IEA Guide to Reporting Energy Technology RD&D Budgets

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Abstract

This manual, developed by the International Energy Agency (IEA), provides comprehensive guidance for national experts responsible for reporting energy technology research, development, and demonstration (RD&D) budgets. It outlines the methodology and classification system used to collect and structure RD&D data across IEA member countries, ensuring consistency and comparability. The manual is divided into two main sections: fundamentals of RD&D budget reporting and a detailed classification of energy technologies. It defines RD&D in alignment with the OECD Frascati Manual and clarifies the scope of public and private sector reporting. It also provides instructions for completing the IEA questionnaire, covering budgetary stages, metadata reporting, and common issues. The classification system spans nine major technology groups, including energy end uses, fossil fuels, renewables, nuclear, hydrogen, CO_2 capture, critical minerals, and cross-cutting technologies. This structure supports accurate data collection and policy analysis, enabling governments and stakeholders to track RD&D investments and inform strategic decisions. The manual serves as a reference tool to improve the quality and transparency of energy RD&D statistics globally.

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Introduction

Background of the IEA data collection

The International Energy Agency (IEA) acts as energy policy adviser for the governments of its 32 member countries and beyond to promote reliable, affordable and clean energy for the world's consumers.

In light of the changing nature of energy systems and the importance that the members place on innovation, one of its priorities is to collect data on research, development and demonstration (RD&D) spending in the field of energy. The IEA has been collecting data on government funding of RD&D activities across countries since 1974. These data provide invaluable information to policy makers across the globe to help their decisions on energy RD&D investments as well as their formulation of other policies affecting innovation, including market pull policies. The private sector can also benefit from a deeper understanding of government activities in energy RD&D.

The quality of IEA statistics and recommendations is directly dependent on the quality of the information delivered by national data collectors in countries. Since the IEA questionnaire uses very precise and technical terms, the availability of guidelines to help national data collectors in their task should greatly enhance the quality of the information on RD&D that is collected.

Concept of the manual

This manual was written by the IEA for experts who collect and issue national RD&D data and submit responses to IEA RD&D surveys; it is mainly intended as a reference document.

The aim of the manual is not to provide statistics from previous surveys. Therefore, no key global figures or country figures are included in this document. The data can be found on the IEA website at:

https://www.iea.org/data-and-statistics/data-product/energy-technology-rd-and-d-budget-database-2

The manual is divided into two parts:

The **fundamentals on the reporting of energy technology RD&D budgets** defines how the questionnaire is structured and presents guidelines on which types of budgets/expenditures should be included by national data collectors in the IEA RD&D questionnaire.

The **classification of energy technologies** gives precise definitions of all energy-related items that correspond to a specific row in the IEA questionnaire. The questionnaire is split into nine main groups: energy end uses; fossil fuels; renewable energy sources; nuclear fission and fusion; hydrogen, hydrogen-based fuels and fuel cells; heat and power generation, storage and supply; CO_2 capture and storage; critical minerals; and cross-cutting technologies and research.

The IEA RD&D guidelines are largely inspired by the 2015 edition of the Organisation for Co-operation and Development (OECD) Frascati Manual: Guidelines for Collecting and Reporting Data on Research and Experimental Development. The Frascati Manual, first published in 1962, is the key reference book about research and experimental development measurement, and it is cited when appropriate. The Frascati Manual can be downloaded for free from https://www.oecd.org.

The IEA Guide to Reporting Energy Technology RD&D Budgets is available online at http://www.iea.org.

Coverage of the data on energy technology RD&D budgets

What is energy RD&D?

Energy RD&D covers research, development and demonstration related to the extraction, conversion, generation, transport, distribution, storage, control and rational use of all forms of energy.

RD&D covers:

- Basic research when it is clearly oriented towards the development of energy-related technologies.
- Applied research.
- Experimental development.
- Demonstration (shown separately).

Deployment is excluded from RD&D.

What does "energy" cover?

In the context of this data collection, **energy** should include the entire value chain from primary forms found in nature, through secondary forms more convenient for transport and storage, to end uses such as heat, light, motive forces and other energy services. Therefore, energy RD&D covers RD&D projects on technologies that are used to extract, convert, generate, transport, distribute, store, control and use energy.

What does "RD&D" cover?

RD&D includes research and development (R&D) and demonstration (D). Both concepts are usually considered and defined separately.

As defined by the OECD Frascati Manual:

R&D comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge. A set of common features identifies R&D activities that aim to achieve either specific or general objectives, even if these are carried out by different performers. For an activity to be an R&D activity, it must satisfy five core criteria.

The activity must be:

- novel
- creative
- uncertain
- systematic
- transferable and/or reproducible. (Frascati Manual, 45)

R&D covers three activities:

"Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts" (Frascati Manual, 50).

"Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective" (Frascati Manual, 51).

"Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes" (Frascati Manual, 51).

The order in which the three types of R&D activity appear is not meant to suggest that basic research leads to applied research and then to experimental development. There are many flows of information and knowledge in the R&D system. Experimental development can inform basic research, and there is no reason why basic research cannot lead directly to new products or processes.

In addition, the concept of **RD&D** in the context of this data collection covers demonstration.

Two concepts of **demonstration** are differentiated in RD&D statistics:

- "'Technical demonstration' (including the development of 'demonstration projects' and 'demonstration models')" which, when it meets the five core criteria mentioned above, is included in experimental development. "Because it is an integral part of an R&D project, it **is an R&D activity**" (Frascati Manual, 73-74).

- "'User demonstration', which takes place when a prototype is operated at or near full scale in a realistic environment to aid the formulation of policy or the promotion of its use" (Frascati Manual, 73), **which should be covered separately as demonstration**;

What is excluded from RD&D?

Note: Please note that there are square brackets around "RD&D" in this manual where the Frascati Manual used "R&D." See the box on page 12 for more information.

The concept of RD&D excludes:

Deployment: the selection and use of a commercially available technology-based product or service in normal operations by businesses, individuals or government agencies with the aim of accelerating the diffusion and adoption of technologies or practices.

RD&D must also be distinguished from a wide range of related activities with a scientific and technological basis; therefore, RD&D efforts exclude projects from the following areas:

Education and training (partially excluded):

In institutions of higher education, research and teaching are always very closely linked, as most academic staff does both, and many buildings, as well as much equipment, serve both purposes. As a main rule … all education and training of personnel in … universities and special institutions of higher education should be excluded from [RD&D]. However, research by students at the doctoral level carried out at universities should be counted, whenever possible, as a part of [RD&D] personnel and expenditures. In some cases, students following a research master's programme … and their associated [RD&D] expenditures may also be counted. (Frascati Manual, 265-66)

Administration and other supporting activities: "The raising, management and distribution of [RD&D] grants to performers by ministries, research agencies, foundations or charities is not [RD&D]." Indirect supporting activities are also excluded from RD&D even if there is usually an allowance for these included "under overheads in the RD&D expenditure of performers. Typical examples are transportation, storage, cleaning, repair, maintenance and security activities. Administration and clerical activities undertaken not exclusively for RD&D, such as the activities of central finance and personnel departments, also come under this heading" (Frascati Manual, 78-79).

Scientific and technical information services: The specialised activities of collecting, coding, recording, classifying, disseminating, translating, analysing and evaluating, `all conducted by scientific and technical personnel, bibliographic services, patent services, scientific and technical information, extension and advisory services and scientific conferences are to be excluded, except when

conducted solely or primarily for the purpose of RD&D support. For example, the preparation of the original report of RD&D findings should be included in RD&D. (Frascati Manual, 76-77)

General-purpose data collection: General-purpose data collection is undertaken generally by government agencies to record natural, biological or social phenomena that are of general public interest or that only the government has the resources to record. Examples are routine topographical mapping; routine geological, hydrological, oceanographic and meteorological surveying; and astronomical observations. (Frascati Manual, 70-71)

Such data-related activities are excluded, except when the data are collected solely or primarily as part of the RD&D. The same reasoning applies to the processing and interpretation of the data.

Testing and standardisation: "This concerns the maintenance of national standards, the calibration of secondary standards and the routine testing and analysis of materials, components, products, processes, soils, atmosphere, etc. These activities are not [RD&D]" (Frascati Manual, 77).

Feasibility studies: The investigation of proposed engineering projects, using existing techniques to provide additional information before deciding on implementation, is not [RD&D]. In the social sciences, feasibility studies are investigations of the socio-economic characteristics and implications of specific situations (e.g. a study of the viability of a petrochemical complex in a certain region). However, feasibility studies on research projects are part of [RD&D]. (Frascati Manual, 77)

Patent and licence work: "All administrative and legal work needed to apply for patents and licences (delivering documentation as an outcome of [RD&D] projects is [RD&D]). However, patent work connected directly with [RD&D] projects is [RD&D]" (Frascati Manual, 61).

Policy-related studies: In this context, "policy" refers not only to national policy but also to policy at regional and local levels, as well as the policy of business enterprises in the pursuit of their economic activity. Policy-related studies cover a range of activities, such as the analysis and assessment of the existing programmes, policies and operations of government departments and other institutions; the work of units concerned with the continuing analysis and monitoring of external phenomena (e.g. defence and security analysis); and the work of legislative commissions of inquiry concerned with general government or departmental policy or operations. (Frascati Manual, 78)

Such studies are excluded.

Routine software development: Software-related activities of a routine nature are not to be considered [RD&D]. Such activities include work on system-specific or program-specific advances that were publicly available prior to the commencement of the work. Technical problems that have been overcome in previous projects on the same operating systems and computer architecture are also excluded. Routine computer and software maintenance are not included in [RD&D]. (Frascati Manual, 66)

Other industrial activities: Care must be taken to exclude activities that, although part of the innovation process, do not satisfy the criteria required to be classified as [RD&D]. For example, … market research, manufacturing start-up, and tooling up and redesign for the manufacturing process are not in their own right [RD&D] activities and cannot be assumed to be part of an [RD&D] project. (Frascati Manual, 60).

Differences between the OECD concept of energy R&D and the IEA concept of energy RD&D

The series of data collected and issued by the OECD Directorate for Science, Technology and Innovation, as well as by other international and national organisations, which compile them under the guidelines in the Frascati Manual, should not be confused with the IEA concept of RD&D, as it differs both in its scope (R&D versus RD&D) and its definition of energy.

The OECD collects data according to socio-economic objectives, one of which is "energy". It covers R&D aimed at improving the production, storage, transportation, distribution and rational use of all forms of energy. It also includes R&D on processes designed to increase the efficiency of energy production and distribution, and the study of energy conservation. It does not include R&D related to prospecting or R&D into vehicle and engine propulsion. The IEA data collection for energy technology RD&D and the OECD R&D survey have different purposes and as such cannot be aligned.

The subject matter scope of the IEA's RD&D data is broader than the Frascati Manual's government budget allocations for the "energy" socio-economic objective, because the former comprises all programmes that focus on: i) sourcing energy; ii) transporting energy; iii) using energy; and iv) enhancing energy efficiency, regardless of their socio-economic objective. It includes programmes that might be included under the "Transport, telecommunications and other infrastructures" socio-economic objective for example.

In addition, the IEA concept of RD&D differs from the Frascati concept of R&D, in that it includes all kinds of "demonstration projects"; and it includes state-owned enterprises. Demonstration projects are included as an additional separately

identifiable component; often this is an important part of the development of new technologies. The project's outcome may be uncertain, and there is an element of risk that is often too large for the private sector to assume alone. The application scope is also broader, as it includes expenditures of state-owned enterprises outside the government sector's budget.

What are RD&D budgets and expenditures?

Energy RD&D budgets and expenditures refers to either planned (budgeted) or actual financial resources allocated to energy research, development and demonstration.

Budgets are government allocations recorded in public budgets, often linked to a specific fiscal year, and may not reflect actual spending.

Actual expenditures are reported by performers and provide more detailed data, though they may be delayed and vary in timing.

Discrepancies between budgeted and actual figures arise due to timing, lack of updates and reporting limitations.

Tax reliefs for RD&D are excluded from standard reporting.

Energy RD&D budgets or expenditures refers to the financial resources allocated or spent on energy-related RD&D activities. These can be either budgeted expenditures, which is planned or allocated funding typically from government sources, or actual expenditures, which reflects the money actually spent on RD&D activities, usually reported by the entities performing the work.

Budgets represent the financial commitment made by a government or funding body to support RD&D. It is initially recorded as an allocation in a public budget and is often linked to a specific fiscal year, even if the actual spending occurs in later years. While these allocations may be updated later to reflect actual outlays, this is not always done with full precision. This approach allows policy makers to track intended support for RD&D and align it with strategic goals or policy objectives. In the context of the Frascati Manual on R&D, budget-based data are referred to as government budget allocations for R&D.

Actual expenditures, on the other hand, refers to the real financial outflows used to carry out RD&D activities. It is reported by the performers of RD&D – such as

research institutions and companies – based on surveys or financial reports that capture the money awarded and spent. These figures may be adjusted later to account for unspent funds or clawbacks. However, there can be ambiguity in whether this spending is recorded in the year the award is made or the year the spending actually occurs, depending on the reporting systems. In addition, the data might not be available until one or two years after the RD&D activities have been performed. This approach allows, however, for better details on the areas of spendings. The analogue to this concept in the Frascati Manual for R&D is the gross expenditure in R&D.

These two measures – budgeted and actual expenditures – often do not match. This discrepancy arises from timing differences, where budget allocations are recorded in one year while actual spending happens in another. It can also result from a lack of updates to budget data to reflect actual disbursements, or from insufficient granularity in budget lines that makes it difficult to isolate RD&D-specific spending. Additionally, reporting gaps may occur when performers are unable to trace funding back to specific budget lines or policy goals.

Energy RD&D data collected by the IEA include both current costs, composed of labour costs and other current costs, and capital expenditures. Deductible taxes on products, such as the value-added tax (VAT), are excluded (Frascati Manual, 118).

Many governments offer tax relief to businesses and other units to reduce the economic cost of RD&D investments. This may involve forgone tax revenues or direct payments when tax liabilities are insufficient. These RD&D subsidies, implemented through the tax system, aim to incentivise RD&D activities. Governments may budget for these subsidies either as specific allocations or on an on-demand basis, adjusting payments as needed. **Tax reliefs are excluded** from this reporting and if considered integral to a national budget, they should be presented separately.

What is included in public?

Central or federal government units and provincial and state government units are included in the scope of public energy RD&D budgets.

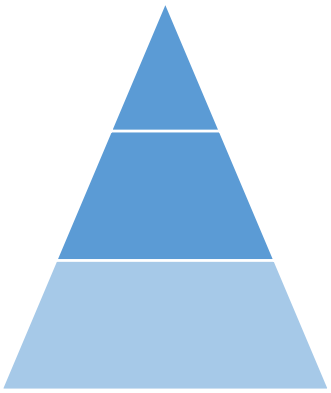
Local and municipal government units are excluded.

For the purposes of public energy RD&D budgets, state-owned enterprises should also be considered as public bodies but shown separately.

Overall, public RD&D collected by the IEA designates government budgets for energy RD&D, regardless of who the performer is.

Who funds?

The IEA scope includes RD&D funded by public bodies either at central or federal level, or at a country's first administrative subdivision level.



Central or federal government units (included)

Provincial and state government units (included when significant)

Local and municipal government units (excluded)

Identification of all public bodies involved in energy-related RD&D

Therefore, by identifying all government bodies involved in financing energy-related RD&D, the national data collector will make sure all concerned entities are covered.

"As defined in the SNA [System of National Accounts] (EC et al., 2009: para. 4.117) … government units are unique kinds of legal entities established by political processes that have legislative, judicial or executive authority over other institutional units within a given area" (Frascati Manual, 234). However, in this manual, the government sector is a broader entity that comprises not only these "core" government units (all bodies, departments and establishments of government, central [federal], regional [state] or provincial – that engage in a range of energy-related activities), but also the non-profit institutions it controls (Frascati Manual, 234).

Examples of government establishments are:

- Ministries or cabinet-level departments.
- Regional councils.
- Independent public agencies.
- Government-funded research organisations.
- Public higher-education establishments.

To be exhaustive, the list of government establishments should include not only entities that dedicate their resources entirely to energy-related RD&D, but also entities that fund energy-related RD&D programmes even though their main focus is on other activities. A wide range of countries make efforts to identify these funders of energy RD&D. There is no single approach that perfectly fits the needs of all the countries, and governments have designed processes for their institutional contexts and refined them over time. The IEA publication Tracking Public Investment in Energy Technology Research: A Roadmap describes the variety of country approaches, also identifying the most important common components: the institutional arrangements; the methods for collecting, classifying and validating the data; the data management and technology processes; and, finally, the dissemination.

Similarly, national entities funding specific non-national programmes related to energy RD&D are included.

In R&D statistics as defined by the Frascati Manual, public enterprises are not considered government establishments but are treated as part of the business enterprise sector. It recommends that these are presented as a subsector of the latter. For energy-related RD&D purposes, reporting focuses on the combined public sector. **State-owned enterprises (SOEs)** should thus be included in the reporting but shown separately.

An SOE is a business entity owned by a national or sub-national government to earn profit for the government, control a natural monopoly, provide commodities to citizens at a lower price, implement government policies, or deliver products and services to remote locations where private vendors face challenges. Governments typically hold majority equity over SOEs and often exercise direct jurisdiction over their operations. In the energy context, these enterprises include, but are not limited to, transmission and distribution network operators for electricity and natural gas, utilities, or nuclear power plant operators. RD&D by SOEs is significant in certain sectors, and some of the funding, though not always, comes from public tax money. Excluding this spending would considerably diminish the usefulness of RD&D energy budgets, although care must be taken to avoid double counting RD&D already included in government RD&D budgets.

It is important to note that spending at the deployment stage, often associated with SOEs, should not be included in RD&D figures.

Who performs?

The IEA scope includes publicly financed energy RD&D performed in any establishment or organisation, at home or abroad, such as: i) public establishments; ii) any of the other three domestic sectors (business enterprise, private non-profit, higher education); and iii) abroad programmes.

Direct expenditures by IEA member countries in energy-related projects undertaken with the European Commission (EC) or other countries (bilaterally or multilaterally) should be included in national energy RD&D data. However, countries' contributions to the EC energy RD&D budget should not be included in national data, since this is directly captured from the EC.

Similarly, only contributions to international RD&D programmes or organisations solely or mainly concerned with energy RD&D should be included, for example contributions to:

- The International Atomic Energy Agency (IAEA).
- The International Thermonuclear Experimental Reactor (ITER).
- The European Organisation for Nuclear Research (CERN).

The IEA RD&D data also take into account the public part of the RD&D financing of public-private partnerships (PPPs).

What is excluded?

- contributions of each of the EU countries to the EC Energy RD&D budget (information on the EC energy RD&D budgets should be supplied directly by the EC)
- RD&D expenses of semi-public or private bodies
- privately funded spending from public bodies (RD&D expenses of public institutions financed by non-governmental sources, such as private companies, are therefore excluded)
- private contributions to PPPs
- RD&D funding from local public bodies, non-governmental organisations and charities.

What is included in the private sector?

Private sector RD&D expenditures should be included in data submitted to the IEA when available.

The focus is on domestic entities, specifically business enterprises (excluding SOEs) and private non-profit organisations.

When available, expenditures in the private sector should be included in the data submitted to the IEA.

In the scope of the IEA private sector RD&D data collection, the following domestic entities should be considered:

- Business enterprises excluding SOEs are companies engaged in commercial activities, irrespective of their size (small, medium or large enterprises), that finance RD&D activities with their resources.
- Private non-profit organisations serving businesses or other sectors include institutions such as foundations or industry associations that fund [RD&D] without a profit motive.

Data from the private sector can be collected through surveys designed to capture RD&D expenditures, tax reporting mechanisms where RD&D expenses are declared for incentives or relief programmes, analysing grant and funding databases; and reviewing publicly available financial statements or annual reports that disclose RD&D-related spending.

How to fill in the questionnaire

The IEA has developed a standardised questionnaire tool to help countries collect and report data consistently with international practices. Respondents are asked to complete the provided tables without making any alterations, as these are used directly for computer processing. This approach ensures comparability across countries, and the IEA plays a key role in verifying and consolidating the data for global analysis and dissemination.

Structure of the questionnaire

Tables

The questionnaire is split into five tables:

- government R&D
- government demonstration
- SOE R&D
- SOE demonstration
- private sector RD&D.

Demonstration data should not be included in general figures of R&D data. Although not usual, if demonstration data on budgets/expenditures are confidential or if it is not possible to separate them, then demonstration can be added to the R&D tables and not shown separately. However, this should be noted in the metadata.

The R&D and demonstration data for **state-owned enterprises** should be given separately in the appropriate tables. If, however, RD&D budgets/expenditures data for the state-owned companies are confidential, then the amounts may be reported with the rest of the RD&D data, either in the government tables or the private sector tables, and this should be noted in the metadata. If, for whatever reason, state-owned companies are not included, then this should also be noted in the metadata.

Private sector RD&D should be submitted when available. An estimation of the coverage of companies covered in the data should be provided in the metadata.

Levels of information

The questionnaire comprises nine groups of energy-related RD&D topics:

- A – Energy end uses
- B – Fossil fuels
- C – Renewable energy sources
- D – Nuclear fission and fusion
- E – Hydrogen, hydrogen-based fuels and fuel cells
- F – Heat and power generation, storage, and supply
- G – CO_2 capture and storage
- H – Critical minerals
- Z – Cross-cutting technologies and research.

For each of those groups, national data collectors should proceed as follows:

1. Group-level data correspond to the total budgets/expenditures allocated to corresponding activities.
2. Data at the two-digit level correspond to a first breakdown of group-level data: the sum of all two-digit level budgets/expenditures should match group-level budgets/expenditures. Every effort should be made to have complete information that adds up at this level.
3. Similarly, data at the three-digit level provide a breakdown of the two-digit level categories, data at the four-digit level provide a breakdown of the three-digit level and data at the fifth-digit level provide a breakdown of the fourth-digit level. Effort should be made to have complete information that adds up at this level when possible.

Unallocated categories

At each of the two-digit, three-digit, four-digit and fifth-digit levels, a row for unallocated budgets/expenditures has been provided. This row should be used in the event that budgets/expenditures cannot be allocated to one specific area at that level, and where it is not possible to estimate the split between two or more of the subcategories.

Frequent reporting issues

This section of the Manual attempts to respond to some frequently asked questions concerning the questionnaire.

In what currency should the data be provided?

RD&D figures should be entered in nominal million national currency units only.

For publication, the IEA Secretariat will convert the national currency units to constant USD (using exchange rates and deflators), to constant USD (using purchasing power parities and deflators) and to constant euros (using exchange rates and deflators).

How should it be noted when the data are not submitted on a calendar year basis?

If the country does not report RD&D budgets/expenditures on a calendar year basis, then the fiscal year should be clearly indicated in the specified row.

How should multi-annual projects be reported?

When reporting RD&D budgets, the Frascati Manual stipulates that multi-annual projects budgeted in only one year or over several should be allocated to the [data] of the year(s) in which they are budgeted, not in the years of performance. Multi-annual programmes that are authorised at some stage but budgeted over several years should be allocated to the years in which they are budgeted, not the year of authorisation. (Frascati Manual, 334)

When reporting multi-year budgets, the budget profile (if available) should be used to distribute the funds over the years of the multi-annual project. If no budget profile is available, then the funds should be allocated equally over the years.

How should multi-technology projects be reported?

When reporting RD&D projects related to different technology areas, every effort should be made to allocate the data with the least loss of information possible. When a project concerns multiple technologies in different areas of the classification, the data should be allocated to the different technologies to the best of the reporter's knowledge instead of the unallocated categories.

How should relevant metadata be reported?

Metadata should be added to the submission of data when it is believed that the information provided will help the reader to better understand limitations to the data (for example, where the category of data requested is not fully congruent with the data provided or where some significant change in the statistics could benefit from explanation). These metadata can be added to the "survey" tab in the

questionnaire, provided in a text file or included in the email when the questionnaire is transmitted.

What are the different budgetary stages and how should the data be revised when data are consolidated?

Although details of the budgetary procedure vary from country to country, seven broad stages can be identified:

1) Forecasts (estimates of funding before beginning of budget discussion)

2) Budget forecasts (preliminary figures as requested by ministries, especially for inter-ministerial discussions)

3) Budget proposals (figures presented to the parliament for the coming year)

4) Initial budget appropriations (figures as voted by the parliament for the coming year, including changes introduced in the parliamentary debate) …

5) Final budget appropriations (figures as voted by the parliament for the coming year, including additional votes during the year)

6) Obligations (money actually committed during the year). (Frascati Manual, 331)

7) Actual outlays (money paid out during the year).

Stages 1-4 describe the government's intentions. The data for budgetary year t should be available as soon as possible [after] the end of year t–1. It is suggested that the preliminary GBARD data should be based on the first budget agreed between the government and the parliament, or stage 4. Some countries might even base their preliminary figures on stage 3. (Frascati Manual, 331)

During the budgetary year, supplementary budgets may be voted, including increases, cuts and reallocations of [RD&D] funding. These are reflected in stage 5. Data should be available as soon as possible after the end of the budgetary year. It is suggested that the final GBARD data should be based on the final budget appropriations. Some countries may have to base their final figures on stages 6 or 7. (Frascati Manual, 331).

Classification of energy technologies and energy technology research

Introduction

The classification is structured with high-level groups indicated by letters and further levels of subcategories indicated by numbers.

The high-level groups are:

A	Energy end uses
B	Fossil fuels
C	Renewable energy sources
D	Nuclear fission and fusion
E	Hydrogen, hydrogen-based fuels and fuel cells
F	Heat and power generation, storage, and supply
G	CO_2 capture and storage
H	Critical minerals
Z	Cross-cutting technologies and research

This classification system is designed to be exhaustive, covering all technologies even if they are not explicitly cited, with provisions for adding new categories as needed. The category codes are defined to allow for additional categories without modifying the existing codes, and a new code system differentiates it from previous classifications to avoid confusion.

The broad range of energy technologies and potential future technologies makes neat classification a difficult task. Technologies and research efforts can be grouped in different ways that reflect the perspectives of stakeholders that work in

different sectors or approach the topic from diverse professional backgrounds. There are four main ways to approach classification and they each have advantages for certain purposes.

- **Technological basis**. For example, all similar combustion technologies, drilling technologies or electrochemical technologies would be classified together, regardless of their energy source or purpose.
- **End-user basis**. For example, technologies for use in buildings, industry, transport or power generation would be classified together, regardless of their energy source or technology type.
- **Energy supply basis**. For example, technologies related to fossil fuels, renewables or waste heat would be classified together, regardless of their end-user or technology type.
- **Cross-sectoral technology activity basis**. For example, technologies related to electricity, heat, hydrogen or chemical fuels would be classified together, regardless of their end-user or energy source.

None of these four ways is entirely satisfactory or maps onto the ways in which public sector funding, regulation or business activities are organised. It is most practical therefore to mix these perspectives in a classification system that reflects to the greatest extent real-world organisation of research, sales and investment activities. This has been the approach of the IEA energy technology classification for gathering RD&D funding data since the 1970s. The latest version aims to maintain maximum consistency with previous versions while accommodating new developments in the energy technology landscape.

The classification adopted by the IEA in consultation with its members, and described in the following pages, employs the following guiding logic:

- Technologies specific to given end uses are primarily allocated to the main end-use categories in the group Energy end uses, including buildings, industry and transport.
- Technologies that are not specific to given energy end uses are allocated with the following order of priority in the case of any overlaps:
  1. Hydrogen, hydrogen-based fuels and fuel cells
  2. CO_2 capture and storage
  3. Renewable energy source
  4. Fossil energy source
  5. Nuclear fission and fusion
  6. Power generation, transmission and distribution
  7. Heat networks
  8. Critical minerals

To illustrate this logic:

- Technologies for using bioenergy capturing CO2 at industrial end use facilities are classified under “A1 Industry”.
- Technologies for capturing CO2 from bioenergy use for hydrogen production are classified under “E Hydrogen, hydrogen-based fuels and fuel cells”.
- Technologies for capturing CO2 from bioenergy use in power generation are classified under “G CO2 capture and storage”.
- Technologies for the use of bioenergy in power generation without CO2 capture are classified under “C4 Bioenergy”.
- Generic technologies for generating electricity from combustion heat regardless of fuel source are classified under “F1 Heat and power generation”.

At each level of the classification, there is a **“not elsewhere classified”** category which contains technologies that are not included in the other sub-categories at the same level, whether they are mentioned by name or not. For example, under “C1 Solar energy”, “C19 Solar energy not elsewhere classified” includes solar energy technologies that are not included in “C11 Solar heating and cooling”, “C12 Solar photovoltaics” or “C13 Solar thermal power and high-temperature applications”, such as solar forecasting.

A – Energy end uses

Definition

Energy end uses refers to the devices, systems and processes that directly consume energy to perform specific tasks or services for end users. These technologies are the final step in the energy chain. It includes, but is not limited to, energy efficiency and electrification technologies.

Energy efficiency refers specifically to techniques, processes, equipment and systems to deliver more services for the same energy input, or the same services for less energy input.

Electrification refers specifically to electrically powered technologies or processes to provide energy services that have traditionally been supplied via the direct use of fossil fuels. An example is a heat pump, which can replace a gas boiler, or an electric vehicle transmission, which is an alternative to an internal combustion engine.

Category A is divided into the following subcategories:

A1	Industry
A2	Residential and commercial buildings, appliances and equipment
A3	Transport
A4	Agriculture and forestry
A5	Construction and civil engineering
A6	Data centres
A9	Energy end uses not elsewhere classified

A1 – Industry

Definition

Industry refers to technologies used in the industrial sector, which covers the manufacturing of semi-finished and finished goods and products, excluding technologies specific to the manufacturing of energy equipment (i.e. battery manufacturing).

Industry subsectors include iron and steel; chemical and petrochemical; non-ferrous metals; non-metallic minerals; machinery; food and tobacco; paper, pulp and print; wood and wood products; and textile and leather among others.

Note: In the International Standard Industrial Classification of All Economic Activities (ISIC) classification (Rev. 4), this corresponds to section C: Manufacturing.

Category A1 is divided into the following subcategories:

A11	Energy-efficient industrial management and processes
A12	Energy-efficient industrial equipment
A13	Direct use of electricity in industrial processes
A14	CO_2 utilisation in industry
A15	Hydrogen use in industry
A19	Industry not elsewhere classified

A1 <u>excludes</u>:

- Biorefining. Ref. C45
- Coal mining. Ref. B21
- Distribution of electricity. Ref. F2
- Distribution of natural gas. Ref. B12
- Energy efficiency improvement in the construction sector. Ref. A5

- Extraction, refining and processing of critical minerals.	Ref. H
- Refineries.	Ref. B12
- Technologies specific to battery manufacturing.	Ref. F511
- Technologies specific to renewable equipment manufacturing.	Ref. C
- Technologies specific to vehicles manufacturing.	Ref. A3
- Upstream power generation and auto-generation.	Ref. B14 Ref. B22 Ref. C Ref. E52 Ref. E7 Ref. F1

A11 – Energy-efficient industrial management and processes

Definition

Energy-efficient industrial management and processes refers to the modification of the nature of any mechanical or chemical step in the value chain of transforming raw materials into finished products, but it does not include technical improvements to pieces of equipment used in such processes (see A12). In addition to improvements to existing industrial processes, it includes modifications to the underlying nature of the industrial transformation steps to reduce their energy consumption, such as a different chemical route to make cement.

Among other elements, A11 <u>includes</u>:

- Combustion, when industry-specific.
- Insulation, energy recycling, continuous operations.

A11 excludes:

- CO_2 utilisation in cement and concrete production. Ref. A14
- Energy efficiency in oil and gas refineries. Ref. B12
- Energy storage. Ref. F5
- Fuel switching to biofuels. Ref. A19
- Fuel switching to hydrogen. Ref. A15
- Non-industrial coal combustion. Ref. B22
- Non-industrial oil and gas combustion (e.g. steam generation). Ref. B14
- Waste heat recovery. Ref. F4

A12 – Energy-efficient industrial equipment

Definition

Energy-efficient industrial equipment refers to devices that are used to achieve a task in industry, but which, although they may be single use, are not consumed in the process. Boilers, burners, mixers and robots are examples of industrial equipment.

It covers the design and engineering of equipment and systems enabling the implementation of energy-efficient processes.

Category A12 is divided into the following subcategories:

A121	Industrial heat pumps
A129	Energy-efficient industrial equipment not elsewhere classified

A12 excludes:

- Equipment and systems for energy storage.	Ref. F5
- Fuel switching to biofuels.	Ref. A19
- High-temperature applications of geothermal.	Ref. C5
- High-temperature applications of solar thermal.	Ref. C13
- Industrial electric motors.	Ref. A13
- Replacement of industrial equipment run on fossil fuels by electric equipment.	Ref. A13
- Thermal heat storage.	Ref. F52
- Waste heat recovery.	Ref. F4

A121 – Industrial heat pumps

Definition

Industrial heat pumps refers to systems that use electrical inputs to transfer heat from one location (source) to another (sink) to provide process heat or cooling. They are used to recover waste and ambient heat, upgrade it to a higher temperature, and supply it for industrial processes.

Heat pumps used in the industrial sector include mechanical vapour compression heat pumps, absorption heat pumps, high-temperature heat pumps, and hybrid heat pumps.

Smaller, lower temperature heat pumps that can be used for industrial or building heating purposes alike are classified under residential and commercial end uses.

A121 excludes:

- District heat pumps.	Ref. F31
- Extraction of shallow geothermal heat.	Ref. C59
- Heat pumps for buildings, including buildings for commercial use.	Ref. A2231

- Heat pumps for undetermined applications. Ref. A2231
- Other forms of electrically generated heat (e.g. resistance, plasma, microwave). Ref. A13

A129 – Energy-efficient industrial equipment not elsewhere classified

Definition

Energy-efficient industrial equipment not elsewhere classified refers to technologies, processes and techniques related to energy-efficient industrial equipment excluding industrial heat pumps.

Among other elements, A129 includes:

- Digital control systems and demand response for industrial processes.
- Energy efficiency systems that integrate waste management.
- Materials with enhanced heat transfer properties.
- Robotics use in industry.

A13 – Direct use of electricity in industrial processes

Definition

Direct use of electricity in industrial processes refers to the direct application of electricity in industrial processes to drive operations, enable production, or perform specific tasks. It excludes indirect uses, such as electricity used for general facility operation (e.g. lighting or heating, ventilation and air-conditioning [HVAC] systems).

The focus is on applications where electricity replaces or augments traditional thermal or mechanical energy sources (e.g. fossil fuels, steam), typically as a means of reducing emissions or reliance on fuels that are imported, costly or otherwise unfavourable in the context. The result may or may not be an increase in energy efficiency of the specific industrial process. Heat pumps are not included in this category.

Among other elements, A13 includes:

- Electric arc processes.
- Electric drives and motors for industrial applications.
- Electric heat generation for industrial processes such as induction heating, resistive heating, and microwave and radiofrequency heating.
- Electricity-driven material deposition for additive manufacturing.
- Electrochemical processes such as electrolysis for metal refining processes.
- Electroplating and surface treatment such as electricity-driven deposition.

A13 excludes:

- Digital control systems for electrified industrial processes.	Ref. A129
- Electric motors for transport.	Ref. A3
- Heat generation for industrial applications using heat pumps.	Ref. A121
- Hydrogen production via electrolysis.	Ref. E11
- Hydrogen use in steel and chemicals production.	Ref. A15

A14 – CO_2 utilisation in industry

Definition

CO_2 utilisation in industry refers to the processes that use captured CO_2 as a feedstock to produce valuable products, store it in long-lived products or enhance process efficiency in industry, including by direct use of CO_2 with or without chemical transformation, as well as mineralisation and solidification processes such as CO_2 binding. Use of CO_2 as an input to the production of urea, chemicals, cement and concrete is included. Use of CO_2 in refrigeration, fire suppression and beverage carbonation is included. It does not include CO_2 utilisation in fuels production.

A14 excludes:

- Biological processes (e.g. algae cultivation) to convert CO_2 into biofuels and other products. Ref. C4
- Carbon dioxide capture processes. Ref. G1
- Long-term carbon dioxide storage without production of a saleable industrial product. Ref. G3
- Synthetic fuels production from biomass. Ref. C4
- Synthetic fuels production from coal. Ref. B23
- Synthetic fuels production from hydrogen and carbon dioxide. Ref. E6
- Synthetic fuels production from oil and gas. Ref. B15

A15 – Hydrogen use in industry

Definition

Hydrogen use in industry refers to the incorporation of hydrogen as both an energy carrier and a chemical feedstock in a wide range of industrial processes. In addition to fuel switching to hydrogen, it covers applications where hydrogen is employed to produce chemicals, as a fuel for high- or low-temperature processes, and as an alternative to fossil fuels in heavy industries such as iron and steel.

A15 excludes:

- Hydrogen production Ref. E1
- Hydrogen use in oil refining. Ref. E51

A19 – Industry not elsewhere classified

Definition

Industry not elsewhere classified refers to technologies, processes and techniques related to industry not included elsewhere in the subcategories of A1, such as life-cycle analyses and fuel switching to biofuels.

A2 – Residential and commercial buildings, appliances and equipment

Definition

Residential and commercial buildings, appliances and equipment refers to technologies, systems and practices aimed at reducing energy consumption and emissions in residential and commercial buildings, including through building design, appliances, and other equipment.

Category A2 is divided into the following subcategories:

A21	Building design and envelope
A22	Buildings operations and efficient building equipment
A23	Appliances and equipment (excluding heating and cooling)
A24	Urban and spatial energy planning
A29	Residential and commercial buildings, appliances and equipment not elsewhere classified

A21 – Building design and envelope

Definition

Building design and envelope refers to techniques, processes, equipment and systems to better ensure the energy efficiency of buildings through their design and the choice of their envelope materials and technologies. It predominantly covers, but is not limited to, the thermal performance of buildings.

Building envelope includes all the components that separate the interior of a building from its external environment (i.e. walls, windows, roofs, foundations). All technologies that are part of this building fabric are included in this category.

Building design and envelope technologies include, among other approaches, systemic approaches that aim for all elements of the building design (energy supply and demand, natural resources, environment, envelope, equipment, operations, and appliances) to work together efficiently as a whole.

Category A21 is divided into the following subcategories:

A211	Building envelope technologies
A212	Building design
A219	Building design and envelope not elsewhere classified

A21 excludes:

-	Control systems for elements of the building envelope.	Ref. A22
-	Devices and appliances not part of the building fabric.	Ref. A23
-	Indoor air quality.	Out of scope
-	Solar heating and cooling.	Ref. C11
-	Solar photovoltaics (including building-integrated photovoltaics [BIPV]).	Ref. C12
-	Technologies reducing energy consumption during the construction of buildings (e.g. lighter materials).	Ref. A5

A211 – Building envelope technologies

Definition

Building envelope technologies refers to materials and hardware related to the structure, assembly, protection or thermal efficiency of the building envelope, including windows. Cold roofs, cold pavements, passive lighting, passive heating and passive cooling through technology and architectural improvements are included in this category. Ductwork, electrical cabling and flue pipes integrated into the building structure for heating, ventilation and cooling are not included in this category.

A211 <u>excludes</u>:

- Active heating, ventilation and cooling systems. Ref. A223

A212 – Building design

Definition

Building design refers to the architectural and engineering activities to design energy-efficient buildings, including digital design tools (including artificial intelligence [AI]).

A219 – Building design and envelope not elsewhere classified

Definition

Building design and envelope not elsewhere classified refers to buildings design and envelope technologies not included elsewhere in the subcategories of A21.

A22 – Buildings operations and efficient building equipment

Definition

Building operations and efficient building equipment refers to techniques, processes, equipment and systems to meet energy needs within a building, with increased energy efficiency, including lighting, heating, cooling, energy management systems, digital control systems and demand response.

Category A22 is divided into the following subcategories:

A221	Building energy management systems (including smart meters)
A222	Building lighting technologies and control systems
A223	Building heating, cooling and ventilation technologies
A229	Building operations and efficient building equipment not elsewhere classified

A22 <u>excludes</u>:

- Appliances not part of the building fabric.	Ref. A23
- Building envelope hardware.	Ref. A211
- Data centres.	Ref. A6
- Heat pumps for district heat.	Ref. F31
- Industrial heat pumps.	Ref. A121
- Light-emitting diodes (LEDs) used in transport.	Ref. A3
- Solar heating and cooling.	Ref. C11
- Solar photovoltaics.	Ref. C12
- Technologies dedicated to improving indoor air quality only.	Out of scope
- Thermal storage.	Ref. F52

- Waste heat recovery. Ref. F4
- Water and waste-water management, not related to energy efficiency. Out of scope

A221 – Building energy management systems (including smart meters)

Definition

Building energy management systems (including smart meters) refers to devices, systems and software that measure and/or control the energy consumption inside a building and allow for its optimisation.

A221 excludes:

- Control systems specific to HVAC only Ref. A223
- Virtual power plants (VPPs) that remotely control the systems within buildings. Ref. F221

A222 – Building lighting technologies and control systems

Definition

Lighting technologies and control systems refers to all aspects related to producing light (including all aspects of developing solid-state lighting, such as LEDs and organic LEDs), manufacturing bulbs or lamps to be used inside buildings, and monitoring their use.

A222 excludes:

- LEDs used in transport. Ref. A3
- Passive lighting. Ref. A211

A223 – Building heating, cooling and ventilation technologies

Definition

Building heating, cooling and ventilation technologies refers to all aspects related to space heating or cooling, ventilation, hot water, and refrigeration inside residential and commercial buildings, with the exception of passive heating and cooling. HVAC control systems are included in this category.

Category A223 is divided into the following sub-categories:

A2231	Building heat pumps
A2232	Hydrogen and hydrogen-based fuels applications in building heating and cooling
A2233	Bioenergy applications in building heating and cooling
A2239	Building heating, cooling and ventilation technologies not elsewhere classified

A223 <u>excludes</u>:

- Passive heating and cooling. Ref. A211
- Solar heating. Ref. C11
- Technologies dedicated to improving indoor air quality only. Out of scope

A2231 – Building heat pumps

Definition

Building heat pumps refers to energy-efficient devices that use compressors to transfer thermal energy from one location (source) to another (sink), used for space heating, space cooling and domestic hot water production in residential and commercial buildings.

Heat pumps used in buildings include air-source heat pumps ground-source heat pumps, water-source heat pumps and hybrid heat pumps.

Desiccant dehumidification systems in conjunction with heat pumps and chillers for buildings are included in this category. Heat pumps that can be used for industrial or building heating purposes alike are included in this category and not under industrial heat pumps.

A2231 excludes:

- Cooling-only systems such as standard air conditioners or chillers. Ref. A2239
- Electric resistance heating and other non-heat pump technologies. Ref. A2239
- Extraction of shallow geothermal heat. Ref. C59
- Heat pumps for district heating. Ref. F31
- Heat pumps intended for use in industry rather than buildings. Ref. A121

A2232 – Hydrogen and hydrogen-based fuels applications in building heating and cooling

Definition

Hydrogen and hydrogen-based fuels applications applications in building heating and cooling refers to the direct use of hydrogen to provide thermal energy for space heating, and cooling and domestic hot water, such as through hydrogen and ammonia boilers.

A2233 – Bioenergy applications in building heating and cooling

Definition

Bioenergy applications in building heating and cooling refers to the direct use of biomass to provide thermal energy for space heating and cooling, and domestic hot water, such as through biomass stoves and burners.

A2239 – Building heating, cooling and ventilation technologies not elsewhere classified

Definition

Building heating, cooling and ventilation technologies not elsewhere classified refer to building heating, cooling and ventilation technologies not included elsewhere in the subcategories of A223.

Among other elements, A2239 includes:

- Food refrigeration, including standalone equipment.
- Improvements to air conditioning technologies.
- Improvements to heating, cooling and ventilation equipment, such as radiators, underfloor systems, natural gas boilers, electric resistance heaters, ducting, circulation and pipework.

A229 – Building operations and efficient building equipment not elsewhere classified

Definition

Building operations and efficient building equipment not elsewhere classified refers to building operations, equipment ancillary devices not included elsewhere in the subcategories of A22, such as energy efficiency improvement of elevator/lift motors or motor drives integrated into the building envelope allowing for a reduction in the energy consumption of buildings.

A23 – Appliances and equipment (excluding heating and cooling)

Definition

Appliances and equipment (excluding heating and cooling) refers to techniques, processes, equipment and systems pertaining to energy-efficient home or commercial appliances that can be used in a building but not integrated to the building envelope nor supplying light, heating or cooling. Examples include highly energy-efficient communications systems, cookers, refrigerators, clothes washers and dryers, and other appliances, and their controls.

Category A23 is divided into the following subcategories:

A231	Cooking technologies
A232	Energy-efficient information and communication technologies (ICT)
A239	Appliances and equipment not elsewhere classified

A23 excludes:

- Appliances related to water or space heating and cooling. Ref. A223
- Batteries with residential and/or commercial end use. Ref. F511
- Building energy management systems. Ref. A221
- Cell phone or laptop batteries. Ref. F511
- Lighting technologies. Ref. A222

A231 – Cooking technologies

Definition

Cooking technologies refers to devices and systems designed for food preparation through heating or other processes, used in residential and commercial kitchens.

These technologies aim to improve energy efficiency, reduce environmental impacts and expand access to clean cooking. They range from traditional biomass stoves to advanced electric and induction systems.

A231 excludes:

- Food refrigeration. Ref. A223
- Industrial food processing equipment. Ref. A12
- Solar-powered cooking. Ref. C11

A232 – Energy-efficient information and communication technologies (ICT)

Definition

Energy-efficient information and communication technologies (ICT) refers to devices, systems and software that enhance the speed, reliability and security of data transmission and communication while minimising energy consumption.

A232 excludes:

- Data centres. Ref. A6

A239 – Appliances and equipment not elsewhere classified

Definition

Appliances and equipment not elsewhere classified refers to electrical and/or mechanical machines which accomplish some household, office or commercial function not included elsewhere in the subcategories of A23.

These include clothes washers and dryers, dishwashers, televisions, computers, mobile phones, and other digital devices.

A24 – Urban and spatial energy planning

Definition

Urban and spatial energy planning refers to the design, management and optimisation of energy infrastructure and its use in urban or rural areas.

A24 excludes:

- District heating and cooling. Ref. F3
- Mini grids and microgrids. Ref. F23

A29 – Residential and commercial buildings, appliances and equipment not elsewhere classified

Definition

Residential and commercial buildings, appliances and equipment not elsewhere classified refers to buildings and appliances technologies not included elsewhere in the subcategories of A2.

A3 – Transport

Definition

Transport refers to technologies and systems that aim to enhance the energy efficiency of the transport of goods or people through all technological means, or change the sources of energy used to generate motive force. It is not linked to any specific economic activity. Manufacturing and recycling of transport equipment is included in this category.

Category A3 is divided into the following subcategories:

A31	Road transport
A32	Rail
A33	Aviation
A34	Shipping
A35	Other non-road transport
A39	Transport not elsewhere classified

A3 excludes:

- Pipeline transport of oil and gas. Ref B12

A31 – Road transport

Definition

Road transport refers to techniques, processes, equipment and systems related to the manufacture and/or the use of vehicles allowed to circulate on roads, e.g. cars, light trucks, heavy trucks, buses, motorcycles and scooters.

It covers the design of more energy-efficient vehicles (e.g. aerodynamics), the development of new materials and assembling techniques for road transport applications allowing for better energy performances (e.g. light alloys, composite materials) and better reusability/recyclability; the development or optimisation of powertrains, including engines, power electronics and systems, vehicle batteries and storage technologies; and waste heat recovery, as well as the design and development of electric vehicle (EV) infrastructure, such as smart chargers, metering and invoicing devices. Electric bicycles and rickshaws that can be ridden without pedalling are included in this category.

Category A31 is divided into the following subcategories:

A311	Storage technologies on board road transport (excluding hydrogen)
A312	Advanced power electronics, motors and EV/HEV systems on board road transport
A313	Advanced combustion engines and powertrains on board road transport
A314	Electric vehicle charging equipment
A315	Hydrogen for road transport
A316	Materials for road transport
A319	Road transport not elsewhere classified

A31 excludes:

- Pedal electric cycles. Out of scope
- Technologies primarily targeting noise reduction, safety improvement, comfort. Out of scope
- Walking and cycling. Out of scope

A311 – Storage technologies on board road transport (excluding hydrogen)

Definition

Storage technologies on board road transport (excluding hydrogen) refers to systems and devices integrated into vehicles that store energy or fuel for propulsion or auxiliary functions, excluding hydrogen and hydrogen fuel cells.

Category A311 is divided into the following subcategories:

A3111	Batteries on board road transport
A3119	Storage technologies on board road transport not elsewhere classified

A311 excludes:

- Hydrogen fuel cells in road vehicles. Ref. A3151
- Hydrogen storage on board road vehicles. Ref. A3153

A3111 – Batteries on board road transport

Definition

Batteries on board road transport refers to electrical storage technologies used on-board for powering on-road vehicles, for providing start-up power to vehicles, for economising fossil fuel at low speed or for providing ancillary power (air conditioning, etc.). This covers all technological developments into cells and modules, as well as controls, testing, recycling and manufacturing of batteries when road transport specific.

A3111 excludes:

- Batteries for non-transport applications. Ref. F511
- Batteries for rail, shipping, aviation and other non-road transport. Ref. A321 Ref. A331 Ref. A341 Ref. A35
- Batteries with no specific application. Ref. F511
- Extraction, refining and processing of critical minerals. Ref. H
- Fuel cells on board road transport. Ref. A3151

A3119 – Storage technologies on board road transport not elsewhere classified

Definition

Storage technologies on board road transport not elsewhere classified refer to storage technologies on board road transport excluding batteries and hydrogen storage.

A312 – Advanced power electronics, motors and EV/HEV systems on board road transport

Definition

Advanced power electronics, motors and EV/HEV systems on board road transport refers to technologies and components used to manage and control power in electric vehicles (EVs) and hybrid electric vehicles (HEVs) including power electronics and electric motors.

A312 <u>excludes</u>:

- Charging infrastructure and controls. Ref. A314
- Control systems for batteries. Ref. A3111

A313 – Advanced combustion engines and powertrains on board road transport

Definition

Advanced combustion engines and powertrains on board road transport refers to combustion engines with enhanced capabilities and more efficient powertrains, including fuel efficiency, additives, flex-fuel engines, engine-fuel optimisation and the use of sustainable fuels to reduce the fuel consumption and CO_2 emissions of liquid and gaseous fuel powered internal combustion engine road vehicles.

Category A313 is divided into the following subcategories:

A3131	Biofuels applications in combustion engines on board road transport
A3139	Advanced combustion engines and powertrains on board road transport not elsewhere classified

A313 excludes:

- CO_2 capture on board road vehicles. Ref. G19

A3131 – Biofuels applications in combustion engines on board road transport

Definition

Biofuels applications in combustion engines on board road transport refers to the use of biofuels in internal combustion engines to power vehicles, including engine modifications for biofuels.

A3139 – Advanced combustion engines and powertrains on board road transport not elsewhere classified

Definition

Advanced combustion engines and powertrains on board road transport not elsewhere classified refers to technologies related to advanced combustion engines and powertrains on board road transport not included elsewhere in the subcategories of A313.

A314 – Electric vehicle charging infrastructure

Definition

Electric vehicle charging infrastructure refers to all aspects of EV charging infrastructure, including physical aspects, such as charging station hardware, catenary lines and dynamic charging on electrified roads, and digital aspects such as smart charging and grid communications.

Category A314 is divided into the following subcategories:

A3141	Electric vehicle digital charging infrastructure
A3149	Electric vehicle infrastructure not elsewhere classified

A3141 – Electric vehicle digital charging infrastructure

Definition

Electric vehicle digital infrastructure refers to the systems, technologies, and communication protocols that enable efficient, secure, and smart charging (algorithms and protocols), including vehicle-to-grid operations and digital platforms to co-ordinate and optimise EV energy flows, charging patterns and grid stability.

A3141 <u>excludes</u>:

- VPPs that remotely control the charging equipment and systems. Ref. F221

A3149 – Electric vehicle charging infrastructure not elsewhere classified

Definition

Electric vehicle charging infrastructure not elsewhere classified refers to technologies related to EV charging infrastructure excluding digital aspects, such as charging station hardware.

A315 – Hydrogen for road transport

Definition

Hydrogen for road transport refers to the technologies related to the use of hydrogen to power vehicles through fuel cell electric drivetrains or hydrogen combustion engines, covering storage, on-board energy conversion and refuelling infrastructure.

Category A315 is divided into the following subcategories:

A3151	Hydrogen fuel cell drivetrains for road transport
A3152	Hydrogen applications in combustion engines on board road transport
A3153	Hydrogen storage on board road transport
A3154	Hydrogen refuelling station and dispensers for road transport
A3159	Hydrogen for road transport not elsewhere classified

A3151 – Hydrogen fuel cell drivetrains for road transport

Definition

Hydrogen fuel cell drivetrains for road transport refers to the systems and technologies that use hydrogen to generate electricity on-board via fuel cells for vehicle propulsion.

A3152 – Hydrogen applications in combustion engines on board road transport

Definition

Hydrogen applications in combustion engines on board road transport refers to the use of hydrogen as a fuel in internal combustion engines to power vehicles, including engine modifications for hydrogen.

A3153 – Hydrogen storage on board road transport

Definition

Hydrogen storage on board road transport refers to the systems and technologies used to safely store hydrogen as a gas, liquid or in a solid on a vehicle, enabling it to be used as an energy carrier for propulsion independently of the power conversion system, such as fuel cells or combustion engines.

A3154 – Hydrogen refuelling stations and dispensers for road transport

Definition

Hydrogen refuelling stations and dispensers for road transport refers to the equipment and technologies to supply hydrogen fuel to road vehicles.

A3159 – Hydrogen for road transport not elsewhere classified

Definition

Hydrogen for road transport not elsewhere classified refers to technologies related to hydrogen as a road transport fuel not included elsewhere in the subcategories of A315.

A316 – Materials for road transport

Definition

Materials for road transport refers to materials and assembly techniques used in the manufacture of vehicle parts, with a view to reducing costs, enhancing the energy performance of the vehicles or their recyclability.

A319 – Road transport not elsewhere classified

Definition

Road transport not elsewhere classified refers to technologies related to efficiency improvement in on-road transport not included elsewhere in the subcategories of A31, including HVAC, aerodynamics and waste heat recovery applied to on-road vehicles and life-cycle analyses related to on-road vehicles.

A32 – Rail

Definition

Rail transport refers to techniques, processes, equipment and systems related to the manufacture and/or the use of vehicles that travel on rails, such as trains, trams and metros.

It covers the design of energy-efficient vehicles (e.g. aerodynamics), the development of new materials and assembling techniques for rail applications allowing for better energy performances (e.g. light alloys, composite materials) and better reusability/recyclability, and the development or the optimisation of energy-efficient powertrains, of power electronics and systems, of on-board energy storage devices and of energy management systems, including for air conditioning. Use of alternative fuels (liquid or gaseous), including hydrogen, is included in this category. Rail transport logistics and systems optimisation is included in this category.

Category A32 is divided into the following subcategories:

A321	Electricity for rail transport
A322	Hydrogen and hydrogen-based fuels for rail transport
A329	Rail not elsewhere classified

A32 excludes:

- Integrated public transport optimisation and fleet management. Ref. A39

A321 – Electricity for rail transport

Definition

Electricity for rail transport refers to technologies and systems that enable the use of electrical energy to power trains, trams or metros, including overhead catenary systems, third rail systems, battery-electric propulsion, and hybrid-electric systems, as well as the supporting infrastructure for energy storage, power distribution and power management.

A322 – Hydrogen and hydrogen-based fuels for rail transport

Definition

Hydrogen and hydrogen-based fuels for rail transport refers to technologies and systems that enable the use of gaseous or liquid hydrogen, as well as synthetic fuels derived from hydrogen (e.g. ammonia) to power trains, including applications in combustion engines and fuel cells propulsion systems, as well as fuel storage, handling and conversion technologies.

A329 – Rail not elsewhere classified

Definition

Rail not elsewhere classified refers to technologies related to aviation not included elsewhere in the subcategories of A32.

A33 – Aviation

Definition

Aviation refers to techniques, processes, equipment and systems related to the manufacture and/or the use of aircraft, such as planes and helicopters.

It covers the design of energy-efficient transport systems (e.g. more efficient turbines or turbines that run with alternative fuels), the development of materials and assembling techniques for aviation applications allowing for better energy performance (e.g. light alloys, composite materials), and the development of energy-efficient or alternative powertrains, of power electronics and systems, of on-board energy storage devices, energy management systems, aviation logistics and systems optimisation. Hydrogen use and storage for aviation is included in this category.

Category A33 is divided into the following subcategories:

A331	Electricity for aviation
A332	Hydrogen and hydrogen-based fuels for aviation
A339	Aviation not elsewhere classified

A33 <u>excludes</u>:

- Production of sustainable aviation fuels from renewable feedstocks. Ref. C413

A331 – Electricity for aviation

Definition

Electricity for aviation refers to technologies and systems that enable the use of electrical energy to power aircraft, including battery-electric propulsion, hybrid-electric systems and electric motors, as well as the supporting infrastructure for energy storage, power management and charging.

A332 – Hydrogen and hydrogen-based fuels for aviation

Definition

Hydrogen and hydrogen-based fuels for aviation refers to technologies and systems that enable the use of gaseous or liquid hydrogen, as well as synthetic fuels derived from hydrogen (e.g. ammonia) to power aircraft, including applications in combustion engines, fuel cells propulsion systems, as well as fuel storage, handling and conversion technologies.

A339 – Aviation not elsewhere classified

Definition

Aviation not elsewhere classified refers to technologies related to aviation not included elsewhere in the subcategories of A33.

A34 – Shipping

Definition

Shipping refers to techniques, processes, equipment and systems related to the manufacture and/or the use of vehicles that travel on water, such as ships and ferries.

It covers the design of energy-efficient transport systems, adaptation to more environmentally friendly fuels, the development of materials and assembling techniques for marine applications allowing for better energy performance (e.g. light alloys, composite materials), and the development of energy-efficient or alternative powertrains, power electronics and systems, on-board energy storage devices, energy management systems, shipping logistics and systems optimisation. Hydrogen, ammonia and methanol use and storage for shipping is included in this category.

Category A34 is divided into the following subcategories:

A341	Electricity for shipping
A342	Hydrogen and hydrogen-based fuels for shipping
A349	Shipping not elsewhere classified

A34 excludes:

- CO_2 capture on board maritime transport. Ref. G19

A341 – Electricity for shipping

Definition

Electricity for shipping refers to technologies and systems that enable the use of electrical energy to power vessels, including battery-electric propulsion, hybrid-electric systems and electric motors, as well as the supporting infrastructure for energy storage, power management and charging or shore power connection.

A342 – Hydrogen and hydrogen-based fuels for shipping

Definition

Hydrogen and hydrogen-based fuels for shipping refers to technologies and systems that enable the use of gaseous or liquid hydrogen, and synthetic fuels derived from hydrogen (e.g. ammonia) to power vessels, including applications in combustion engines, fuel cells propulsion systems, as well as fuel storage, handling and conversion technologies tailored to maritime operations.

A349 – Shipping not elsewhere classified

Definition

Shipping not elsewhere classified refers to technologies related to shipping not included elsewhere in the subcategories of A34. This includes equipment, materials and systems for improving the energy efficiency of waterborne vessels, including novel sail designs, antifouling techniques and cold-ironing.

A35 – Other non-road transport

Definition

Other non-road transport refers to techniques, processes, equipment and systems pertaining to transport systems used primarily outside of conventional road networks, such as construction vehicles (e.g. cranes, bulldozers), tractors, forklifts, golf carts, mowers and wheelchairs.

A35 <u>excludes</u>:

- Aviation. Ref. A33
- Integrated public transport optimisation and fleet management. Ref. A39

- Rail. Ref. A32
- Shipping. Ref. A34

A39 – Transport not elsewhere classified

Definition

Transport not elsewhere specified refers to techniques, processes, equipment and systems pertaining to transport systems not specific to any mode of transport mentioned elsewhere in the subcategories of A3.

Among other elements, A39 includes:

- Design of road infrastructure to reduce transport energy consumption.
- Integrated public transport optimisation.
- LEDs used in vehicles not covered elsewhere.
- Nuclear propulsion for space or submarine applications.
- Vehicle and transport system simulation and testing not covered elsewhere.

A39 excludes:

- Improvement of energy efficiency of industrial equipment such as industrial cranes. Ref. A12

A4 – Agriculture and forestry

Definition

Agriculture and forestry refers to the techniques, processes, equipment and systems to reduce the energy consumption or energy-related emissions in forestry and agriculture.

Among other elements, A4 includes:

- Development of energy-efficient equipment and processes in agriculture and forestry.
- Energy efficiency improvements in the use of fertilisers.
- Research on agricultural and forestry practices.

A4 excludes:

- Biofuels. Ref. C4
- Improvement of CO_2 assimilation by crops. Ref. C49

A5 – Construction and civil engineering

Definition

Construction and civil engineering refers to the development and implementation of technologies, materials and processes to improve energy efficiency and reduce energy-related emissions in the construction sector, including building and civil engineering works such as roads.

It covers the use of materials (including wood and composites) and the improvement of processes to reduce energy consumption during construction works but excludes the design of energy-efficient buildings once built.

A5 excludes:

- CO_2 use in cement production. Ref. A14
- Construction vehicles. Ref. A35
- Design of energy-efficient buildings. Ref. A212
- Renewable energy integration in construction. Ref. C

A6 – Data centres

Definition

Data centres refers to the optimisation of the use of energy to perform computing tasks, minimising energy waste, maximising energy performance in data centres and enhancing how data centres interact with the electricity grid and other power connections.

This involves implementing technologies and strategies that reduce power consumption, improve cooling systems and enhance overall operational efficiency. Dynamic voltage, frequency scaling and advanced power supply units for energy optimisation, as well as modular and edge data centres that optimise energy use and reduce latency, are included in this category.

A24 excludes:

- Energy storage systems.	Ref F5
- Non-data centre ICT efficiency.	Ref A232
- Renewable energy use in data centres.	Ref C

A9 – Energy end uses not elsewhere classified

Definition

Energy end uses not elsewhere classified refers to techniques, processes, equipment and systems pertaining to energy efficiency, electrification and other end uses not included elsewhere in category A.

B – Fossil fuels

Definition

Fossil fuels refers to technologies, processes and strategies for the production, transportation, utilisation (not elsewhere specified) and transformation of coal, natural gas, oil and peat.

Category B is divided into the following subcategories:

B1	Oil and gas
B2	Coal
B3	Oil-, gas- and coal-related methane management
B9	Fossil fuels not elsewhere classified

B1 – Oil and gas

Definition

Oil and gas refers to technologies, processes, equipment and systems related to the identification, extraction, distribution, combustion (not included elsewhere) and transformation into other non–electrical energy products of liquid and gaseous hydrocarbons of fossil origin.

Liquid hydrocarbons of fossil origin include crude oil, liquids extracted from natural gas, and fully or partly processed products from the refining of crude oil.

Gaseous hydrocarbons of fossil origin include natural gas, which is a mixture of gaseous hydrocarbons, primarily methane, but generally also including ethane, propane and higher hydrocarbons in much smaller amounts and some non-combustible gases such as nitrogen and carbon dioxide.

Category B1 is divided into the following subcategories:

B11	Conventional oil and gas production
B12	Refining, transport and storage of oil and gas
B13	Non-conventional oil and gas production
B14	Oil and gas combustion
B15	Oil and gas transformation
B19	Oil and gas not elsewhere classified

B1 excludes:

- Methane emissions management. Ref. B3

B11 – Conventional oil and gas production

Definition

Conventional oil and gas production refers to techniques, processes, equipment and systems designed to increase the amount of oil and/or gas extracted by conventional means from underground oil and/or gas reservoirs or fields.

Conventional oil and gas production is sometimes referred to as secondary and tertiary recovery of oil and gas.

Among other elements, B11 includes:

- Advanced exploration methods (geophysical, geochemical, seismic and magnetic) for onshore and offshore prospecting.
- Deep-drilling equipment and techniques.
- Enhanced oil recovery without techniques to increase CO_2 storage.
- Hydrofracturing techniques.

- Injection of numerous gases, chemicals or micro-organisms.
- Reservoir engineering.
- Thermal recovery.
- Water and waste-water treatment specific to enhanced oil and gas production.

B11 excludes:

- Non-conventional oil and gas production.	Ref. B13
- Oilfield brine direct lithium extraction.	Ref. H2
- Production of hydrogen-based synthetic fuels containing carbon of fossil origin.	Ref. E6

B12 – Refining, transport and storage of oil and gas

Definition

Refining, transport and storage of oil refers to techniques, processes, equipment and systems applied to the transport of crude oil from its point of production to oil refineries, to the crude oil transformation chain inside refineries, and to storage of refined oil products and their transport to their points of use.

Refining, transport and storage of gas refers to techniques, processes, equipment and systems applied to each step from gas production to delivery of natural gas at point of use, including liquefied natural gas (LNG).

Among other things, B12 includes:

- Design and operation of natural gas liquefaction and vaporisation units.
- Gasification of naphtha and feedstocks.
- Mitigation of the environmental impact of refineries.
- Natural gas transportation in the form of compact hydrate structures.
- Optimisation of the mix of refined products.

- Refinery efficiency improvement.
- Safety aspects of LNG storage and transport.
- Strategic storage of liquid and gaseous hydrocarbons.
- Transportation of liquid and gaseous hydrocarbons, pipeline network system evaluation and research on sub-marine pipelines.

B12 excludes:

- Hydrogen production. Ref. E1
- Hydrogen storage. Ref. E2

B13 – Non-conventional oil and gas production

Definition

Non-conventional oil and gas production refers to techniques, processes, equipment and systems either to directly extract non-conventional oils or gases out of the ground, or to extract oil- or gas-rich materials out of the ground and to process them ex situ to recover hydrocarbons.

Non-conventional oils refers to mineral oils obtained by non-conventional production techniques, such as oils that are extracted from reservoirs containing extra heavy oils or oil sands, which need heating or treatment in situ before they can be brought to the surface for refining/processing. They also include the oils extracted from oil sands, extra heavy oils, coal and oil shale which are at, or can be brought to, the surface without treatment and require processing after mining (ex situ processing).

Non-conventional gases, often referred to as unconventional gases, refers to natural gas with low permeability either contained in oil rock (tight gas) or in shale rock (shale gas), methane-rich gas stored within coal structures (coal-bed methane), and natural gas hydrates.

Among other elements, B13 includes:

- Advanced drilling technologies and hydraulic fracturing.
- Deepwater extraction of non-conventional oil and gas.
- Depressurisation to recover gas from hydrates.

- In situ processes for shale gas.
- Production of oil from tar sands.
- Retorting technologies for ex situ processing of shale oils.

B13 excludes:

- Biofuels production.	Ref. C4
- Enhanced oil recovery as a complement to CO_2 storage.	Ref. G3
- Enhanced oil recovery from conventional fields.	Ref. B11
- Hydrogen production.	Ref. E1
- Production of hydrogen-based synthetic fuels.	Ref. E6

B14 – Oil and gas combustion

Definition

Oil and gas combustion refers to techniques, processes, equipment and systems to burn oil or gas in order to generate power or supply energy to non-specific applications, such as steam generation.

This category includes general work on combustion cycles, whether conventional or combined, heat generation, turbines and turbo engines, but does not include associated electricity generation technologies. Flue gas clean-up, excluding CO_2 removal, is included in this category. Specific applications of oil and gas combustion for industry, transport and buildings are not included in this category.

B14 excludes:

- CO_2 capture from oil and gas combustion.	Ref. G11
- Combustion specific to the building sector, such as for building heating.	Ref. A2
- Combustion specific to vehicles propulsion.	Ref. A3
- Development or improvement of burners and furnaces.	Ref. A12

- Reduction of energy consumption in industrial processes. Ref. A11
- Specific industrial combustion processes, such as glass melting, metals refining and cement kilns. Ref. A11

B15 – Oil and gas transformation

Definition

Oil and gas transformation refers to techniques, processes, equipment and systems to transform oil or gas into non-electricity, non-heat products, excluding hydrogen or hydrogen-based fuels. This includes methane partial oxidation to methanol, gas-to-liquid technologies and Fischer-Tropsch synthesis based on petroleum or natural gas products, including waste polymers.

B15 excludes:

- CO_2 capture. Ref. G1
- Production of hydrogen-based synthetic fuels. Ref. E6
- Reduction of energy consumption in industrial processes. Ref. A11
- Steam methane reforming or other techniques to produce hydrogen. Ref. E12

B19 – Oil and gas not elsewhere classified

Definition

Oil and gas not elsewhere classified refers to techniques, processes, equipment and systems involving oil or gas not included elsewhere in the subcategories of B1. Environmental, safety and health aspects of oil and gas, both onshore and offshore, including offshore structures, are included in this category.

B2 – Coal

Definition

Coal refers to techniques, processes, equipment and systems related to solid fossil fuels consisting of carbonised vegetal matter and products derived from them including liquids and gases.

NB: For the purposes of this classification, peat is included in B2 although it is not considered as coal in the Standard International Energy Product Classification (SIEC).

Category B2 is divided into the following subcategories:

B21	Coal production, preparation and transport
B22	Coal combustion
B23	Coal transformation
B29	Coal not elsewhere classified

B2 excludes:

- Methane emissions management. Ref. B3

B21 – Coal production, preparation and transport

Definition

Coal production, preparation and transport refers to techniques, processes, equipment and systems applied to each step from coal mining to delivery at point of use, including the production of secondary coal products. These steps include geological surveys, deposit evaluation, mining (e.g. surface and underground mining), mechanical preparation of coal (e.g. removal of inorganic sulphur and other non-combustible material, crushing, dewatering), blending, production of secondary

coal products such as coke and briquettes, and its transport. Methane extraction from virgin seams, working or abandoned mines is included in this category.

B21 <u>excludes</u>:

- Coal transformation into synthesis gas (syngas), organic gases or liquids. Ref. B23
- Environmental, safety and health aspects of coal. Ref. B29
- Mining vehicles. Ref. A35

B22 – Coal combustion

Definition

Coal combustion refers to techniques, processes, equipment and systems to burn coal to generate electrical power or to supply heat to non-specific applications.

This category includes general work on combustion cycles, whether conventional or combined, heat generation, turbines and turbo engines, but does not include associated electricity generation technologies. Flue gas clean-up, excluding CO_2 removal, is included in this category. Specific applications of coal combustion for industry, transport and buildings are not included in this category.

B22 <u>includes</u>:

- Boilers (including conventional utility boiler, fluidised bed combustion) and combustion efficiency measurement systems.
- Coal combustion for heat.
- Integrated gasification combined cycle (IGCC) units.
- Pre- and post-combustion removal of sulphur and nitrogen species.
- Re-powering, retrofitting, life extensions and upgrading of coal power plants.

B22 excludes:

- CO_2 capture from coal combustion. Ref. G11
- Coal co-firing with biomass. Ref. C44
- Direct coal use in industry, transport and buildings. Ref. A
- Environmental, safety and health aspects of coal. Ref. B29
- Hydrogen production from coal. Ref. E12

B23 – Coal transformation

Definition

Coal transformation refers to techniques, processes, equipment and systems to transform coal into syngas, organic gases or liquids. This includes underground coal gasification in situ (for the production of syngas, methane or other organic gases), liquefaction (whether direct or via gasification), hydrogenation and Fischer-Tropsch synthesis based on coal.

B23 excludes:

- Environmental, safety and health aspects of coal. Ref. B29
- Fischer-Tropsch synthesis based on oil and gas. Ref. B15
- Hydrogen production. Ref. E1
- IGCC power generation. Ref. B22
- Techniques, equipment, systems and processes related to coal combustion. Ref. B22

B29 – Coal not elsewhere classified

Definition

Coal not elsewhere classified refers to techniques, processes, equipment and systems related to coal not included elsewhere in the subcategories of B2. Environmental, safety and health aspects of coal, including management of ashes and coal wastes, are included in this category.

B3 – Oil-, gas- and coal-related methane management

Definition

Oil-, gas- and coal-related methane management refers to techniques, processes, equipment and systems to monitor, reduce and control methane emissions from fossil fuel operations.

B9 – Fossil fuels not elsewhere classified

Definition

Fossil fuels not elsewhere classified refers to techniques, processes, equipment and systems related to fossil fuels that are not mentioned elsewhere in category B.

C – Renewable energy sources

Definition

Renewable energy sources refers to techniques, processes, equipment and systems to harness and utilise fuels and energy obtained directly from solar radiation, indirectly from its effects on the biosphere and the life within it, from geothermal energy, and from gravitational forces. It does not include fossil fuels, which cannot be replenished on a decadal timescale. Manufacturing and recycling of renewable energy equipment is included in this category.

Category C is divided into the following subcategories:

C1	Solar energy
C2	Wind energy
C3	Ocean energy
C4	Bioenergy
C5	Geothermal energy
C6	Hydroelectricity
C9	Renewable energy sources not elsewhere classified

C1 – Solar energy

Definition

Solar energy refers to technologies, processes, equipment and systems that harness solar radiation to generate energy for various applications. This includes advancements in photovoltaic (PV) technologies that generate electricity from solar radiation, and solar thermal systems.

Category C1 is divided into the following subcategories:

C11	Solar heating and cooling
C12	Solar photovoltaics
C13	Solar thermal power and high-temperature applications
C19	Solar energy not elsewhere classified

C11 – Solar heating and cooling

Definition

Solar heating and cooling refers to techniques, processes, equipment and systems to generate thermal energy from solar radiation at temperatures below circa 250 °C, mainly with a view to heating or cooling of water or air.

Among other elements, C11 includes:

- Flat plate solar collectors.
- Intelligent control systems of solar energy flows.
- Solar low-temperature process heating.
- Solar-assisted ventilation.
- Solar cooking.
- Solar cooling technologies such as absorption refrigeration cycles and desiccant cycles.
- Solar drying (e.g. of agricultural products).
- Solar swimming pool heating.
- Solar water heating.

C11 excludes:

- Building design and envelope for passive solar heating. Ref. A21
- Concentrating solar power (CSP). Ref. C13
- Solar high-temperature applications. Ref. C13
- Solar PV technology. Ref. C12
- Thermal storage technologies. Ref. F52

C12 – Solar photovoltaics

Definition

Solar photovoltaics refers to techniques, processes, equipment and systems to produce electricity by the direct conversion of solar radiation in semiconductor devices (solar cells), including improving the efficiency and the manufacture of PV equipment and systems.

Category C12 is divided into the following subcategories:

C121	Solar cell technologies
C122	Solar modules
C123	Integrated photovoltaics
C124	Solar photovoltaics systems
C129	Solar photovoltaics not elsewhere classified

C12 excludes:

- Electricity storage technologies. Ref. F51
- Solar heating and cooling. Ref. C11

C121 – Solar cell technologies

Definition

Solar cell technologies refers to the materials, structures, and manufacturing processes used to convert sunlight into electricity in solar PV systems. The scope includes solar cell efficiency, cost reduction, material sustainability, and performance under diverse conditions regardless the product or application. Assembly into solar PV modules is not included in this category.

Among other elements, C121 <u>includes</u>:

- Dye sensitised cells, thermo-PV cells, quantum dots and wells.
- Next-generation semiconductors for PV applications.
- Passivated Emitter and Rear Cells (PERC) for crystalline silicon solar cells.
- Polymer solar cells, including organic cells.
- Thin-film and perovskite solar cells.
- Transparent conductive materials for PV applications.
- Tunnel oxide passivated contact (TOP-Con), heterojunction and back contact.

C121 <u>excludes</u>:

- Assembly of solar cells into a solar module. Ref. C122
- Concentrating solar power (CSP). Ref. C13
- Downstream components of solar PV systems, such as inverters. Ref. C124

C122 – Solar modules

Definition

Solar modules refers to the assembly of multiple interconnected solar cells, typically encapsulated in a protective structure that includes glass, polymer layers and an aluminium frame.

C122 excludes:

- Downstream components of solar PV systems, such as inverters. Ref. C124
- Solar cell technologies. Ref. C121

C123 – Integrated photovoltaics

Definition

Integrated photovoltaics refers to PV systems integrated into the structure of buildings (e.g. roof, façade, windows), infrastructure (e.g. noise barriers, road surface) or vehicles (e.g. car roofs, boats), functioning as both an energy-generating solution and a structural element.

Among other elements, C123 includes:

- Anti-reflective and self-cleaning coatings.
- Customisable BIPV designs to match architectural needs.
- Encapsulation and lamination materials.
- Transparent PV embedded in windows or glass facades.

C123 excludes:

- Building design and envelope except BIPV elements. Ref. A21
- Non-photovoltaic solar technologies integrated in buildings. Ref. C11
- Solar heating and cooling. Ref. C11

C124 – Solar photovoltaics systems

Definition

Solar photovoltaic systems refers to integrated configurations of solar panels, inverters, mounting structures, wiring, monitoring, controls and associated components to facilitate the production of usable electricity. These systems can vary

in size, design and purpose, ranging from small-scale residential installations to utility-scale solar farms. Concentrating PV, floating PV and agrivoltaics are included in this category.

C124 <u>excludes</u>:

- General inverters not integrated into solar PV systems. Ref. F212
- Solar cell technologies. Ref. C121
- Solar modules Ref. C122
- Solar PV integrated into structures such as buildings or vehicles Ref. C123

C129 – Solar photovoltaics not elsewhere classified

Definition

Solar photovoltaics not elsewhere classified refers to techniques, processes, equipment and systems related to solar PV not included elsewhere in the subcategories of C12. Resource assessments for solar PV and life-cycle analysis of solar PV are included in this category.

C13 – Solar thermal power and high-temperature applications

Definition

Solar thermal power and high-temperature applications refers to techniques, processes, equipment and systems to generate high-temperature (i.e. above around 250 °C) heat from solar radiation captured by concentrating solar thermal systems.

C13 <u>includes</u>:

- CSP collectors.
- Design, construction and testing of solar thermal power plants.

- Molten-salt storage integrated in CSP.
- Resource assessment for solar thermal power.
- Solar-high-temperature applications for process heat.
- Solar chemistry based on high-temperature processes (e.g. for water detoxification).

C13 <u>excludes</u>:

- High-temperature electrolysis for hydrogen production.	Ref. E11
- Power storage technologies.	Ref. F51
- Solar heating and cooling.	Ref. C11
- Solar PV technologies.	Ref. C12
- Thermal storage technologies not integrated in CSP.	Ref. F52

C19 – Solar energy not elsewhere classified

Definition

Solar energy not elsewhere classified refers to techniques, processes, equipment and systems related to solar energy not included elsewhere in the subcategories of C1.

C19 <u>includes</u>:

- Solar forecasting.

C2 – Wind energy

Definition

Wind energy refers to technologies, processes, equipment and systems that harness wind power for electricity generation. This includes advancements in wind turbine design, materials and systems for both onshore and offshore wind applications, as well as wind energy equipment manufacturing.

Category C2 is divided into the following subcategories:

C21	Onshore wind technologies
C22	Offshore wind technologies
C29	Wind energy not elsewhere classified

C21 – Onshore wind technologies

Definition

Onshore wind technologies refers to techniques, processes, materials and equipment to produce electricity from onshore devices driven by wind, including the enhancement of the performance, reliability and manufacturing of the equipment.

Among other elements, C21 includes:

- Low wind speed technologies.
- Megawatt-scale technologies.
- Off-ground, high-altitude wind technologies (e.g. flying turbines, kites).
- Small-scale technologies, including rooftop and community scales.

C21 excludes:

- Electrical storage.	Ref. F51
- Hybrid wind energy systems.	Ref. C29
- Wind resource and site characterisation.	Ref. C29
- Wind technologies not specific to onshore or offshore systems.	Ref. C29

C22 – Offshore wind technologies

Definition

Offshore wind technologies refers to techniques, processes, materials and equipment to produce electricity from offshore devices driven by wind, including the enhancement of the performance, reliability and manufacturing of the equipment.

Category C22 is divided into the following subcategories:

C221	Fixed-bottom offshore wind technologies
C222	Floating offshore wind technologies
C229	Offshore wind technologies not elsewhere classified

C22 <u>excludes</u>:

- Electrical linkage of offshore sites to land. Ref. F21
- Hybrid wind energy systems. Ref. C29
- Wind resource and site characterisation. Ref. C29
- Wind technologies not specific to onshore or offshore systems. Ref. C29

C221 – Fixed-bottom offshore wind technologies

Definition

Fixed-bottom offshore wind technologies refers to techniques, processes, materials and equipment to produce electricity from offshore devices mounted on structures fixed to the seabed, including the enhancement of the performance, reliability and manufacturing of the equipment. They are distinguished from floating offshore wind technologies by their reliance on fixed substructures (not just cables) that connect them to the seabed.

The types of foundation include monopile, jacket, gravity-based, and tripod or tripile foundations.

C222 – Floating offshore wind technologies

Definition

Floating offshore wind technologies refers to techniques, processes, materials and equipment to produce electricity from offshore devices that use buoyant platforms anchored to the seabed with mooring lines (allowing turbines to capture stronger and more consistent wind resources in deeper marine environments), including the enhancement of the performance, reliability and manufacturing of the equipment.

The platform types include spar-buoy platforms, semi-submersible platforms, tension-leg platforms and barge platforms.

C229 – Offshore wind technologies not elsewhere classified

Definition

Offshore wind technologies not elsewhere classified refers to techniques, processes, equipment and systems related to offshore wind energy not included elsewhere in the subcategories of C22, including the research of all the common elements to fixed-bottom and floating technologies such as wind turbines.

C29 – Wind energy not elsewhere classified

Definition

Wind energy not elsewhere classified refers to techniques, processes, equipment and systems related to wind energy not included elsewhere in the subcategories of C2. Wind resource assessment, hybrid onshore/offshore wind energy systems, wind forecasting and wind technologies not specific to onshore or offshore systems are included in this category.

C29 excludes:

- Grid integration. Ref. F221
- Integration of wind energy with hydrogen production. Ref. E11
- Load management. Ref. F221

C3 – Ocean energy

Definition

Ocean energy refers to techniques, processes, equipment and systems to generate power from devices which exploit sources of ocean energy. Equipment to convert ocean energy into useful forms of energy, whether at small or large scales, as well as materials development and resource assessment are included in this category.

Examples of ocean energy sources are tides, waves, salinity gradient ocean current power and ocean thermal power (e.g. temperature differences in seas).

Category C3 is divided into the following subcategories:

C31	Tidal energy
C32	Wave energy
C33	Salinity gradient power
C34	Ocean thermal power
C39	Ocean energy not elsewhere classified

C3 excludes:

- All activities linked to algae harvesting or use. Ref. C41
- CO_2 capture from oceans. Ref. G12
- Grid integration. Ref. F221

C31 – Tidal energy

Definition

Tidal energy refers to techniques, processes, equipment and systems to generate power from tidal currents or from the differences of water level caused by tides. Tidal stream, tidal lagoon and related turbine technologies are included in this category, along with resource and siting assessments.

C31 excludes:

- Hydroelectricity turbines. Ref. C6
- Ocean current power. Ref. C39

C32 – Wave energy

Definition

Wave energy refers to techniques, processes, equipment and systems to generate power from the motion of waves, focusing on equipment design, optimisation, resource assessment, environmental assessment, forecasting and siting.

C32 excludes:

- Energy transfer from offshore unit to land. Ref. F21
- Ocean current power. Ref. C39

C33 – Salinity gradient power

Definition

Salinity gradient power, also called osmotic power, refers to any techniques, processes, equipment and systems to generate power from salinity differences between sea and fresh water, such as osmosis and reverse electrodialysis. This

category covers all technologies dedicated to salinity gradient power, as well as resource assessment, environmental assessment, forecasting and siting.

C34 – Ocean thermal power

Definition

Ocean thermal power, also called Ocean Thermal Energy Conversion (OTEC), refers to techniques, processes, equipment and systems to generate electricity by exploiting the temperature difference between warm surface seawater and cold deep seawater. This category covers all technologies dedicated to ocean thermal power, as well as resource assessment, environmental assessment, forecasting and siting.

C39 – Ocean energy not elsewhere classified

Definition

Ocean energy not elsewhere classified refers to techniques, processes, equipment and systems related to ocean energy not included elsewhere in the subcategories of C3. Non-tidal ocean current energy and seawater air conditioning are included in this category, covering technologies dedicated to these techniques, as well as resource assessment, environmental assessment, forecasting and siting.

C4 – Bioenergy

Definition

Bioenergy refers to technologies, processes, equipment and systems related to energy derived from biomass.

Biomass is organic material obtained from living or recently living organisms, such as agricultural residues, forestry by-products, dedicated energy crops and municipal waste. It excludes fossilised or partly fossilised material.

Category C4 is divided into the following subcategories:

C41	Liquid biofuels production
C42	Solid bioenergy production
C43	Gaseous bioenergy production
C44	Bioenergy applications for heat and electricity
C45	Biorefining
C49	Bioenergy not elsewhere classified

C41 – Liquid biofuels production

Definition

Liquid biofuels production refers to the processes and technologies involved in the production of renewable liquid fuels derived from organic biomass, used primarily in the transportation sector and, to a lesser extent, in industry and power generation. They encompass bioethanol, biodiesel and advanced liquid biofuels, produced through various biological, chemical and thermochemical processes. All technologies for the preparation and transformation of biomass to retail liquid fuels are included in this category, along with related improvements to fuel quality, scale of production and costs.

Category C41 is divided into the following subcategories:

C411	Biogasoline production
C412	Biodiesel production

C413	Biojet kerosene production
C419	Liquid biofuels production not elsewhere classified

C41 <u>excludes</u>:

- Applications of liquid biofuels for transport. Ref. A3
- Conversion of liquid biofuels to thermal or electrical energy. Ref. C44
- Improvement of energy crops. Ref. C49
- Improvement of microalgae productivity and content. Ref. C49
- Research on liquid biofuel production potential and associated land-use effects. Ref. C49
- Technologies for biomass preparation and transformation not specific to biofuels. Ref. C45

C411 – Biogasoline production

Definition

Biogasoline production refers to the processes and technologies involved in converting biomass-derived feedstocks into biogasoline.

Biogasoline is a renewable liquid fuel that can be used in conventional spark-ignition internal combustion engines without significant modifications. It includes biomethanol, bioethanol, biobutanol, bio-MTBE and bio-ETBE.

Among other elements, C411 <u>includes</u>:

- Aqueous phase reforming (APR).
- Biogasoline production from thermal routes, i.e. through gasification and Fischer-Tropsch synthesis.
- Catalytic fast pyrolysis.
- Hydro-processing of bio-oils.

- Improvement of feedstock selection: utilisation of agricultural and forestry residues, algae, and sugar and starch to produce biogasoline.

C412 – Biodiesel production

Definition

Biodiesel production refers to the processes and technologies involved in converting lipid-based feedstocks into biodiesel.

Biodiesel is a renewable fuel that can be used in diesel engines with little or no modification. It includes FAME, thermally produced biodiesel, microalgal biodiesel, straight vegetable oil and hydrogenated vegetable oil diesel (HVO). FAME (fatty acid methyl ester) is produced through transesterification of vegetable oils, animal fats or waste oils and can be blended with petroleum diesel or used as a stand-alone fuel. Thermally produced biodiesel includes routes that incorporate gasification and Fischer-Tropsch synthesis. All feedstocks are within the scope of the category, including *inter alia* vegetable oils, used cooking oil, animal fats and microalgae-derived lipids.

C413 – Biojet kerosene production

Definition

Biojet kerosene production refers to the processes and technologies used to produce sustainable aviation fuels (SAF) from renewable feedstocks. Biojet fuels are designed to replace or blend with conventional petroleum-based jet fuels. All conversion pathways – including via gasification and Fischer-Tropsch synthesis – and advances in feedstock utilisation are included in this category. The use of bio-derived CO_2 in the production of hydrogen-based SAF is not included.

C413 <u>excludes</u>:

- Hydrogen-based SAF production. Ref. E6

C419 – Liquid biofuels production not elsewhere classified

Definition

Liquid biofuels production not elsewhere classified refers to technologies, processes and techniques related to liquid biofuels production not included elsewhere in the subcategories of C41. Production of biocrude, bio-oils, bio-LPG and coprocessing of biomass-derived feedstocks into conventional petroleum refining processes are included in this category.

C42 – Solid bioenergy production

Definition

Solid bioenergy production refers to techniques, processes, equipment and systems to obtain solids fuels from biomass, remove non-flammable or toxic residues or otherwise increase their density and caloric value.

Solid biofuels are solid non-fossil materials of biological origin used for energy purposes, including primary solid biofuels, such as harvested biomass, harvest residues, biomass processing residues and animal residues; and secondary solid biofuels: biomass pellets, briquettes and charcoal.

Category C42 is divided into the following subcategories:

C421	Fuelwood, wood residues and by-products production
C422	Charcoal and biochar production
C429	Solid biofuels production not elsewhere classified

C42 <u>excludes</u>:

- Conversion of solid bioenergy to thermal or electrical energy. Ref. C44

- Research on biomass production potential and associated land-use effects. Ref. C49
- Technologies for growing biomass, including higher CO_2 assimilation in plants. Ref. C49

C421 – Fuelwood, wood residues and by-products production

Definition

Fuelwood, wood residues and by-products production refers to the technologies and practices that convert raw wood and wood waste into energy carriers and value-added products for heating, power generation and industrial applications.

It includes the sustainable collection of wood from managed forests and thinning operations, and residues from logging activities; the utilisation of by-products from sawmills, furniture manufacturing and wood processing; and treatment processes, such as drying, chipping, pelletisation, densification and size reduction techniques to optimise the quality and consistency of raw materials.

C421 <u>excludes</u>:

- Charcoal production through pyrolysis and carbonisation. Ref. C422
- Combustion systems for fuelwood, wood residues and by-products. Ref. C44

C422 – Charcoal and biochar production

Definition

Charcoal and biochar production refers to the technologies and practices involved in the thermochemical conversion of wood or biomass into solid carbonaceous products, through processes such as pyrolysis or carbonisation.

It includes different conversion technologies: traditional charcoal kilns; modern pyrolysis systems; and retort and closed-system technologies.

C422 excludes:

- Combustion systems for charcoal. Ref C44

C429 – Solid bioenergy production not elsewhere classified

Definition

Solid biofuels production not elsewhere classified refers to technologies, processes and techniques related to solid biofuels production not included elsewhere in the subcategories of C42, such as the production of solid biofuels from bagasse, animal waste and organic municipal waste.

C43 – Gaseous bioenergy production

Definition

Gaseous bioenergy production refers to techniques, processes, equipment and systems to obtain combustible gases from the anaerobic fermentation or gasification of biomass, including biomass in waste and landfill. Upgrading gaseous bioenergy by separating the flammable fraction (mainly methane) from associated inert gases (mainly CO_2) and by eliminating toxic or corrosive impurities is included in this category.

It includes thermochemical and biochemical processes, and the objective is to improve the performance, the reliability and the competitiveness of the production processes.

Category C43 is divided into the following subcategories:

C431	Gaseous bioenergy production from thermal processes
C432	Gaseous bioenergy production from anaerobic fermentation
C433	Biomethane production
C439	Gaseous bioenergy production not elsewhere classified

C43 excludes:

- Conversion of gaseous bioenergy to thermal or electrical energy. Ref. C44
- Hydrogen production from biomass. Ref. E14
- Research on bioenergy production potential and associated land-use effects. Ref. C49

C431 – Gaseous bioenergy production from thermal processes

Definition

Gaseous bioenergy production from thermal processes refers to techniques, processes, materials, equipment and systems to obtain gaseous bioenergy products, including synthesis gas, via the use of thermal processes, such as gasification or pyrolysis of biomass.

C431 excludes:

- Hydrogen production from biomass. Ref. E14

C432 – Gaseous bioenergy production from anaerobic fermentation

Definition

Gaseous bioenergy production from anaerobic fermentation refers to the biological breakdown of organic matter by micro-organisms in oxygen-free environments, resulting in the generation of gases, primarily methane and CO_2, collectively known as biogas.

This process can be applied to a variety of feedstocks such as agricultural residues, municipal organic waste, animal manure and energy crops.

C432 excludes:

- Upgrading biogases to biomethane. Ref C433

C433 – Biomethane production

Definition

Biomethane production refers to the upgrading of biogases to biomethane.

Biomethane is a secondary energy product derived mainly from either synthesis gas or biogases from anaerobic digestion and is chemically identical to the methane found in natural gas. It involves multiple physical processes to increase the concentration of biomethane by removing impurities such as carbon dioxide, water, nitrogen, oxygen, siloxane and other volatile compounds, and making it suitable for use as a renewable substitute for natural gas. Different techniques may be involved, including *inter alia* water scrubbing (absorption), pressure swing adsorption, membrane separation and chemical absorption.

C433 <u>excludes</u>:

- Methane production from hydrogen Ref. E6

C439 – Gaseous bioenergy production not elsewhere classified

Definition

Gaseous bioenergy production not elsewhere classified refers to technologies, processes and techniques related to gaseous bioenergy production not included elsewhere in the subcategories of C43.

C44 – Bioenergy applications for heat and electricity

Definition

Bioenergy applications for heat and electricity refers to techniques, processes, materials, equipment and systems to generate heat, cooling or electricity from bioenergy, or any combinations of these three energy outputs from the same plant, such as combined heat and power (CHP).

It covers improving the performance, the reliability and the environmental footprint (such as with fuel gas purification) of devices for generating heat from bioenergy and designing thermodynamic and mechanical systems to efficiently produce electricity from bioenergy. Only technologies specific or tuned to bioenergy, or for co-firing bioenergy with fossil fuels, are included in this category.

C45 excludes:

- Bioenergy applications for heat and power integrated into industrial processes.	Ref. A19
- Bioenergy applications in buildings heating and cooling	Ref. A2233
- Biomass stoves for cooking	Ref. A231
- Design of district heating and district cooling systems.	Ref. F3
- Purification and upgrading of biogases.	Ref. C43
- Use of bioenergy in transport	Ref. A3

C45 – Biorefining

Definition

Biorefining refers to two technology areas. One is the production of one or more energy or non-energy products (excluding heat and electricity) alongside a liquid, solid or gaseous energy product from a biomass input at a single site. The other is the processing of biomass into a state that can be further processed into a variety of different potential liquid, solid or gaseous that are undetermined by the technology developer.

For the first area, specific technologies contributing to a biorefinery that are covered by other categories within C4 are not included in this category unless integrated together to specifically facilitate multiple products.

For the second area, examples include converting biomass to a fermentable state, such as via acid hydrolysis.

C46 excludes:

- Energy efficiency improvements at pulp and paper plants. Ref. A1

C49 – Bioenergy not elsewhere classified

Definition

Bioenergy not elsewhere classified refers to techniques, processes, materials, equipment and systems related to bioenergy not included elsewhere in the subcategories of C4. Improvement of energy crops and algae, including enhanced CO_2 assimilation, analysis of potential availability and land-use impacts of bioenergy, and encapsulation of biomass to prevent the release of its CO_2 content, for example in hermetic stores, are included in this category.

C49 excludes:

- Use of wood in construction. Ref. A5

C5 – Geothermal energy

Definition

Geothermal energy refers to techniques, processes, materials, equipment and systems to extract heat from the earth (usually as heated water or steam) and deliver it to users as usable energy. Both shallow and deep sources of geothermal energy are included in this category.

Category C5 Is divided into the following subcategories:

C51	Geothermal energy from hydrothermal resources
C52	Enhanced geothermal systems
C53	Closed-loop geothermal systems

C54	Drilling and exploration for geothermal energy
C59	Geothermal energy not elsewhere classified

C5 excludes:

- Design of building heat pumps for ground source geothermal. Ref. A2231
- Design of industrial heat pumps for ground source geothermal. Ref. A121
- District heating and cooling not pertaining to piping hot water and steam from geothermal. Ref. F3
- Efficient building equipment. Ref. A22
- Lithium extraction from geothermal brines. Ref. H2
- Thermal energy storage. Ref. F52
- Underground energy storage for extraction in the form of heat. Ref. F52

C51 – Geothermal energy from hydrothermal resources

Definition

Geothermal energy from hydrothermal resources refers to techniques, processes, equipment, materials and systems to extract heat from the earth's hot water and distribute it in the form of heat or electricity. This category covers all technologies dedicated to geothermal energy from hydrothermal resources – including dry steam, flash steam and binary cycle power plants – as well as resource assessment, environmental assessment, forecasting and siting.

C51 excludes:

- Enhanced geothermal systems. Ref. C52
- Geosciences pertaining to geothermal systems. Ref. C54

C52 – Enhanced geothermal systems

Definition

Enhanced geothermal systems refers to techniques, processes, materials, equipment and systems to capture thermal energy through engineered geothermal reservoirs that expend or create geothermal capacity by increasing the permeability of hot underground rock. This is typically achieved by drilling deep wells and opening up natural fractures in the rock and/or creating new ones through hydraulic, thermal or chemical stimulation. This category covers all technologies dedicated to enhanced geothermal systems as well as resource assessment, environmental assessment, forecasting and siting.

C52 excludes:

- Geosciences pertaining to geothermal systems. Ref. C54

C53 – Closed-loop geothermal systems

Definition

Close-loop geothermal systems refers to techniques, processes, materials, equipment and systems to capture thermal energy by drilling and sealing deep, artificial circuits through which a working fluid is circulated. These systems function as underground heat exchangers, where the fluid is heated by surrounding hot rock formations via conductive heat transfer, without any chemical interaction with the geological environment. This category covers all technologies dedicated to closed-loop geothermal systems as well as resource assessment, environmental assessment, forecasting and siting.

C53 excludes:

- Geosciences pertaining to geothermal systems. Ref. C54

C54 – Drilling and exploration for geothermal energy

Definition

Drilling and exploration for geothermal energy refers to techniques, processes, materials, equipment and systems to design energy-efficient drilling and exploration technologies aimed at recovering thermal heat from underground. Drilling practices for both direct use (low temperature) and electrical generation (high temperature) wells are included in this category. Geosciences pertaining to geothermal systems are included in this category.

C54 excludes:

- Advanced drilling technologies for non-conventional oil and gas. Ref. B13

C59 – Geothermal energy not elsewhere classified

Definition

Geothermal energy not elsewhere classified refers to techniques, processes, materials, equipment and systems related to geothermal energy not included elsewhere in the subcategories of C5.

Among other elements, C59 includes:

- Collecting, treating and piping hot water and steam for direct use (for greenhouses, aquaculture or community usage).
- Geothermal resource assessments not specific to categories C51 to C54.
- Low-temperature applications (below 150 °C), including the extraction of shallow geothermal heat.
- Mitigation of environmental risks associated with geothermal energy.

C59 excludes:

- Design of building heat pumps for ground source geothermal. Ref. A2231
- Design of industrial heat pumps for ground source geothermal. Ref. A121

C6 – Hydroelectricity

Definition

Hydroelectricity refers to techniques, processes, materials, equipment and systems related to the generation of electricity through the harnessing of energy from flowing or falling water.

It covers both large-scale and small-scale hydroelectric systems.

Category C6 is divided into the following subcategories:

C61	Large hydroelectricity (capacity of 10 MW and above)
C62	Small hydroelectricity (capacity of less than 10 MW)
C69	Hydroelectricity not elsewhere classified

Among other elements, C6 includes:

- Generation optimisation as part of integrated water management systems.
- Hydromechanical engineering, civil engineering and electrical engineering.
- Improving the efficiency, reliability and longevity of equipment through computational fluid dynamics design, advanced manufacturing processes and new materials.
- Research on fish-friendliness.

C6 excludes:

- Mechanical energy storage (hydro pumped storage). Ref. F512

C61 – Large hydroelectricity (capacity of 10 MW and above)

Definition

Large hydroelectricity refers to techniques, processes, materials, equipment and systems to produce electricity from devices driven by flowing or falling fresh water, whenever the capacity of such systems is 10 MW of electrical output and above. This category covers all technologies dedicated to large hydroelectricity as well as resource assessment, environmental assessment, forecasting and siting.

C62 – Small hydroelectricity (capacity of less than 10 MW)

Definition

Small hydroelectricity refers to techniques, processes, materials, equipment and systems to produce electricity from devices whose electrical capacity is less than 10 MW, including run-of-river devices. This category covers all technologies dedicated to small hydroelectricity as well as resource assessment, environmental assessment, forecasting and siting.

C69 – Hydroelectricity not elsewhere classified

Definition

Hydroelectricity not elsewhere classified refers to techniques, processes, materials, equipment and systems related to hydroelectricity not included elsewhere in the subcategories of C6, such as technologies not specific to hydroelectricity scale.

C9 – Renewable energy sources not elsewhere classified

Definition

Renewable energy sources not elsewhere classified refers to techniques, processes, materials, equipment and systems related to renewable energy sources not included elsewhere in category C. This category includes supporting measuring, monitoring and verifying technologies in renewable energy not specific to one source, and forecasting and optimisation of energy generation from renewable sources when not specific to one source.

C9 excludes:

- Renewables grid integration. Ref. F221

D – Nuclear fission and fusion

Definition

Nuclear fission and fusion refers to techniques, processes, materials, equipment and systems to generate electricity from the heat derived from a nuclear reaction on earth.

Category D is divided into the following subcategories:

D1	Nuclear fission
D2	Nuclear fusion
D3	Hybrid nuclear fission and fusion
D9	Nuclear fission and fusion not elsewhere classified

D1 – Nuclear fission

Definition

Nuclear fission refers to techniques, processes, materials, equipment and systems to generate heat in nuclear fission reactors and supply thermal or electrical energy from them.

Nuclear fission is a heat-producing reaction in which the nucleus of an atom splits in a way that sustains a controlled chain reaction and releases a significant amount of energy.

The heat is removed from the nuclear fuel by a coolant and used either directly or to produce steam that can drive a turbine for power generation.

Category D1 is divided into the following subcategories:

D11	Large nuclear reactors
D12	Small modular nuclear reactors
D13	Nuclear fuel cycle and waste management
D14	Nuclear fission supporting technologies
D19	Nuclear fission not elsewhere classified

D1 excludes:

- Non-energy-related applications of nuclear fission. Out of scope
- Nuclear propulsion for transport. Ref. A3

D11 – Large nuclear reactors

Definition

Large nuclear reactors refers to techniques, processes, materials, equipment and systems to generate electricity in nuclear fission reactors designed to produce an amount of electrical power exceeding 300 MW_e.

It includes the reactor, reactor-specific equipment, nuclear fuel management system, boiler, cooling circuits, installation and associated control/command systems. Electricity generation technologies are included if they are nuclear specific. Improvements and standardisation of reactor design, including at different power ranges than presently commercialised, are included, as well as specific testing methodologies and devices.

Category D11 is divided into the following subcategories:

D111	Large water-cooled reactors
D112	Large liquid metal-cooled fast reactors

D113	Large gas-cooled reactors
D114	Large molten salt-cooled reactors
D119	Large nuclear reactors not elsewhere classified

D11 excludes:

- Construction, aero-refrigerant systems and connection to grid. Ref. D149
- Electricity transmission and distribution. Ref. F2
- High-temperature hydrogen production processes coupled with nuclear heat sources. Ref. E11

D111 – Large water-cooled reactors

Definition

Large water-cooled reactors (WCR) refers to nuclear fission reactors that use water as both a coolant and a neutron moderator, with a power capacity over 300 MW_e.

The main types of water-cooled reactors include pressurised water reactors (PWRs), boiling water reactors (BWR) and heavy water reactors (HWR). PWRs keep water under high pressure to prevent it from boiling, using a secondary loop to generate steam for electricity production. BWRs boil water directly in the reactor core, and the generated steam is used to drive the turbines without a secondary loop. HWRs use heavy (deuterium-containing) water as both a moderator and a coolant.

D111 excludes:

- Large supercritical water-cooled reactors. Ref. D119

D112 – Large liquid metal-cooled fast reactors

Definition

Large liquid metal-cooled reactors (LMR) refers to nuclear fission reactors using liquid metals as coolants, with a power capacity over 300 MW_e.

The main types of liquid metal-cooled reactors include sodium-cooled fast reactors (SFR) and lead-cooled fast reactors (LFR).

D113 – Large gas-cooled reactors

Definition

Large gas-cooled reactors (GCR) refers to nuclear fission reactors using gases such as CO_2 or helium as coolants, with a power capacity over 300 MW_e.

Types of gas-cooled reactors include advanced gas-cooled reactors (AGR), high-temperature gas-cooled reactors (HTGR) and pebble-bed reactors.

D114 – Large molten salt-cooled reactors

Definition

Large molten salt-cooled reactors (MSR) refers to nuclear fission reactors using molten salt mixtures as coolant, with a power capacity over 300 MW_e.

D119 – Large nuclear reactors not elsewhere classified

Definition

Large nuclear reactors not elsewhere classified refers to techniques, processes, materials, equipment and systems related to nuclear reactors with a power capacity over 300 MW_e and not included elsewhere in the subcategories of D11. Large supercritical water-cooled reactors are included in this category.

D12 – Small modular nuclear reactors

Definition

Small modular nuclear reactors (SMR) refers to techniques, processes, materials, equipment and systems to generate electricity in nuclear fission reactors designed to produce an amount of electrical power equal to or below 300 MW_e. These reactors are designed for enhanced modularity, standardised installation and, in some cases, deployment in remote locations or for captive power. The smallest SMRs are known as mini or micro reactors.

It includes the reactor, reactor-specific equipment, nuclear fuel management system, boiler, cooling circuits, installation and associated control/command systems. Electricity generation technologies are included if they are nuclear specific. Improvements and standardisation of reactor design, including at different power ranges than presently commercialised, are included, as well as specific testing methodologies and devices.

Category D12 is divided into the following subcategories:

D121	Small pressurised water-cooled reactors
D122	Small liquid metal-cooled fast reactors
D123	Small gas-cooled reactors
D124	Small molten salt-cooled reactors
D125	Small heat-pipe-cooled reactors
D129	Small nuclear reactors not elsewhere classified

D12 <u>excludes</u>:

- Construction, aero-refrigerant systems and connection to grid. Ref. D149
- Electricity transmission and distribution. Ref. F2
- High-temperature hydrogen production processes coupled with nuclear heat sources. Ref. E11

D121 – Small pressurised water-cooled reactors

Definition

Small pressurised water-cooled reactors (PWR) refers to reactors that use water as both a coolant and a neutron moderator, with a power capacity equal to or below 300 MW_e. They keep water under high pressure to prevent it from boiling, using a secondary loop to generate steam for electricity production.

D121 <u>excludes</u>:

- Small supercritical water-cooled reactors. Ref. D129

D122 – Small liquid metal-cooled fast reactors

Definition

Small liquid metal-cooled reactors (LMR) refers to nuclear fission reactors that use liquid metals as coolants, with a power capacity equal to or below 300 MW_e.

The main types of liquid metal-cooled reactors include sodium-cooled fast reactors (SFR) and lead-cooled fast reactors (LFR).

D123 – Small gas-cooled reactors

Definition

Small gas-cooled reactors (GCR) refers to nuclear fission reactors using gases such as CO_2 or helium as coolants, with a power capacity equal to or below 300 MW_e.

The main types of gas-cooled reactors include advanced gas-cooled reactors (AGR) and high-temperature gas-cooled reactors (HTGR) and pebble-bed reactors.

D124 – Small molten salt-cooled reactors

Definition

Small molten salt-cooled reactors (MSR) refers to nuclear fission reactors using molten salt mixtures as coolant, with a power capacity equal to or below 300 MW_e.

D125 – Small heat-pipe-cooled reactors

Definition

Small heat-pipe-cooled reactors refers to nuclear fission reactors that use heat pipes to transfer heat from the reactor core to a heat exchanger or power conversion system, with a power capacity equal to or below 300 MWe.

D129 – Small modular nuclear reactors not elsewhere classified

Definition

Small modular nuclear reactors not elsewhere classified refers to techniques, processes, materials, equipment and systems related to small modular nuclear reactors not included elsewhere in the subcategories of D12. Small supercritical water-cooled reactors are included in this category.

D13 – Nuclear fuel cycle and waste management

Definition

Nuclear fuel cycle and waste management refers to techniques, processes, materials, equipment and systems to supply nuclear fuel to nuclear fission reactors

for energy purposes, and to manage and either reprocess or dispose of spent nuclear fuel.

It includes mining, enrichment, processing, transportation, storage, fissile material recycling and/or reprocessing, and waste treatment and disposal.

Category D13 is divided into the following subcategories:

D131	Front end of the fuel cycle
D132	Back end of the fuel cycle (excluding reprocessing and recycling)
D133	Reprocessing and recycling of nuclear waste products
D139	Nuclear fuel cycle and waste management not elsewhere classified

D131 – Front end of the fuel cycle

Definition

Front-end of the nuclear fuel cycle refers to all the processes involved in preparing nuclear fuel for use in a reactor. This may include the front end of the nuclear fuel cycle for uranium- or thorium-based fuel cycles.

Among other elements, this includes the mining (including in situ leaching with acid or alkaline solutions to dissolve uranium), milling, crushing, grinding, conversion of yellowcake into uranium hexafluoride, enrichment to increase the concentration of the fissile isotope U235, deconversion and fabrication of nuclear fuel (pellets, rods and assemblies), as well as activities related to secondary sources and down-blending uranium from higher enriched products to lower enriched products.

D131 <u>excludes</u>:

- Recycling of waste products into nuclear fuels. Ref. D133

D132 – Back end of the fuel cycle (excluding reprocessing and recycling)

Definition

Back end of the nuclear fuel cycle (excluding reprocessing and recycling) refers to processes involved in managing spent nuclear fuel after it has been used in a reactor.

This includes cooling, wet and dry storage, waste classification, treatment, conditioning, transportation and disposal (geological or near-surface) of spent fuel and radioactive waste. The siting of nuclear waste repositories is included in this category.

D132 excludes:

- Recycling of waste products into nuclear fuels. Ref. D133

D133 – Reprocessing and recycling of nuclear waste products

Definition

Reprocessing of nuclear waste products refers to the transmutation or partition of waste products to separate usable fissile materials (such as uranium and plutonium) from spent nuclear fuel and the reuse of the recovered materials in the fabrication of new nuclear fuel. Among other elements, reprocessing and recycling technologies include advanced aqueous reprocessing, pyro processing, volume reduction through transmutation and mixed oxide fuel fabrication.

D139 – Nuclear fuel cycle and waste management not elsewhere classified

Definition

Nuclear fuel cycle and waste management not elsewhere classified refers to techniques, processes, materials, equipment and systems related to the nuclear fuel cycle and waste management that are not included elsewhere in the subcategories of D13.

D14 – Nuclear fission supporting technologies

Definition

Nuclear fission supporting technologies refers to techniques, processes, materials, equipment and systems not directly linked to the reactor nor the fuel cycle; however, they are applied when designing or operating a nuclear power plant.

Category D14 is divided into the following subcategories:

D141	Nuclear plant safety and integrity
D142	Nuclear environmental assessments, monitoring and protection
D143	Nuclear decommissioning, dismantling and site recovery
D149	Nuclear fission supporting technologies not elsewhere classified

D141 – Nuclear plant safety and integrity

Definition

Nuclear plant safety and integrity refers to the general integrity of nuclear plants and to nuclear safety of plant operators, including substation control (structure, corrosion, seismic protection systems) and system upgrading.

Among other elements, D141 <u>includes</u>:

- Cybersecurity of nuclear plants.
- Development of safeguard technologies and practices.
- Enhanced fissile material control.
- Radiological protection.
- Robotics and communication with a view to allowing for increasingly diverse unmanned actions in a potentially radioactive environment.

D142 – Nuclear environmental assessments, monitoring and protection

Definition

Nuclear environmental assessments, monitoring and protection refers to the measures, technologies and practices aimed at safeguarding the environment both within and outside the nuclear plant.

This includes monitoring radiation levels, protecting water quality and preserving local wildlife habitats.

D143 – Nuclear decommissioning, dismantling and site recovery

Definition

Nuclear decommissioning, dismantling and site recovery refers to processes, technologies and strategies involved in the safe and efficient decommissioning, dismantling and site recovery of nuclear fission facilities.

It covers the planning, execution and management of activities required to retire nuclear power plants and related installations, ensuring that radioactive materials are safely managed, structures are dismantled, and sites are remediated for future use.

D143 <u>excludes</u>:

- Radioactive waste management. Ref. D132
- Reprocessing and recycling of nuclear waste products Ref. D133

D149 – Nuclear fission supporting technologies not elsewhere classified

Definition

Nuclear fission supporting technologies not elsewhere classified refers to techniques, processes, materials, equipment and systems specific to nuclear fission that are not included elsewhere in the subcategories of D14. Generic construction techniques, aero-refrigerant systems and connection to grid are included in this category.

D19 – Nuclear fission not elsewhere classified

Definition

Nuclear fission not elsewhere classified refers to techniques, processes, materials, equipment and systems related to nuclear fission not included elsewhere in the subcategories of D1, such as the sociological, economic and environmental impacts of nuclear energy.

D2 – Nuclear fusion

Definition

Nuclear fusion refers to techniques, processes, materials, equipment and systems to generate energy by combining light atomic nuclei, typically isotopes of hydrogen, such as deuterium and tritium, to form a heavier nucleus while releasing a significant amount of energy.

It encompasses fusion technologies, spanning fundamental plasma physics, reactor design, fuel preparation and recycling, and system integration.

Category D2 is divided into the following subcategories:

D21	Magnetic confinement
D22	Inertial confinement
D23	Hybrid magnetic and electrostatic confinement
D24	Magneto-inertial confinement
D29	Nuclear fusion not elsewhere classified

D2 <u>excludes</u>:

- Non-energy-related applications of nuclear fusion. Out of scope

D21 – Magnetic confinement

Definition

Magnetic confinement refers to techniques, processes, materials, equipment and systems based on magnetic fields, which create the conditions under which light nuclei, in their plasma state, fuse.

Relevant plasma physics research is included, along with stellarators, tokamaks, spherical tori, reverse-field pinches and related materials and components.

D22 – Inertial confinement

Definition

Inertial confinement refers to techniques, processes, materials, equipment and systems based on heating and compressing a fuel (typically in the form of pellets), by means of high-energy beams of laser light, electrons or ions, thus creating the conditions under which light nuclei fuse.

Relevant plasma physics research is included, along with direct, indirect and fast drive plasma ignition devices and related materials and components.

D23 – Hybrid magnetic and electrostatic confinement

Definition

Hybrid magnetic and electrostatic confinement refers to the fusion that combines magnetic fields and electrostatic potentials to trap and compress plasma, facilitating conditions for nuclear fusion.

Relevant plasma physics research is included, along with advanced gridless designs, superconducting magnets, high-temperature plasma operation and machine learning for control systems and related materials and components.

D24 – Magneto-inertial confinement

Definition

Magneto-inertial confinement fusion refers to a hybrid approach combining elements of magnetic and inertial confinement to achieve conditions necessary for nuclear fusion. This method uses magnetic fields to stabilise the plasma while it is rapidly compressed by mechanical, laser or pulsed electrical drivers.

Relevant plasma physics research is included, along with reactor designs and related materials and components.

D29 – Nuclear fusion not elsewhere classified

Definition

Nuclear fusion not elsewhere classified refers to techniques, processes, materials, equipment and systems related to nuclear fusion not included elsewhere in the subcategories of D2. Fundamental research on fusion, associated modelling activities, sensors, measuring technologies, and materials and safety issues applicable to nuclear fusion regardless of the confinement mode are included in this category.

D3 – Hybrid nuclear fission and fusion

Definition

Hybrid nuclear fission and fusion refers to systems combining nuclear fission and fusion processes to generate power.

In these systems, a fusion reactor would serve as a neutron source to sustain or amplify fission reactions in a surrounding blanket of fissile or fertile material.

D9 – Nuclear fission and fusion not elsewhere classified

Definition

Nuclear fission and fusion not elsewhere classified refers to techniques, processes, materials, equipment and systems related to nuclear fission and fusion not included elsewhere in category D.

E – Hydrogen, hydrogen-based fuels and fuel cells

Definition

Hydrogen, hydrogen-based fuels and fuel cells refers to techniques, processes, materials, equipment and systems involved in the production, storage, distribution and conversion of hydrogen, as well as the development and utilisation of hydrogen-based synthetic fuels and fuel cells. Technologies for the use of hydrogen and hydrogen-based fuels in specific end uses in the industry, transport and building sectors are included in Group A.

Category E is divided into the following subcategories:

E1	Hydrogen production
E2	Hydrogen storage
E3	Transport of hydrogen
E4	Hydrogen distribution infrastructure and systems
E5	Hydrogen uses
E6	Hydrogen-based fuels
E7	Fuel cells (excluding transport applications)
E9	Hydrogen, hydrogen-based fuels and fuel cells not elsewhere classified

E <u>excludes</u>:

- Hydrogen applications in building heating and cooling. Ref. A2232
- Hydrogen as a fuel for rail transport. Ref. A322
- Hydrogen as a fuel for road transport. Ref. A315
- Hydrogen as a fuel for shipping. Ref. A342

- Hydrogen as an aviation fuel. Ref. A332
- Hydrogen refuelling stations and dispensers for road transport Ref. A3154
- Hydrogen use in industry. Ref. A15

E1 – Hydrogen production

Definition

Hydrogen production refers to techniques, processes, materials, equipment and systems to produce hydrogen and to purify it at levels acceptable for its further use as an energy source or in energy-related applications.

Category E1 is divided into the following subcategories:

E11	Hydrogen production via electrolysis
E12	Hydrogen production from fossil fuels without CO_2 capture
E13	Hydrogen production from fossil fuels with CO_2 capture or via non-oxidative processes
E14	Hydrogen production from biomass
E15	Geological hydrogen
E19	Hydrogen production not elsewhere classified

E1 <u>excludes</u>:

- Hydrogen safety. Ref. E4
- Nuclear fusion. Ref. D2
- Photolytic process. Ref. C13

E11 – Hydrogen production via electrolysis

Definition

Hydrogen production via electrolysis refers to the process of splitting water into hydrogen and oxygen using electrical energy, regardless the origin of the electricity.

Among other elements, E11 includes:

- Advanced electrode materials.
- Alkaline electrolysers.
- Anion exchange membrane electrolysers.
- Electrolyser operation to co-locate with or otherwise follow variable electricity supply.
- Microbial electrolysis cells.
- Photoelectrolysis and photochemical electrolysis.
- Proton exchange membrane (PEM) electrolysers.
- Solid oxide electrolyser cells (SOEC).
- Solid oxide fuel cells (SOFC).

E11 excludes:

- Biomass electrolysis. Ref. E14

E12 – Hydrogen production from fossil fuels without CO_2 capture

Definition

Hydrogen production from fossil fuels without CO_2 capture refers to technologies and processes that generate hydrogen from fossil fuels (natural gas, coal or oil), without integrating CO_2 capture.

Among other elements, E12 includes:

- Autothermal reforming.
- Catalyst improvements.
- Coal gasification integrated with hydrogen production.
- Partial oxidation of fossil fuels integrated with hydrogen production.
- Steam methane reforming.

E12 excludes:

- Electrolysis using electricity produced from fossil fuels. Ref. E11
- Hydrogen production from fossil fuels with CO_2 capture or via non-oxidative processes. Ref. E13

E13 – Hydrogen production from fossil fuels with CO_2 capture or via non-oxidative processes

Definition

Hydrogen production from fossil fuels with CO_2 capture or via non-oxidative processes refers to technologies and processes that generate hydrogen from fossil fuels, primarily natural gas, coal or oil, while mitigating associated CO_2 emissions with CO_2 capture or by utilising non-oxidative conversion routes that avoid CO_2 production (e.g. methane pyrolysis). All technical elements of hydrogen production that are designed or modified to accommodate or improve the costs or efficiency of CO_2 capture and storage are included.

Among other elements, E13 includes:

- Autothermal reforming with CO_2 capture.
- Coal gasification integrated with hydrogen production with CO_2 capture.
- Methane pyrolysis (also known as methane splitting, methane decomposition, methane cracking).
- Non-oxidative reforming.

- Steam methane reforming with CO_2 capture.

E13 <u>excludes</u>:

- Electrolysis using electricity produced from fossil fuels. Ref. E11

E14 – Hydrogen production from biomass

Definition

Hydrogen production from biomass refers to the conversion of organic biomass feedstocks, such as agricultural residues, forestry by-products, dedicated energy crops or organic waste, into hydrogen, with or without CO_2 capture.

E14 <u>includes</u>:

- Biochemical conversion processes of biomass to hydrogen.
- Biomass electrolysis.
- Biomass gasification integrated with hydrogen production.
- Biomass pyrolysis and catalytic reforming integrated with hydrogen production.

E14 <u>excludes</u>:

- Microbial electrolysis. Ref. E11

E15 – Geological hydrogen

Definition

Geological hydrogen, also called natural hydrogen, refers to technologies related to the extraction of naturally occurring hydrogen directly from underground resources. Stimulated mineralogical processes to increase hydrogen production rate is an example of this.

E19 – Hydrogen production not elsewhere classified

Definition

Hydrogen production not elsewhere classified refers to technologies, processes and techniques related to hydrogen production not included elsewhere in the subcategories of E1. Hydrogen production from nuclear fission or fusion heat is included in this category.

E2 – Hydrogen storage

Definition

Hydrogen storage refers to techniques, processes, materials, equipment and systems to store small or large volumes of hydrogen for further use.

Hydrogen storage includes physical storage, where pure hydrogen is stored under gaseous or liquid form (including via adsorption or in metal organic frameworks [MOFs]), and chemical storage, where hydrogen atoms are reversibly bonded with other substances to form storable chemical compounds (e.g. metal hydrides, liquid organic hydrogen carriers).

E2 <u>excludes</u>:

- Hydrogen-based fuels as a means of storing hydrogen.	Ref. E6
- Hydrogen safety.	Ref. E4
- Hydrogen storage in the form of ammonia.	Ref. E6
- Hydrogen tanks mounted on board vehicles.	Ref. A3
- Liquid organic hydrogen carriers	Ref. E3
- Materials used in the compression, liquefaction and regasification of hydrogen for transport purposes.	Ref. E3
- Siting for hydrogen infrastructures.	Ref. E4

E3 – Transport of hydrogen

Definition

Transport of hydrogen refers to techniques, processes, materials, equipment and systems to convey hydrogen from one location to another. This includes transport via pipelines, trucks, ships, barges, and the compression, liquefaction, regasification or use of liquid organic hydrogen carriers to enable this.

E3 excludes:

- Hydrogen-based fuels as a mean of transporting hydrogen. Ref. E6
- Hydrogen distribution networks inside industrial premises. Ref. A15
- Hydrogen refuelling stations and dispensers. Ref. A3
- Hydrogen safety. Ref. E4
- Siting for hydrogen infrastructures. Ref. E4

E4 – Hydrogen distribution infrastructure and systems

Definition

Hydrogen distribution infrastructure and systems refers to techniques, processes, materials, equipment and systems not included elsewhere aimed at facilitating the use of hydrogen as a source of energy, including distribution. Technologies and techniques for hydrogen-specific sensors and meters, hydrogen safety and siting of hydrogen distribution infrastructure are included in this category. Pipelines for longer distance transport of hydrogen are not included in this category.

E4 excludes:

- Hydrogen distribution networks inside industrial premises. Ref. A15
- Hydrogen pipelines for long distance transport of hydrogen. Ref. E3

- Hydrogen storage technologies at refuelling station. Ref. A3
- Hydrogen use downstream of refuelling station. Ref. A3

E5 – Hydrogen uses

Definition

Hydrogen uses refers to techniques, processes, materials, equipment and systems not covered elsewhere needing or consuming hydrogen as a source of energy, including through combustion and excluding fuel cells. Technologies for the use of hydrogen in specific end uses in the industry, transport and building sectors are included in category A.

Category E5 is divided into the following subcategories:

E51	Hydrogen use in oil refining
E52	Electricity generation from hydrogen
E59	Hydrogen uses not elsewhere classified

E5 excludes:

- Design of fuel cells applications for electricity generation. Ref. E7
- Hydrogen applications in building heating and cooling. Ref. A2232
- Hydrogen as a fuel for rail transport. Ref. A322
- Hydrogen as a fuel for road transport. Ref. A315
- Hydrogen as a fuel for shipping. Ref. A342
- Hydrogen as an aviation fuel. Ref. A332
- Hydrogen refuelling stations and dispensers for road transport. Ref. A3154

- Hydrogen safety.	Ref. E4
- Hydrogen use in industry.	Ref. A15
- Supporting, measuring, monitoring and verifying technologies for hydrogen.	Ref. E4
- Use of hydrogen as a cooling agent, and not as a fuel.	Out of scope

E51 – Hydrogen use in oil refining

Definition

Hydrogen use in oil refining refers to the use of hydrogen as a critical reagent and process fluid to upgrade crude oil into cleaner, higher-value fuels.

It includes its use in hydroprocessing operations such as hydrotreating, hydrocracking, and desulphurisation, which remove impurities, reduce sulphur content and break down heavy hydrocarbon fractions. It also includes technological advancements aimed at improving process efficiency and catalyst performance.

E52 – Electricity generation from hydrogen

Definition

Electricity generation from hydrogen refers to the production of electrical energy from hydrogen via combustion, for example in turbines. The design of fuel cells used to generate electricity is excluded but their integration in power generation plant is included.

E52 <u>excludes</u>:

- Fuel cells for stationary applications.	Ref. E7
- Hydrogen fuel cell drivetrains for transport.	Ref. A3
- Hydrogen use in combustion engines for transport applications.	Ref. A3

E59 – Hydrogen uses not elsewhere classified

Definition

Hydrogen uses not elsewhere classified refers to technologies, processes and techniques related to hydrogen uses not included elsewhere. Hydrogen blending in natural gas grids is included in this category.

E6 – Hydrogen-based fuels

Definition

Hydrogen-based fuels refers to techniques, processes, materials, equipment and systems related to producing, transporting and using fuels (when not covered elsewhere) whose energy content is derived from the chemical energy of hydrogen's diatomic bond. Hydrogen-based fuels are synthesised by combining hydrogen with elements, such as carbon or nitrogen, to create fuels that are easier to handle than hydrogen and, in some cases, compatible with existing infrastructures.

Among other elements, E6 includes:

- Ammonia.
- Cracking of ammonia to hydrogen.
- Hydrogen-based liquid fuels with biogenic carbon inputs.
- Hydrogen-based synthetic diesel.
- Hydrogen-based synthetic gasoline.
- Hydrogen-based synthetic kerosene.
- Hydrogen-based synthetic methane.
- Hydrogen-based synthetic methanol.

E6 excludes:

- Coal-to-liquid. Ref. B23
- Gas-to-liquid. Ref. B15
- Hydrogen-based fuels use in heating (e.g. ammonia boiler). Ref. A2232
- Hydrogen-based fuels use in transport applications (e.g. ammonia-powered ships). Ref. A3
- Liquid organic hydrogen carrier. Ref. E3

E7 – Fuel cells (excluding transport applications)

Definition

Fuel cells (excluding transport applications) refers to techniques, processes, equipment, materials, catalysts, electrolytes, membranes and systems to conceive, design and engineer fuel cells, which are electrochemical devices that convert the energy of a chemical reaction directly into electricity, with heat as a by-product. In fuel cells, the fuel and oxidant are stored externally, enabling them to continue operating as long as fuel and oxidant are supplied.

Most fuel cells use the oxygen contained in the ambient air around the fuel cell as oxidant, and either hydrogen or methanol (or another hydrocarbon) as fuel.

It covers fuel cells aimed at providing power or heat and power for stationary use, including for residential use, emergency power supply, and combined heat and power plants and excludes fuel cells applications for transport.

Among other elements, E7 includes:

- Control and command systems and their integration in combined heat and power plants.
- Molten carbonate fuel cells.
- Phosphoric acid fuel cells.
- Proton exchange membrane fuel cells for stationary uses.

E7 excludes:

- Batteries for portable applications. Ref. F511
- Fuel cells drivetrains for transport Ref. A3
- Hydrogen tanks to be mounted on board vehicles. Ref. A3
- Hydrogen refuelling stations. Ref. A3
- Solid oxide fuel cells. Ref. E11

E9 – Hydrogen, hydrogen-based fuels and fuel cells not elsewhere classified

Definition

Hydrogen, hydrogen-based fuels and fuel cells not elsewhere classified refers to technologies, processes and techniques related to hydrogen, hydrogen-based fuels and fuel cells not included elsewhere.

F – Heat and power generation, storage and supply

Definition

Heat and power generation, storage and supply refers to technologies, systems and strategies for generating electricity and heat that are not specific to any one energy source. It does not cover heat and power generation technologies specific to fossil fuels, renewable energy, nuclear, hydrogen or devices in buildings, or via fuel cells.

It also covers technologies, systems and strategies for the distribution of heat and power, whether centralised or in smaller distributed grids.

It includes all types of electricity and heat storage techniques except those on board vehicles or those that use hydrogen or hydrogen-based fuels.

Category F is divided into the following subcategories:

F1	Heat and power generation
F2	Electricity transmission and distribution
F3	District heating and cooling
F4	Waste energy recovery or utilisation
F5	Energy storage (excluding transport applications)
F9	Heat and power generation, storage and supply not elsewhere classified

F <u>excludes</u>:

- Electricity generation from hydrogen. Ref. E52
- Heat and power generation from coal combustion. Ref. B22
- Heat and power generation from fuel cells. Ref. E7
- Heat and power generation from nuclear. Ref. D

- Heat and power generation from oil and gas combustion. Ref. B14
- Heat and power generation from renewable energy sources. Ref. C
- Hydrogen-based fuels storage. Ref. E6
- Hydrogen storage. Ref. E2

F1 – Heat and power generation

Definition

Heat and power generation refers to all technologies, systems and strategies for generating electricity and heat that are not specific to any one energy source. It does not cover heat and power generation technologies specific to fossil fuels, renewable energy, nuclear, hydrogen or devices in buildings, or via fuel cells.

Category F1 is divided into the following subcategories:

F11	Heat and power generation technologies
F12	Heat and power generation supporting technologies
F19	Heat and power generation not elsewhere classified

F1 excludes:

- Buildings heating and cooling. Ref. A223
- District heating and cooling. Ref. F3
- Electricity generation from hydrogen. Ref. E52
- Heat and power generation from coal combustion. Ref. B22
- Heat and power generation from fuel cells. Ref. E7
- Heat and power generation from nuclear. Ref. D
- Heat and power generation from oil and gas combustion. Ref. B14
- Heat and power generation from renewable energy sources. Ref. C

F11 – Heat and power generation technologies

Definition

Heat and power generation technologies refers to techniques, processes, materials, equipment and systems not covered elsewhere to produce electric energy and useful thermal energy, either individually or combined.

Among other elements, F11 includes:

- Combined heat and power not covered elsewhere.
- Devices connected to engines or turbines and producing electric power, such as alternators.
- Free-piston engines.
- Industrial auto-generation not covered elsewhere.
- Magneto-hydrodynamics.
- Organic Rankine cycles.
- Pressure energy harvesting (e.g. piezoelectricity).
- Stirling engines.
- Superconducting generating machines.
- Thermoacoustics.

F11 excludes:

- Buildings heating and cooling. Ref. A223
- District heating and cooling. Ref. F3
- Electricity generation from hydrogen. Ref. E52
- Heat and power generation from coal combustion. Ref. B22
- Heat and power generation from fuel cells. Ref. E7
- Heat and power generation from nuclear. Ref. D

- Heat and power generation from oil and gas combustion. Ref. B14
- Heat and power generation from renewable energy sources. Ref. C
- Vehicle-mounted electric generators. Ref. A3
- Waste energy recovery. Ref. F4

F12 – Heat and power generation supporting technologies

Definition

Heat and power generation supporting technologies refers to techniques, processes, materials, equipment and systems to assist heat and power generation, such as cooling systems (including use of non-traditional cooling water sources).

It includes measurement, monitoring and verification of power generation units, including with sensors and information technology systems to ensure an optimised performance of the power generation. It includes reduction of thermal, air, water and noise pollution.

F12 excludes:

- Vehicle-mounted power generation supporting technologies. Ref. A3

F19 – Heat and power generation not elsewhere classified

Definition

Heat and power generation not elsewhere classified refers to technologies, processes and techniques related to heat and power generation not included elsewhere.

F2 – Electricity transmission and distribution

Definition

Electricity transmission and distribution refers to the delivery of power from generation to end users.

Transmission refers to the high-voltage (typically above 110 kW) transfer of electricity over long distances, typically from power generation to substations.

Distribution refers to the transfer of electricity from substations, where voltage is stepped down for local delivery. These medium-to-low voltage (typically below 33 kV) systems deliver power to residential, commercial and industrial consumers, including through the integration of distributed energy resources (DERs).

Category F2 is divided into the following subcategories:

F21	Electricity transmission and distribution technologies
F22	Grid communication, control systems and integration
F23	Mini grids and microgrids
F29	Electricity transmission and distribution not elsewhere classified

F2 excludes:

- Electricity storage. Ref. F51
- Meters on consumer premises. Ref. A221

F21 – Electricity transmission and distribution technologies

Definition

Electricity transmission and distribution technologies refers to techniques, processes, materials, equipment and systems to transfer electrical energy from the generating power source to consumers.

Category F21 is divided into the following subcategories:

F211	Cables and conductors
F212	AC/DC conversion
F219	Electricity transmission and distribution technologies not elsewhere classified

F21 excludes:

- Batteries (excluding transport applications). Ref. F511
- Grid communication, control systems and integration. Ref. F22
- Industrial electric equipment, including drives, contactors and starters. Ref. A12
- Residential and commercial electric equipment, including switches and meters. Ref. A22

F211 – Cables and conductors

Definition

Cables and conductors refers to all cable and conductor technologies, including conventional (including HVDC), superconducting and composite core, and related components and aspects related to underground or above-ground installation and operation.

F212 – AC/DC conversion

Definition

AC/DC conversion refers to technologies and devices that convert alternating current into direct current and vice versa.

F212 includes:

- Grid-forming inverters.
- Smart inverters.

F212 excludes:

- Inverters specific to solar PV applications. Ref. C124

F219 – Electricity transmission and distribution technologies not elsewhere classified

Definition

Electricity transmission and distribution technologies not elsewhere classified refers to technologies, processes and techniques related to electricity transmission and distribution technologies not included elsewhere in the subcategories of F21.

Among other elements, F219 includes:

- Circuit breakers (including fluoronitrile circuit breakers).
- Harmonic cleansers.
- High-power semiconductors.
- Switchgears and static Volt-Ampère reactive (VAR) compensators.
- Thyristor-controlled phase-shifting transformers.
- Thyristor-controlled series capacitors.
- Transformers (including smart transformers).
- Wireless (e.g. microwave power beaming, laser power beaming).

F22 – Grid communication, control systems and integration

Definition

Grid communication, control systems and integration refers to techniques, processes, materials, equipment and systems to manage a transmission and distribution power network so that supply and demand match, failures are anticipated and prevented, and interoperability between grids is granted.

Category F22 is divided into the following subcategories:

F221	Load management and integration
F222	Grid control systems and monitoring
F223	Standards, interoperability and grid cybersecurity
F229	Grid communication, control systems and integration not elsewhere classified

F22 <u>excludes</u>:

- Energy systems analysis. Ref. Z1

F221 – Load management and integration

Definition

Load management and integration refers to the technologies related to balancing the supply of electricity to ensure secure and reliable operation of the power system.

Among other elements, F221 <u>includes</u>:

- Distributed energy resource management systems (DERMS).
- Grid integration of variable renewable electricity.
- Grid modelling and forecasting.
- Metering infrastructure devices.
- VPP.

F221 excludes:

- Demand response devices installed on consumer premises or operated locally by consumers. Ref. A221

F222 – Grid control systems and monitoring

Definition

Grid control systems and monitoring refers to sensors and other devices to monitor power flows, power quality and power-related costs.

Among other elements, F222 includes:

- Advanced power system visualisation and control tools.
- Dynamic line rating.
- Phasor measurement units and fault recorders.
- Use of drones or helicopters for grid inspection.

F223 – Standards, interoperability and grid cybersecurity

Definition

Standards, interoperability and grid cybersecurity refers to developing grid standards, data protocols for communicating between grid-related devices, maintaining grid security and allowing for power to be carried between grids.

Among other elements, F223 includes:

- Enhanced security protocols to prevent curtailment.
- Cryptography, authentication and integrity checks.
- Mesh networks.
- Power line communication.

- Supervisory control and data acquisition (SCADA) systems application for grids.
- Two-way communications protocols for grids.
- Wireless ad hoc networks.

F223 excludes:

- Data protocols for smart meters specifically. Ref. A221

F229 – Grid communication, control systems and integration not elsewhere classified

Definition

Grid communication, control systems and integration not elsewhere classified refers to technologies, processes and techniques related to grid communication, control systems and integration not included elsewhere in the subcategories of F22.

F23 – Mini grids and microgrids

Definition

Mini grids and microgrids refers to techniques, processes, materials, equipment and systems to design and manage a transmission and distribution power network so that supply and demand match, and failures are anticipated and prevented.

Mini grids and microgrids are localised energy systems that can operate independently or in conjunction with the main grid. These systems are designed to enhance energy access, reliability and resilience while integrating renewable energy sources, advanced control technologies and storage solutions. Due to their modularity, they are typically used for rural electrification, disaster recovery and remote or islanded energy generation.

F23 excludes:

- Energy storage. Ref F5
- Renewable energy generation. Ref C

F29 – Electricity transmission and distribution not elsewhere classified

Definition

Electricity transmission and distribution not elsewhere classified refers to technologies, processes and techniques related to electricity transmission and distribution not included elsewhere in the subcategories of F2.

F3 – District heating and cooling

Definition

District heating and cooling refers to centralised systems that distribute thermal energy (hot water, steam or chilled water) to multiple buildings or facilities (including industrial plants) through a network of insulated pipes.

District heating and cooling systems, also called thermal networks, provide heat or cooling (or both) to end-users, typically in the form of hot water. and sometimes domestic hot water. Among other elements, this category includes high-efficiency insulation specific to district heating and cooling networks, metering and control systems specific to district heating and cooling networks, and zoning and load management of such systems.

Category F3 is divided into the following subcategories:

F31	District heat pumps
F39	District heating and cooling not elsewhere classified

F3 excludes:

- Collecting, treating and piping hot water and steam for direct district use.	Ref. C59
- Energy storage systems.	Ref. F5
- Heat generation with fossil fuels.	Ref. B
- Heat generation with renewable technologies.	Ref. C
- Seawater air conditioning	Ref. C39
- Waste heat recovery.	Ref. F4

F31 – District heat pumps

Definition

District heat pumps refers to systems that transfer heat from one location (source) to another (sink) to provide heating or cooling to be distributed in a network to several customers. They are used to recover waste heat, upgrade it to a higher temperature, and supply it for space or domestic water heating.

Heat pumps used for district heating and cooling include air-source heat pumps, ground-source heat pumps, water-source heat pumps, high-temperature heat pumps and hybrid heat pumps.

F31 excludes:

- Direct electric heat in industry.	Ref. A13
- Extraction of shallow geothermal heat.	Ref. C59
- Heat pumps for buildings, including buildings for commercial use.	Ref. A2231
- Heat pumps for undetermined applications.	Ref. A2231
- Industrial heat pumps.	Ref. A121

F39 – District heating and cooling not elsewhere classified

Definition

District heating and cooling not elsewhere classified refers to technologies, processes and techniques related to district heating and cooling excluding district heat pumps.

F4 – Waste energy recovery and utilisation

Definition

Waste energy recovery and utilisation refers to techniques, processes, materials, equipment and systems to recover all or part of the excess energy generated by industrial, residential, commercial or community applications. This energy may be in the form of heat, mechanical energy, pressure or other residual energy streams. The recovered energy can be converted into power or into thermal energy at a different temperature (higher or lower), or other usable forms.

Among other elements, F4 includes:

- Development or optimisation of low-temperature thermodynamic cycles.
- Mapping heat sources.
- Pressure recovery turbines.
- Thermoelectricity.
- Waste heat from data centres or waste-water treatment plants for district heating.

F4 excludes:

- District heating when not using waste heat. Ref. F3
- Energy storage. Ref. F5

- Heat pumps. Ref. A121 Ref. A2231 Ref. F31
- Industrial process optimisation except waste heat recovery. Ref. A11
- Organic Rankine cycles. Ref. F11
- Thermoacoustics. Ref. F11
- Waste heat recovery devices mounted on board vehicles. Ref. A3

F5 – Energy storage (excluding transport applications)

Definition

Energy storage (excluding transport applications) refers to technologies and systems designed to store energy for applications outside the transport sector. It covers a broad range of storage methods that, among other services, provide grid stability, support electrification and complement variable renewable energy sources, manage inter-seasonal heat load variability, supply backup power, and enable demand response across residential, commercial and industrial sectors. Storage of molecular fuels – fossil fuels, bioenergy and hydrogen – (also called chemical storage) is included in the respective categories of those fuels and not in category F5.

Category F5 is divided into the following subcategories:

F51	Electrical storage
F52	Thermal energy storage
F59	Energy storage not elsewhere classified

F51 – Electrical storage

Definition

Electrical storage refers to all means of storing electricity so that it can be used as electricity at a point in the future. This includes electrochemical energy storage such as batteries (except technologies primarily designed for use on board vehicles) and mechanical energy storage based on potential energy (gravitational, elastic) or rotational kinetic energy. All basic research into these approaches in included. Chemical energy storage via hydrogen or hydrogen-based fuels is included in category E.

Category F51 is divided into the following subcategories:

F511	Batteries (excluding transport applications)
F512	Mechanical storage
F519	Electrical storage not elsewhere classified

F51 excludes:

- Chemical energy storage via hydrogen or hydrogen-based fuels.	Ref. E
- Electric batteries for transport applications.	Ref. A3
- Fuel cells.	Ref. E7 Ref. A3
- Grid communication, control systems and integration.	Ref. F22
- Thermal storage.	Ref. F52

F511 – Batteries (excluding transport applications)

Definition

Batteries (excluding transport applications) refers to techniques, processes, materials, equipment and systems for storing electricity in batteries and accumulators for stationary portable or undetermined applications.

All types of rechargeable electrochemical batteries are included, such as lithium-ion batteries, flow batteries and redox flow batteries, as well as supercapacitors and ultracapacitors. Among other elements associated with the relevant applications, this category includes electrolytes, electrodes, battery management, reuse of batteries, recycling of batteries, manufacturing of batteries and life-cycle analysis.

F511 <u>excludes</u>:

- Batteries for transport applications. Ref. A3
- Fuel cells. Ref. E7 Ref. A3

F512 – Mechanical storage

Definition

Mechanical storage refers to techniques, processes, materials, equipment and systems for the conversion of electrical energy into mechanical energy, and its further reconversion back to electricity.

Forms of mechanical storage of energy include gravitational potential energy (for example pumped hydro storage), elastic potential energy (for example compressed air energy storage [CAES] or liquid air energy storage) and rotational kinetic energy (for example flywheels). Advanced mechanics for the design of large equipment for mechanical energy storage, such as air compressors, are included in this category.

F519 – Electrical storage not elsewhere classified

Definition

Electrical storage not elsewhere classified refers to technologies, processes and techniques related to electrical storage not included elsewhere. Photochemical and other forms of chemical energy storage for electricity that do not involve splitting water to form hydrogen are included in this category, as well as superconducting magnetic energy storage.

F52 – Thermal energy storage

Definition

Thermal energy storage refers to techniques, processes, advanced materials, equipment and systems using gases, liquids or solids in reservoirs to retain an elevated temperature for later use as heat or for power generation. It includes technologies for extracting the heat again for productive uses.

Forms of thermal energy storage include those based on hot water, phase change materials, molten salts or other types of sensible or latent heat storage for cooling, heating or electrical purposes.

F52 <u>excludes</u>:

- Building design and envelope. Ref. A21
- District heating. Ref. F3
- Heat pumps for buildings or unspecified applications. Ref. A2231
- Heating, cooling and ventilation technologies used in buildings. Ref. A223
- Industrial heat pumps. Ref. A121
- Solar heating and cooling. Ref. C11

- Solar thermal power and high-temperature applications of solar heat. Ref. C13
- Thermal storage for CSP units. Ref. C13

F59 – Energy storage not elsewhere classified

Definition

Energy storage not elsewhere classified refers to technologies, processes and techniques related to energy storage not included elsewhere.

F9 – Heat and power generation, storage and supply not elsewhere classified

Definition

Heat and power generation, storage and supply not elsewhere classified refers to technologies, processes and techniques related to heat and power generation, storage and supply not included elsewhere.

G – CO_2 capture and storage

Definition

CO_2 capture and storage refers to techniques, processes, materials, equipment and systems to reduce CO_2 emissions from large point sources, such as power generation or industrial facilities that use fossil fuels or biomass, or from ambient air or water. It involves capturing CO_2, compressing it, and in most cases, transporting it by pipeline, ship, rail or truck for storage or use. It covers the injection of the captured CO_2 into deep geological formations, such as depleted oil and gas reservoirs or saline aquifers, for permanent storage.

Category G is divided into the following subcategories:

G1	CO_2 capture
G2	CO_2 transport
G3	CO_2 storage
G9	CO_2 capture and storage not elsewhere classified

G <u>excludes</u>:

- CO_2 enhanced oil recovery. Ref. B11
- CO_2 utilisation in industrial facilities. Ref. A14
- Hydrogen production from fossil fuels with CO_2 capture. Ref. E13
- Production of hydrogen-based fuels from hydrogen and CO_2. Ref. E6
- Use of molten carbonate fuel cells for CO_2 capture. Ref. E7

G1 – CO_2 capture

Definition

CO_2 capture refers to techniques, processes, materials, equipment and systems to produce a concentrated stream of CO_2, from mainly large point sources (e.g. fossil fuel power plants or industrial sources) or from ambient air or water, to be transported for use or storage.

CO_2 capture (also known as CO_2 separation) techniques include, among others, those based on adsorption, absorption, permeation across membranes, chemical looping, condensation and cryogenics.

Category G1 is divided into the following subcategories:

G11	CO_2 capture from fossil fuels power plants
G12	Direct air capture
G13	Bioenergy with CO_2 capture
G14	CO_2 capture from industry
G19	CO_2 capture not elsewhere classified

G1 <u>excludes</u>:

- Hydrogen production with CO_2 capture. Ref. E13
- Techniques, processes, materials, equipment and systems related to coal combustion not integrated with CO_2 capture, including IGCC. Ref. B22
- Techniques, processes, materials, equipment and systems related to oil and gas combustion not integrated with CO_2 capture. Ref. B14

G11 – CO_2 capture from fossil fuel power plants

Definition

CO_2 capture from fossil fuels power plants refers to techniques, processes, materials, equipment and systems to produce a concentrated stream of CO_2 from fossil fuel power plants.

CO_2 capture can occur before the heat generating fuel combustion steep (so-called pre-combustion, which typically follows gasification) or after it (so-called post-combustion, in which the flue gas is treated). Modifications to the power plant design to enhance the CO_2 capture cost or efficiency are included in this category, whether for new plants or existing plants via retrofitting. All elements relating to oxy-combustion are examples of such modifications.

G11 <u>excludes</u>:

- CO_2 storage — Ref. G3
- CO_2 transport. — Ref. G2

G12 – Direct air capture

Definition

Direct air capture (DAC) refers to techniques, processes, materials, equipment and systems to extract CO_2 directly from ambient air or from water whose CO_2 concentration is in equilibrium with the air (and therefore has the purpose of reducing atmospheric CO_2 concentrations). Among other elements, technologies using chemical solvents or sorbents are included in this category, as well as so-called enhanced weathering techniques that expose minerals to ambient air.

G12 <u>excludes</u>:

- CO_2 storage (except enhanced weathering) — Ref. G3
- CO_2 transport. — Ref. G2

G13 – Bioenergy with CO_2 capture

Definition

Bioenergy with CO_2 capture (BECCS) refers to the integrated process of generating energy from biomass, such as agricultural residues, forestry by-products or dedicated energy crops, and capturing the CO_2 emissions produced during the conversion process. CO_2 capture from biomass use in industrial processes is included in this category and not in Category A1.

G13 <u>excludes</u>:

- CO_2 storage	Ref. G3
- CO_2 transport.	Ref. G2

G14 – CO_2 capture from industry

Definition

CO_2 capture from industry refers to the suite of technologies and processes designed to capture CO_2 emissions directly from industrial sources, such as cement and steel production, chemical manufacturing and other heavy industrial operations. It includes the redesign of processes, such as the integration of oxyfuel cement kilns or top gas recycling in steel plants, to facilitate the integration of CO_2 capture.

G14 <u>excludes</u>:

- Bioenergy with CO_2 capture application in industry.	Ref. G13
- CO_2 storage	Ref. G3
- CO_2 transport.	Ref. G2
- Hydrogen production with CO_2 capture.	Ref. E13

G19 – CO_2 capture not elsewhere classified

Definition

CO_2 capture not elsewhere classified refers to technologies, processes and techniques related to CO_2 capture not included elsewhere in the subcategories of G1. CO_2 capture on board vehicles (including ships) is included in this category.

G19 excludes:

- CO_2 storage — Ref. G3
- CO_2 transport. — Ref. G2

G2 – CO_2 transport

Definition

CO_2 transport refers to techniques, processes, materials, equipment and systems to convey CO_2 between locations regardless of the physical state (gas, liquid) of the CO_2.

Types of CO_2 transport include, among others, pipelines, tanker trucks, tanker ships, barges, and associated temporary or buffer storage, whether onsite or offshore.

G2 excludes:

- CO_2 compression. — Ref. G1

G3 – CO_2 storage

Definition

CO_2 storage refers to techniques, processes, materials, equipment and systems to prevent captured CO_2 from reaching the atmosphere. It includes technologies for

injecting CO_2 into underground geological reservoirs for permanent storage as well as permanent above-ground storage, such as via mineralisation to mineral carbonates or other compounds. Geological CO_2 storage may occur in existing oil and gas fields, depleted oil and gas reservoirs, basalt formations, deep saline aquifers or coal seams. Monitoring and verification of stored CO_2 (including for integrity, health and safety) is included in this category, as well as management and modelling of CO_2 behaviour underground.

G9 – CO_2 capture and storage not elsewhere classified

Definition

CO_2 capture and storage not elsewhere classified refers to technologies, processes and techniques related to CO_2 capture and storage not included elsewhere in category G.

H – Critical minerals

Definition

Critical minerals refers to the techniques, processes, materials, equipment and systems to extract, refine and process mineral resources for the development and deployment of energy technologies, such as copper, lithium, nickel, cobalt and rare earth elements. The scope of critical minerals is provided at https://www.iea.org/topics/critical-minerals.

Category H is divided into the following subcategories:

H1	Critical minerals exploration
H2	Critical minerals extraction
H3	Critical minerals processing and refining
H4	Critical minerals recycling
H9	Critical minerals not elsewhere classified

H1 – Critical minerals exploration

Definition

Critical minerals exploration refers to the identification, assessment and evaluation of mineral resources for the development and deployment of energy technologies.

Technologies for critical minerals exploration include, among others, remote sensing and geophysical surveys, geochemical analysis and drilling and sampling techniques.

H2 – Critical minerals extraction

Definition

Critical minerals extraction refers to the techniques, processes, materials, equipment and systems for the physical removal and recovery of mineral resources for the development and deployment of energy technologies.

It covers innovative mining techniques, extraction methods and sustainable processing practices, including *inter alia* lithium extraction from oilfield and geothermal brines, in situ leaching, automation and remote-controlled operations, selective extraction and ore sorting, and open-pit and underground mining methods.

H2 <u>excludes</u>:

- Mining vehicles. Ref. A35

H3 – Critical minerals processing and refining

Definition

Critical minerals processing and refining refers to the techniques, processes, materials, equipment and systems upgrading extracted raw materials into high-purity, market-ready products suitable for use in energy technologies.

It covers the chemical, physical and metallurgical processes needed to separate, purify and transform mined critical minerals into refined materials that meet the quality standards required by industries such as battery manufacturing, renewable energy systems and electronics. Among others, these processes include comminution, beneficiation, dewatering, hydrometallurgical processing, pyrometallurgical processing and electrochemical processing.

H4 – Critical minerals recycling

Definition

Critical minerals recycling refers to technologies, processes and techniques related to the recovery, processing and reintegration of critical minerals from end-of-life products, industrial waste or scrap materials not included elsewhere.

H4 excludes:

- Battery recycling.	Ref. F511 Ref. A3111
- Solar equipment recycling.	Ref. C1
- Transport equipment recycling.	Ref. A3
- Wind equipment recycling.	Ref. C2

H9 – Critical minerals not elsewhere classified

Definition

Critical minerals not elsewhere classified refers to technologies, processes and techniques related to critical minerals not included elsewhere in category H, such as supply chain monitoring.

Z – Cross-cutting technologies and research

Definition

Cross-cutting technologies and research refers to technologies that apply to various parts of the energy system. These include advanced digital tools, new materials, integrated modelling and simulation, and techniques to optimise systems that are not included in any other categories.

Category Z is divided into the following subcategories:

Z1	Energy system analysis
Z2	Digital tools for energy systems
Z9	Cross-cutting technologies and research not elsewhere classified

Z1 – Energy system analysis

Definition

Energy system analysis refers to the sociological, economic and environmental impact of energy that is not specifically related to one technology area listed elsewhere.

It also includes systems analysis related to energy not covered elsewhere, behavioural and other social science research into energy, and modelling related to energy and not covered elsewhere.

Z2 – Digital tools for energy systems

Definition

Digital tools for energy systems refers to the software, data analytics and communication technologies not included elsewhere that enable the efficient monitoring, control, optimisation, and integration of energy assets, including the use of AI.

Among other elements, Z2 includes:

- Digital tools for energy trading, energy retail (e.g. blockchain peer-to-peer markets, pay-as-you-go mobile payments; locational bidding tools).
- Emissions tracing in energy value chains.

Z2 excludes:

- VPP. Ref. F221

Z9 – Cross-cutting technologies and research not elsewhere classified

Definition

Cross-cutting technologies and research not elsewhere classified refers to technologies, processes and techniques related to cross-cutting technologies and research not included elsewhere in category Z.

Annex

Abbreviations and acronyms

AC	alternating current
AI	artificial intelligence
BIPV	building-integrated photovoltaics
CO_2	carbon dioxide
CSP	concentrating solar power
DC	direct current
EC	European Commission
ETBE	ethyl tert-butyl ether
EV	electric vehicle
GBARD	Government Budget Allocation for R&D
HEV	hybrid electric vehicle
HVAC	heating, ventilation and air conditioning
HVDC	high voltage direct current
IEA	International Energy Agency
ICT	information and communication technology
IGCC	integrated gasification combined cycle
LED	light-emitting diode
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MTBE	methyl tertiary-butyl ether
OECD	Organisation for Co-operation and Development
PPP	public-private partnership
PV	photovoltaic
R&D	research and development
RD&D	research, development and demonstration
SAF	sustainable aviation fuel
SOE	state-owned enterprise
USD	United States dollar
VPP	virtual power plant

Units of measure

kV	kilovolt
kW	kilowatt
MW	megawatt
MW_e	megawatt electric
W	watt

International Energy Agency (IEA)

For further information, please contact: RDD (rdd@iea.org).

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