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Geoscience competence management and requirements to support the acceleration of the energy transition

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Abstract

By ratifying the Paris Climate Agreement, The Netherlands has committed to an ambitious climate policy with the Dutch government aiming to significantly reduce greenhouse gas emissions. The transformation of the energy system to achieve sustainability, security, and affordability goals requires time, a long-term policy perspective and a renewed appreciation for technical competence development.

The value and understanding of the subsurface are essential to the future of sustainable energy generation. In this paper, a technical competence framework is presented, which has been developed to aid in managing and developing the technical workforce required to utilize that subsurface value. The core competences identified have been broken down into distinct levels of proficiency, including a description of proof points. This aims to support and guide the individual professional to allow carrying out a self-assessment and to establish their technical competence profile. Many of the core competences are valid across value chains (hydrocarbon exploration, production and storage, geothermal, and CO_2 and H_2-storage) supporting the deployment and rotation of technical staff across value chains. Within the volatile and uncertain conditions of the energy transition, a high professional standard and a high level of mobility allow for shifting focus to other business priorities and requirements rapidly; they aid to job security conditions and encourage personal development and professional growth. This paper aims to provide the Dutch professional geoscientific community recommendations on how to further improve the resilience of the skill pool.

A number of bottlenecks and challenges to enhance a thriving community of energy-geoscientists are identified, though mitigation measures are (partly) in place and will offer the opportunity to further strengthen the shared ambition to support and accelerate the energy transition, to continue substituting hydrocarbon-based energy with sustainable resources and to limit the net CO_2 output from the energy industry.

The role of geoscientists in the energy transition: focus on the Netherlands

A series of 17 Sustainable Development Goals (SDG's) were adopted in 2015 by the United Nations, with the aim to achieve those goals by 2030. These ambitious goals include eradicating poverty and hunger, facilitating sustainable economic growth and social development, and protecting the environment. A matrix showing how geoscientists could support achieving those SDG's was developed by Gill (2017) and focuses on the contribution by geoscientists from various professional disciplines (Figure 1). The SDG's have successively been addressed by Roberts (2020), Pereira et al. (2021) and The Geological Society as input to an overview of geoscience support to SDG's (https://www.geolsoc.org.uk/education-and-resources/geoscience-for-the-future-poster/). In this paper, we aim to summarize the importance and type of competence development and management required to support the acceleration of the energy transition from a geoscientific point of view, with a particular focus on achieving SDG's within the context of the current Dutch Climate Policy (https://www.government.nl/topics/climate-change/climate-policy).

The Paris Climate Agreement is closely linked to achieving those SDG's and is a legally binding international treaty on climate change, adopted in Paris in 2015. It aims to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels. By ratifying the Paris Climate Agreement, The Netherlands has committed to an ambitious climate policy (Van Vuuren et al., 2017) with the Dutch government aiming to reduce greenhouse gas emissions by 49% (compared to 1990 levels) by 2030 and 95% by 2050. These goals are laid down in the Climate Act (2019, https://www.klimaatakkoord.nl/klimaatakkoord).

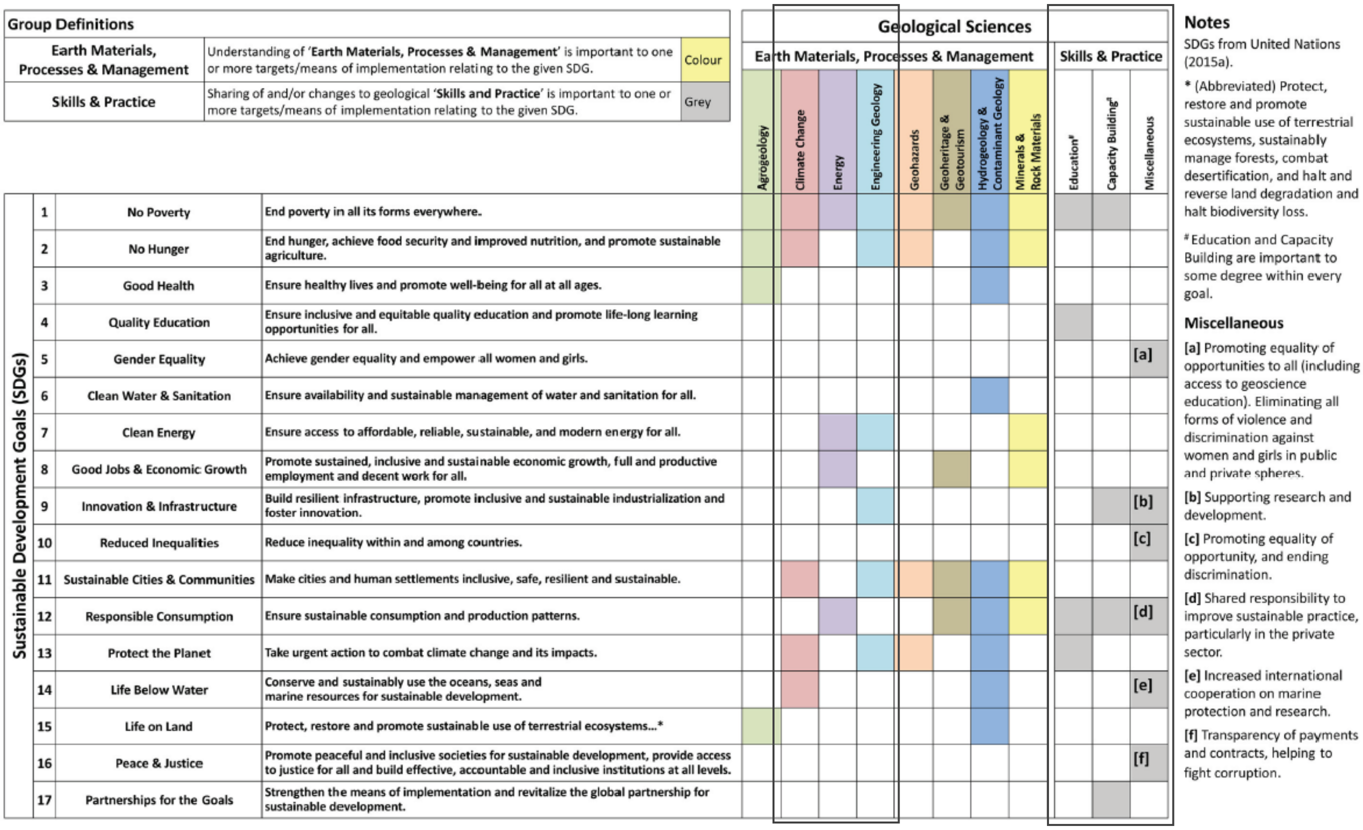

Figure 1. A matrix showing how geoscientists could support achieving those SDG's highlighting geological sciences areas relevant to the energy transition revised after Gill, 2017.

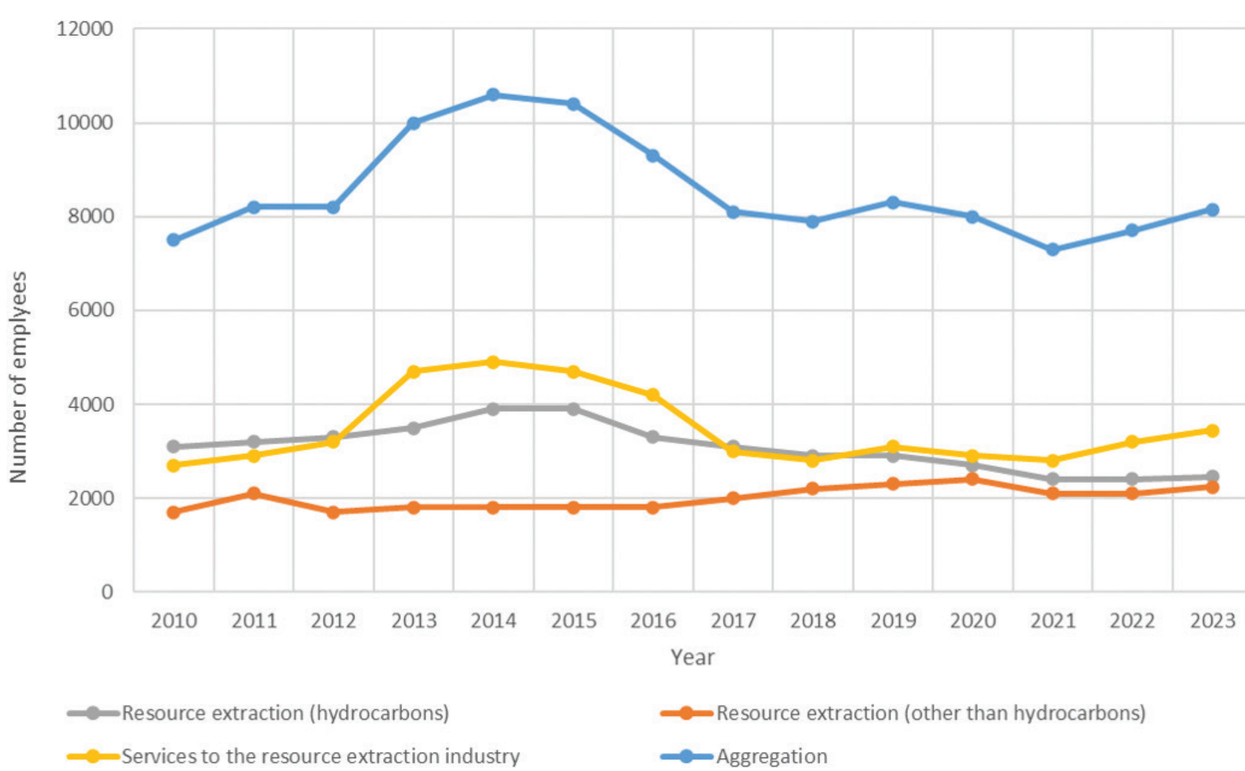

Figure 2. Overview of number of employees in the Dutch resource extraction industry, including supporting service industries in the time period 2010–2023 (Source: Arbeidsmarkt Monitor Human Capital Topsectoren 2024).

The Climate Act, the National Energy and Climate Plan, and the National Climate Agreement contain the policies and measures to achieve those climate goals. The required transformation of the energy system to meet sustainability and affordability goals requires time, long-term policy perspective, and renewed focus on technical competence development.

The Dutch energy landscape can be characterized by the presence of energy intensive (hard to abate) types of industry due to the historic ample availability and high reliability of domestic natural gas in the period 1970–2018. Sources of energy in the current Dutch energy system can be characterized as a mix of renewable (ca 14%), nuclear (ca 1%), hydrocarbon-based (ca 83%, mainly fossil), and other types (1%) of energy (EBN Infographic, 2024, https://www.ebn.nl/feiten-en-cijfers/infographic/). The ongoing transformation into a more sustainable and carbon-neutral energy system will require continued progression and increase of the relative contribution of sustainable energy types. In addition, carbon capture, utilization, and sequestration will be required to minimize net greenhouse gas emissions from using fossil energy types, which still appear challenging to phase out in the foreseeable future.

Many forms of energy production require subsurface resources; knowledge and technologies to exploit these resources are underpinned by geoscience. Geoscience will therefore continue to play a key role in delivering access to energy sources, managing energy and CO_2 storage, and contributing to a decarbonized energy future (Gardiner et al., 2023; Stephenson, 2021).

Energie Beheer Nederland (EBN) is a company owned by the Dutch state and a so-called policy participation. Though being a non-operating partner or stakeholder in most Dutch subsurface (energy) activities, EBN is committed to supporting the transition to a more sustainable energy system. The complexity and dimensions of the energy transition require a broad vision on the future energy system. Through dedicated research, advice, and steering on innovation together with strategic cooperations, EBN puts focus on areas of low-carbon (low enthalpy) geothermal energy, subsurface energy storage (hydrogen, natural gas, thermal energy), the extraction of energy (hydrocarbons), and the transport, disposal, and geological storage of CO_2. With these activities, it is EBN's ambition to contribute to the realization of societal value, including healthy financial returns, thereby contributing to the realization of the Climate Act and Sustainable Development Goals (SDG) where applicable.

A set of key technical competences within the Geoscience discipline has been identified at EBN, which are deemed essential to secure that Geoscience role and to deliver energy source access within the context of EBN's role to support the energy transition.

Technology job family and their competences

Part of the EBN vision statement claims that "the value of the subsurface – and understanding of it – is essential to the future of sustainable energy generation above ground". In order to identify and realize that value, EBN has developed a substantial (technical) knowledge base and competence framework to understand the Dutch subsurface within the context of the requirements of the energy system, to qualify and quantify the value of natural resources, to support the extraction or storage of natural resources and energy, and to progress toward achieving Climate Policy and SDGs. This competence framework is

Table 1. EBN technical skillpools and subdivision into disciplines and subdisciplines

EBN skillpool	Discipline	Subdiscipline
Geoscience	Geoscience	Exploration Geoscience
		Production Geoscience
		Acquisition & Processing Geophysics
		Geomechanics
		Petrophysics
Reservoir Engineering	Subsurface Flow Engineering	Reservoir Engineering
	Production Engineering	Production Technology
		Production Operations
		Maintenance, Reliability & Turnaround
Facility Engineering	Mechanical Engineering	Mechanical, Materials, Integrity
		Rotating Equipment
		Utilities, Energy and Heat Transfer
	Civil, Offshore & Pipelines	Civil, structure & Offshore
		Pipelines & Subsea
	Instrumentation, Control & Electrical	Process Automation & Control
		Electrical Engineering
	Project Engineering	Project Engineering
	Process Engineering	Process Engineering
		Flow Assurance
Well Engineering	Wells	Completions & Well Interventions
		Well Planning and Design
		Drilling and operations

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most likely applicable across the entire energy system and not unique for EBN.

Technical support and guidance to the business processes within EBN is provided by technical professionals grouped into four skill pools within the technology function family as part of EBN's professional ladder: Geoscience, Facility & Process Engineering, Reservoir Engineering, and Well Engineering. These skill pools can be further subdivided into disciplines and subdisciplines, as illustrated in Table 1.

Technical core activities of the Technology function family include (but are not limited to):

- supervision and management of Health, Safety, and Environment performance,
- subsurface value identification and realization including the analysis and interpretation of data,
- the definition and translation of technical specifications for business projects,
- the engineering, management, and/or execution of technical projects,
- the introduction, evaluation, and optimization of standard operating procedures,
- the technical evaluation of investment proposals,
- the identification and mitigation of technical risks (threats and opportunities) and uncertainties,
- technical knowledge development, capture, and sharing, and
- the functional management of information systems and technical toolboxes.

Competences and proficiency level

At EBN, a competence is described as the ability to demonstrate the right level of knowledge and skills to be successful in the execution of the person's job function or role and to achieve goals set. Competences required to conduct and support the business can be separated into behavioral 'soft' skills, such as Integrity, Cooperation, Vision, Inventiveness and Responsibility, and technical professional skills and knowledge, such as the ability to construct a structural-stratigraphic framework, to estimate in-place volumes through a material balancing equation, or to calculate bore hole stability. In this paper, we focus on the technical (Geoscience) competences relevant to EBN's mission and vision, and trusting these are also applicable outside EBN.

To identify and distinguish proficiency levels and their link to personal development and progression for the various technical competences, EBN recognizes and includes the level of:

- complexity of activities required to perform duties and tasks,
- expertise within a certain (sub)discipline,
- ability to assess the results and consequences of integrating with other disciplines,
- ability to identify and mitigate subsurface risks and uncertainties,
- autonomy a person is able to work within, and
- influence radius and level of (stakeholder) engagement.

Within these conditions, this Technical Competence Framework recognizes four levels of increasing proficiency, see also Table 2, ranging from the inexperienced to the expert:

- Basic/starter: Has a basic level of awareness of the specified activity, its terminology, and concepts. May have some experience of doing the activity and will be able to carry out straightforward relevant tasks to the required standard under supervision.
- Practitioner: Has the knowledge and experience to carry out standard relevant tasks confidently and can work independently and take own initiative demonstrating the desired behavior.
- Influencer: Sets a good example to encourage the desired behavior of colleagues in a nearby environment, has the knowledge and experience to carry out complex, specialist or non-standard tasks confidently and consistently. Is aware of alternative approaches and can provide guidance, instruction, and advice on the activity to others.
- Inspirator: Is recognized as an expert both by internal and external peers, motivates people in the organization to exhibit desired behavior. Sets conditions and standards and

Table 2. Overview and definition of competence proficiency levels

Competence level		Description	Level of experience	Influence range	Risk exposure (RAM)
Basic/starter (Awareness)	4	Basic skills are available to show desired behavior when the situation calls for it.	Starter, no hands-on experience	Me/Myself	RAM VERY LOW: Low priority, strive for continuous improvement
Practitioner (Foundation)	3	Works independently and takes own initiative demonstrating desired behavior	Low level of experience	Colleagues/Team	RAM LOW: Low priority, strive for continuous improvement
Influencer (Skilled)	2	Sets a good example to encourage the desired behavior of colleagues in a nearby environment	High level of experience	Team/Business Unit	RAM Middle/Low: strive for continuous improvement
Inspirator (Advanced)	1	Motivates people in the organization to exhibit desired behavior. Sets conditions and shows leadership to raise people's competencies to a higher level.	Acknowledged expert inside and outside organization	Organization/External	RAM High/Middle: Take measures to remove threat or lower risk (As Low As Reasonably Possible)/Not acceptable: intervene and stop work, lower risks, investigate and make improvement plan

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shows leadership to encourage people to raise competencies to a higher level.

While developing from a Basic to an Influencer (or even Inspirator) level, one is expected to demonstrate an increasing level of skills and knowledge, will require less supervision and guidance, will increase the ability to integrate with other (technical) competencies, and will be exposed to and responsible for larger and more complex projects with more pronounced and complex risk profiles. During this development, one's radius of influence is increasing from personal, to peer, to team, to organization, and beyond.

Competence profiles

The ability to plan and execute technical core activities is carefully managed through a process of people planning. As part of that planning, it is required to focus on the safeguarding of individual development in the following required competences:

- Behavioral competences (or 'soft skills').
- General technical competences including
    - opportunity, risk & uncertainty analysis, and management,
    - an understanding of energy-/value systems,
    - project engineering & management, and
    - information and data & document management/digital technologies.
- Technical discipline core competences that can be
    - a broad competence sub-set (the 'generalist') related to a technological discipline, subdiscipline, or cross-discipline that is necessary to control to create a good end-product (or part of it) or
    - a specific skill set (the 'specialist') that incorporates knowledge, experience, and technical abilities.

The definition of geoscience within the context of the energy transition

By grouping key aspects of geoscience according to Gill (2017), the 'energy' group can be described as follows:

'Identifying and advising on potential energy sources (e.g. geothermal, hydrocarbons) required for energy supply and infrastructure. Contributing to the safe extraction and storage of natural resources, including the disposal of energy waste, and the development of energy infrastructure'. This is however a quite broad description and applicable to non-geoscientists as well.

At EBN, the practice of geoscience means the application of principles of geoscience that includes, but is not limited to, principles of geology, geophysics, geochemistry, petrophysics, and geomechanical engineering to any act of sampling or acquiring data, processing, evaluating, examining, interpreting, reporting, and/or advising that is carried out to support the life cycle of natural resources exploration and exploitation.

In general, seven stages can be identified in the exploitation lifecycle of a natural resource: Identify (or: Explore), Assess (or: Appraise), Select, Define (or: Develop), Execute, Operate, and Abandon/Re-use. In view of the pre-dominant role of EBN as a non-operating partner or shareholder in several natural resource lifecycles, the amount of geoscience support and workload for project and asset management in these lifecycles generally gravitates toward the earlier phases, and the required level of geoscientific support waning off during later phases of the lifecycles. This is reflected in the Technical Competence Frameworks; hence, more Execution and Operate Phases-focused competences may receive less attention here as compared to the Technical Competence Frameworks of an operating partner.

Value chains

Geoscientists within EBN are working in various value chains, which have arisen from a strategic business needs perspective, albeit many of the geoscience competencies needed are interchangeable. These value chains are hydrocarbon extraction and storage (traditional oil and gas exploration, production, and storage), geothermal (mainly focused on low-enthalpy sedimentary aquifer geothermal energy), CO_2-storage (underground storage in depleted gas fields as well as in aquifers), and H_2-storage (covering the complete range of possibilities including exploration, H_2 conversion in depleted gas fields, and H_2 storage in depleted gas fields as well as salt caverns).

Geoscience technical core competences in the energy transition

Geoscientists, as described in this paper (and in literature such as Gill, 2017), are considered to be those professionals who have the knowledge, skills, and practical capabilities to achieve outcomes for the business-oriented process of natural resource exploitation (after Gray & Croft, 2022). EBN's geoscientist focus lies toward the practical application of geoscience skills and knowledge, rather than on deep scientific research studies and experiments. For the latter, EBN relies on their partnerships with universities and other knowledge and research centers. For each of the life-cycle components of the various value chains, the required type and level of technical competences can be broken down into a series of dedicated core competences for the geoscientists relevant to that component.

Table 3 (Kloosterman, 2024). Each of the Technical Competence Frameworks included here (Appendices 1–5) defines the required core competencies for each subject area (discipline). It forms the basis for, among others, the building of modern, flexible, and adaptive training solutions; the definition of personal development targets; the execution of competence assurance activities; as well as the input to business wide strength/weakness analyses and mitigations (Kloosterman, 2024). Generic competences valid for all work- and value chains such as 'organizational health and resource planning' or 'project planning' is of paramount importance as well but out of scope for the current overview.

The core competences identified for each of these series (based on their business relevance for each of the EBN value chains) have been broken down further (Table 4) and include a more bespoke description of proof points. This breakdown aims to support and guide the individual to allow carrying out

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Table 3. Business relevance of geoscience subdisciplines per life-cycle component of each of the value chains

Value chain: / Life-cycle component:	Hydrocarbons	Geothermal	CO_2 storage	H_2 storage
Exploration	Exploration Geoscience (geology, geophysics, and geochemistry)			
	Acquisition & processing Geophysics			
	Petrophysics			
Appraisal	Exploration/Production Geoscience (geology, geophysics, and geochemistry)			
	Acquisition & processing Geophysics			
	Petrophysics			
	Geomechanics			
Development	Production Geoscience (geology, geophysics, and geochemistry)			
	Petrophysics			
	Geomechanics			
Production & Monitoring	Production/Injection Geoscience (geology, geophysics, and geochemistry)			
	Acquisition & processing Geophysics			
	Petrophysics			
	Geomechanics			
Re-use, Abandonment, and Decommissioning	Production Geoscience (geology, geophysics, and geochemistry)			
	Petrophysics			
	Geomechanics			

a self-assessment and to establish their technical competence profile, after careful validation by operational and/or functional managers. Many of the core competences are valid across all value chains supporting the deployment and possible rotation of technical staff across all those value chains applicable to EBN, thereby supporting organizational health and resource planning with the company. Within the volatile and uncertain conditions of the energy transition, a high level of mobility allows for shifting focus to other business requirements rapidly. On a personal level it allows for getting exposure to different aspects through job variation; it aids to social job security conditions, and thereby encourages personal development. The current competence profile aids the individual employee to identify areas of personal strength and weakness, which supports further personal development planning and, hence, a continued individual professional development.

To date, there is no formal (European or Dutch) legal obligation or framework for EBN to recognize professional certifications (such as for Certified Competent Persons) for the individual to act as a competent practitioner and sign-off, for example, natural resource estimates. Nevertheless, the implementation of the current Technical Competence Frameworks within EBN's performance and personal development management framework aligns with the EFG's EurGeol certification requirements (academic qualifications, professional experience, code of ethics, and continuing professional development).

Mobility and transfer of competences/knowledge across value chains

The individual core competences that are associated to a subject area are generally directly transferrable across value chains. Hence, staff mobility is easily maintained between the value chains, and geoscience students can develop a broad geoscientific base that is useful to all value chains, without the need to specialize during their studies.

A high level of staff mobility across work streams will also enhance the transfer, exchange, and capture of knowledge and skills between work streams. People with different proficiency levels in different core competencies can thereby support an increase of the overall proficiency levels.

Some core competencies are specifically required for a particular value chain, for example knowledge on source rocks and hydrocarbon generation and expulsion, which is required in the hydrocarbons work stream, or geothermal resource assessment, which differs from the traditional volumetrically linked resource assessment required in hydrocarbon extraction & storage value chains. These work stream-specific geoscientific core competencies are actually in the minority and probably will only encompass 10% or less of the range of skills required, amplifying the statement that core competencies are transferrable between value chains.

Bottlenecks and opportunities

To support long-term strategic business goals, it is the ultimate aim to reach a fully technical competent workforce within the company, in which geoscientists can thrive, where there is the ability and ambition to develop talent to the fullest, where knowledge can be optimized and well distributed over the different value chains. The main bottleneck and challenge currently faced by EBN is a general shortage of competent technical staff within the job market. This makes it difficult to recruit and employ the required amount of staff, with the right level of experience and competences, and also results in non-desired competition with other companies for attracting staff. From a broad value chain perspective, this competition hampers the energy transition and delays reaching the Climate Act goals and ambitions.

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Table 4. Geoscience competences relevant to EBN

Geoscience subdiscipline	Relevant geoscience competence
Exploration Geoscience	Play Based Exploration
	Regional Basin & Prospect Evaluation
	Structural Geology
	Sedimentology & Stratigraphy
	Seismic 2D/3D/4D interpretation techniques
	Well Ties & Depth Conversion
Production Geoscience	Static 3D Reservoir Modeling: Structural Framework building
	Static 3D Reservoir Modeling: Reservoir property modeling
	Reservoir integrity: Seal & Fault Analysis
	Resource and Reserves Assessment
	Operations Geology
	Geological Well Design & Preparation
Acquisition & processing Geophysics	Seismic acquisition operational design and support
	Seismic Data Acquisition Design & Processing
	Borehole Geophysics & VSP
	Reservoir Geophysics and Seismic QI
Petrophysics	Formation Evaluation
	Core Analysis & SCAL
	Well Logging & Coring
	Geochemistry & Mineralogy
Geomechanics	Reservoir & Seal Geomechanics incl. Seismicity
	Wellbore Stability

General factors contributing to a shortage of technical staff are sought in:

1) A changing energy landscape and economic cyclicity (seasonal, decennial economic up- and downturns).
2) Demographic trends (aging workforce and over-representation of the 45+ age groups) and little gender diversity (mostly male).
3) A less attractive work environment (work-life balance, financially less compelling, (perceived) status of technical professional ladder compared to other more attractive career-ladders).
4) Challenging conditions due to increasingly stronger steer by institutions how to cooperate with the 'fossil industry', and the need here for continuing engagement and mutual understanding between stakeholders.
5) The public image of geoscience within the energy transition.

Concerning the first point, hydrocarbon production profiles for the Dutch on- and offshore demonstrate a considerable and continuing decline over time (NLOG, 2024, https://www.nlog.nl/), causing decreasing hydrocarbon upstream activity levels and therefore shrinking geoscience resource pools and associated loss of geoscience knowledge and skills in that part of the industry. This is a trend supported by data on employment levels in the resource extraction industry (Figure 1) and generally recognized throughout North-Western Europe (see e.g. Goffey et al., 2023). New energies and storage businesses are slowly picking up pace, with an increasing demand for geoscientific support. However, skills and knowledge losses impact the energy industry's present and notably future ability to deliver more sustainable energy solutions. At EBN, it is observed that the increased rate of failure to recruit acceptable job candidates results from a decreased energy system-focused geoscience community in The Netherlands.

In the Netherlands, demographic trends in the workforce employed in the resource extraction industry and supporting service industries (point 2) show a strongly aging and predominantly male workforce (Source: Arbeidsmarkt Monitor Human Capital Topsectoren [2024], https://topsectorenarbeidsmarktmonitor.nl/).

- On average, between 15 and 18% of the employees are female (in a simple binary male-female classification). This average is quite stable over the period 2010–2023 across the sectors measured.
- The number of employees in the age classes above 35 is quite stable (ca 600–800 people per class over the time period 2010–2023), but the number of people in the age classes 25–35 strongly decreased from 800 people in 2014 to 300 in 2023, and the age class below 25 not even represented in the workforce since 2017.

On top of this, over the last 10 years, a global trend of decreasing numbers of undergraduate intake in geoscientific educational programs has been observed (De Bresser, 2024; Goffey et al., 2023; Rogers et al., 2023). Aggregated intake numbers of bachelor students in Dutch geoscience programs (Figure 2) show similar patterns with a general decline trend of ca 28% when comparing 2023 (321 students) intake to peak intake in 2014 (445 students) (De Bresser, 2024). The potential and possible closure of University Geoscience departments due to decreased funding to Universities or the fact that Geoscience educations generally are more expensive (fieldworks, research facilities) may threaten this total number of students to further decrease.

The above offers also several opportunities to strengthen employment opportunities and to satisfy the need for a sufficiently competent Geoscience workforce to support achieving goals as part of the energy transition.

In view of the perceived image problems of geoscientists (De Bresser, 2024; Rogers et al., 2023), earth science educations are slowly adapting a public visual narrative that reflects framing of earth science education in the context of SDGs, rather than the frame where Earth Science has succeeded on the back of hydrocarbon exploration and exploitation (Stewart et al., 2023). However, it should be emphasized that, within EBN, there is a common perception that classic technical competences rooted in the hydrocarbon value chain such as seismic interpretation, structural-stratigraphic framework construction, petrophysical interpretation, etc. remain essential and necessary for supporting and delivering business decisions in all value chains within the New Energies domains, despite of how these competences are framed.

In addition, companies could improve their cooperation with universities, for example, in the area of people planning (shared resources, shared operations), more reliable and access to professional learning and development, and more modern types of engagement, for example, in the form of e-learnings and short-term learning-on-the-job opportunities for (under) graduates and Young Professionals.

One small contribution by EBN to solving this is the recruitment and in-house professional development of future energy specialists, including geoscientists, as part of a dedicated Trainee and Internship Program. During the EBN Traineeship, which takes 3 years, Young Professionals are provided the opportunity to step up and increase their personal competence profiles by working in different job postings in at least two of the value chains. This Traineeship program aims to deliver Young Professionals with at minimum a Practitioner Level in certain skill profiles and value chains, which should be sufficient to put them into the right position for future job opportunities for starters in the energy domain.

All Dutch Universities, in the meantime, have started setting up guidelines on how to assess and accept the level of cooperation between Universities and the 'fossil industry'. As illustrated in this paper, a significant amount of competences required for the geoscientists working in the energy transition are common for all work streams. Education at Universities concerning basic knowledge and competences traditionally acquired in the hydrocarbon extraction and storage value chains should therefore be continued. This can further strengthen the level of collaboration based on the shared ambition to support and accelerate the energy transition, thereby using the geoscience knowledge that was gained in the past in a constructive way for a sustainable future. In addition, these Geoscience competences are still required to manage and support ongoing abandonment activities in view of the natural decline of oil & gas infrastructure in the Dutch on- and offshore.

Conclusions

A technical competence framework has been developed, and the core competences identified have been broken down into distinct levels of proficiency, including a description of proof points. Many of the core competences are valid across all value chains, supporting the deployment of Geoscientists across value chains and energy systems. Within the volatile and uncertain conditions of the energy transition, a high professional standard and a high level of mobility are allowing for rapid adjustment to shifts in business requirements, aid to job security conditions, and encourage personal development and professional growth.

A number of bottlenecks and challenges to continue developing and maintaining a thriving community of energy-geoscientists are identified, with mitigation measures being addressed. This will provide further opportunities to strengthen the shared ambition to support and accelerate the energy transition.

Competing interests

All authors are employed at EBN B.V., and the authors declare no competing interests.

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Appendices (if any, their use should be restricted to a minimum);

Appendix 1. EBN high level competence framework.
Appendix 2. EBN gas transition competence framework.
Appendix 3. EBN CO_2 transport and storage competence framework.
Appendix 4. EBN sustainable heat (Geothermal) competence framework.
Appendix 5. EBN hydrogen competence framework.

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