOLDM_g ≈ MMÓLÓ† - LSS

- í 2 MÂDMÔHÑDñhúra ašT 1šhñlMñrñahñdañ LRMÖMs ī
- í 2 MÂDMÔHÑDñhúra MañDñlMñrñahñdañ RiaúhñGñlShñhlsäx MañDñlñBD ÑðT i LRMÖMs ī
Yöñmí 2 MÂDMOMB² dñ 1shñlñhñCæ2 w 2 MBD 1shñs aä MañDñl shñlshñhñ wñ shñs NñlñBD² w 2 MÂDM
BD ÑðT MMñrñBD ñ T ñe2 Nñ2 1shñ2 yMñl DñOaMñrñ2 eñlMñhñDñlñOyMñt MñrñMñM= Yr ðz hñhñw² eñlMñhñDñlñRñM M ðMñhñl
hñ DñT 2 DñfñlñMñBD² DñMñlñeLñ wñ hñshí DñMñ 2 GñlñMñt MñrñMñ OM
- í 2 MÂDMÔHÑDñhúra ašT 2 ShñlñMñt Mñ 2 GñlñGñlñMñPñ vMñlñeLñ aäMñLRMÖMs Yr
- í 2 MÂDMÔHÑDñhúra =óñT ñe2 vMñrñahñdañ LRMñ M
- í 2 MÂDMÔHÑDñhúra MñlñeLñ shñlDñOyMñt Mñ 2 GñD DñhñLRMÖMs ī
- í 2 MÂDMÔHÑDñhúra í aëññ² DñMñrñahñdañ RiaúhñGñlShñhlsäx MañDñlñBD ÑðT i LRMÖMs ī
- í 2 MÂDMÔHÑDñhúra YöñD² vMñrñahñdañ LRMÖMs ī
- í 2 MÂDMÔHÑDñhúra í 2 sz wñ 2 Gñlñ eññ² DñMñrñahñdañ LRMñ ; ī
- í 2 MÂDMÔHÑDñhúra í 2 oñ NñT hñsiz 2 Gñlñ Bñd lñ 2 DñT hñMñhñDñlñf² gñvñlñMñRñ ; ī
- í 2 MÂDMÔHÑDñhúra Oñrñsñéñl² 2 Gñlñhñeo ñ NñL DñOaMñrñ2 eññlñLñRñ† -= ī
- í 2 MÂDMÔHÑDñhúra MañrñDñt hñsiz 2 GñlñMñrñahñdañ LRMÖM=-= ; ī
- í 2 MÂDMÔHÑDñhúra í 2 LñDñ hñM aðñMñrñahñdañ LRMÖM ī
- í 2 MÂDMÔHÑDñhúra OñaMñrñ2 eñlñsñlñBDñhñwñ aäMñrñBD aT hñsñr sñ hñ LRMÖ ~ ī



ԴԵԼԻՑԱՅԻ Ի Ի ՄԾ

- Ճօ՛՛ՆՌԵՎՈՐՏԻՄԱՀՆԱԿԻ ՈՒՄԱՇԴ ՈՒ ԽԱՌ
- Ի Հ Հ ՈՒՆԻՇԻ ՈՒ ԽԱՌ
- ՄԱՇԴ ՈՒ ԽԱՎԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Ե՛ՎՄԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Յ Ո Մ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Յ Ո Ւ Շ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Ի Ա Ե Վ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Յ Ո Ւ Շ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ
- ± Ո Ւ Շ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Ճօ՛՛ՆՌԵՎՈՐՏԻՄԱՀՆԱԿԻ ՈՒ ԽԱՌ
- Ի Հ Հ ՈՒՆԻՇԻ ՈՒ ԽԱՌ
- ՄԱՇԴ ՈՒ ԽԱՎԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Կ Ո Վ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Ծ Ո Վ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ
- Ն Ո Վ ՈՒԵՐ ՈՒ ԽԱՆՎԱՀԻ ՈՒ ԽԱՌ



‡ -=○○=n ü ü à

- і ² МѣД յ-їД ² аћоШҮД јаѡН љ ОТ ² ДИМѣДНяМѣїш² енѣ МѣДНїMр аЃDиNиI ² Ш
- ь МНў3 Га² Ш љ DиNиIМѣДНя
- ь МНў3 Га² Ш љ МѣДНя Mє ь Т љM
- ь МНў3 Га² Ш љ ≈ћоїш² енѣ МѣДНя љ ДЕОИИёIЛ
- ь МНў3 Га² Ш љ ≈ћоїш² енѣ МѣДНїMр аЃMиёIД ѡ єМиH
- ¬їД ² аћоШҮД јаѡН ѕ аДмї љ МиёIД ѡ ² аЃ≈² љиц² я МѣДНя
- ¬їД ² аћоШҮД јаѡН ѕ аДмї љ ¹ ² МиёIСе² МїGО виШ ѡ ќ ДИмї МѣДНя йД аМиШ ѡ





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