Non-Electric & Cogeneration Virtual Workshop with End Users

WORKSHOP SYNOPSIS AND FINDINGS

17-18 June 2025; 13:00–16:00 CEST
Virtual

Contents

Workshop Overview and Key Findings

Key Insights from the Workshop

- Nuclear heat has broad industrial relevance. There are many potential applications: district heating, hydrogen, food and drink, cement, asphalt, mining, chemicals, potash, and more. Many have distinct temperature, pressure, and integration requirements.
- Combined heat and power using nuclear energy is technically mature, but deployment depends on local infrastructure and regulation. Past and current projects demonstrate feasibility, but factors such as siting, grid interaction, market changes, and permitting complexity influence their replicability today.
- Large-scale deployment of nuclear steam for industrial use is already occurring in China and government supported demonstrations are planned in other polities such as Japan. Demonstration projects are useful to build confidence and demonstrate the regulatory and financial pathways to commercial projects.
- There are "low-hanging fruit" where technical coupling is expected to be simple, including low-temperature electrolysis and district heating in certain jurisdictions.
- Process industries familiar with complex and large-scale infrastructure projects may be best positioned to lead early deployments. Sectors such as chemicals and oil and gas may be better suited to succeed with first-of-a-kind (FOAK) projects due to their experience with high-risk capital projects and onsite energy supply and demand management.
- Public trust and local engagement remain essential. Gaining social license requires proactive, transparent engagement.

- Policy and permitting must evolve to support industrial-scale nuclear applications. Streamlined licensing, market recognition for nuclear heat, and mechanisms to reward early adopters were identified as key enablers.
- Past and current projects highlight the importance of coordinated design and planning when integrating nuclear systems into industrial operations. This includes addressing interface considerations (e.g. balance of plant, cross-contamination, physical security, regulatory and ownership jurisdictions), redundancy planning, contractual flexibility for long-term steam supply, and public and regulatory scrutiny readiness.

Workshop Overview

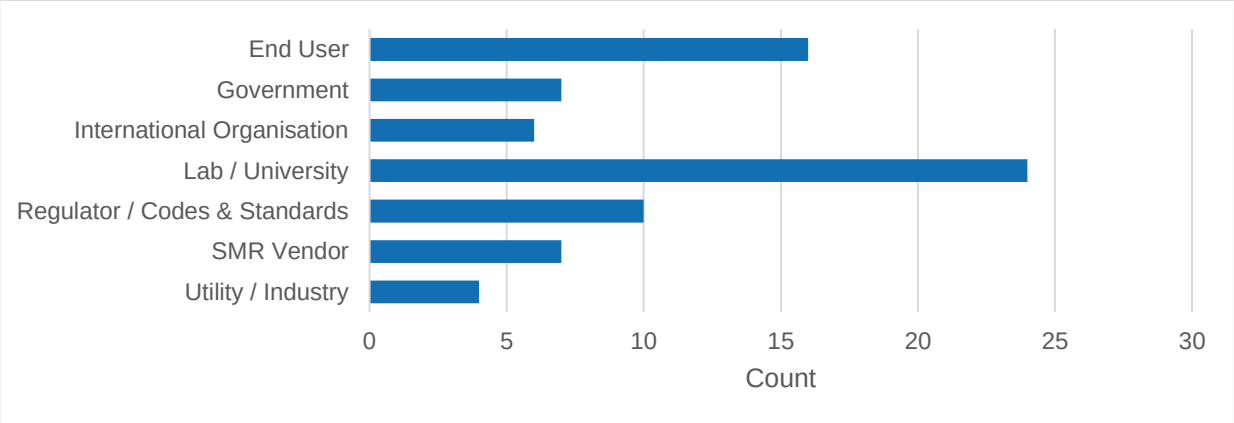
Generation IV International Forum (GIF) Non-Electric and Cogeneration Applications (NECA) Working Group hosted the Non-Electric & Cogeneration Virtual Workshop with End Users on June 17-18, 2025. The goal of this virtual workshop was to identify key challenges faced by industrial energy end-users in adopting non-electric and cogeneration applications of nuclear energy.

The focus was on areas outside of technological and financial considerations, such as those related to regulatory approval, policy frameworks, implementation logistics, and operational feasibility. The goal was to highlight these challenges, identify where barriers existed, and discuss the support needed to overcome them.

This closed-door workshop will bring together industrial energy end users, regulators, and technology vendors to discuss non-electric and cogeneration applications of nuclear energy. The programme features case studies, expert perspectives, and moderated discussions aimed at identifying real-world implementation barriers such as regulatory, operational, and policy-related hurdles.

The audience for the webinar included 74 participants, including significant participation from energy end users who may be considering nuclear energy, and representatives from regulatory bodies, codes and standards organisations, or technical service organisations that support regulators.

Figure 1: Composition of the audience.

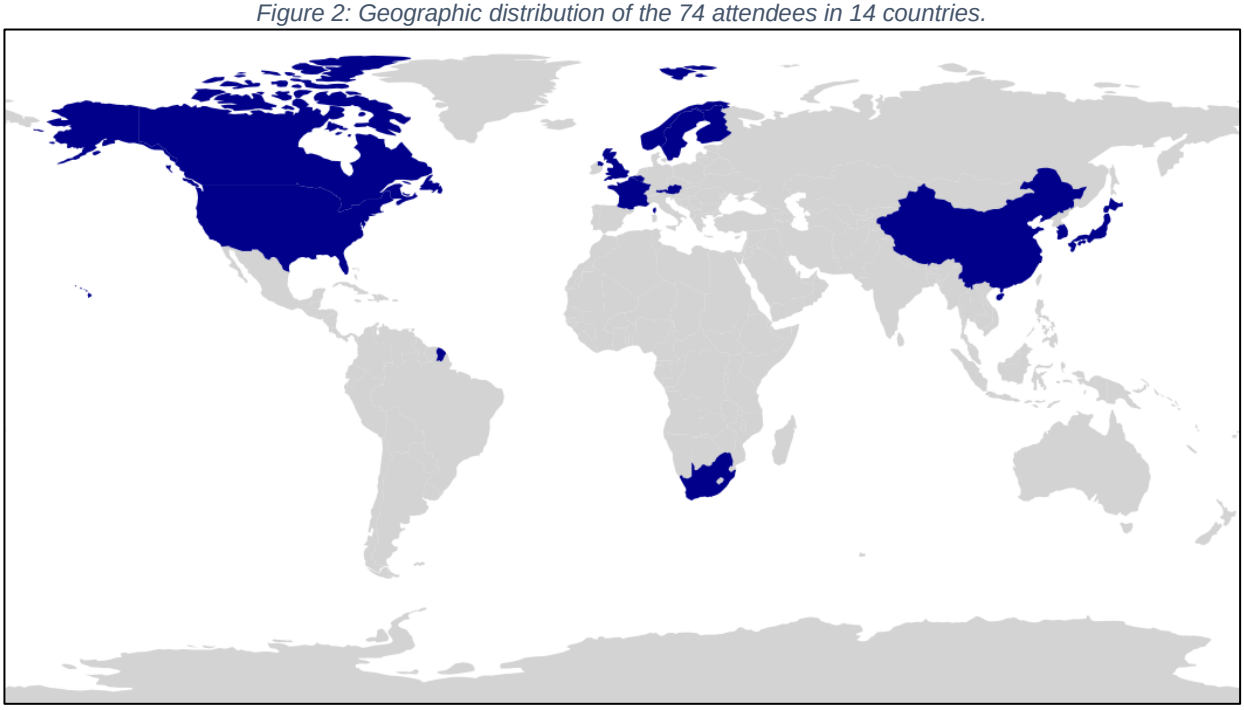


The participants represented interests from a range of countries: United Kingdom (15), France (15), Canada (11), Korea (7), United States (7), and China (5), as well as participation from Sweden, South Africa, Norway, the Netherlands, Japan, Austria, Finland, and Belgium.

In addition to scene-setting remarks, information was primarily provided through presentations. The event featured the following sessions:

Session 1: Operational experience with non-electric systems
Session 2: District heating and industrial heating networks
Session 3: Diversity of non-electric and cogeneration applications of nuclear energy
Session 4: Opportunity for process industries

Figure 2: Geographic distribution of the 74 attendees in 14 countries.



Besides the opening remarks, the event followed Chatham house rules. Comments are therefore intentionally included without attribution to the speaker to enable anonymity and increased knowledge sharing. Names are included in this document if permission was explicitly provided.

This virtual workshop builds on the success of previous in-person end-user workshops hosted by the NECA Working Group, including the Workshop - Non-Electric Applications of Nuclear Heat in Toronto, Canada in October 2022 and the Workshop on Non-Electric and Hybrid Applications of Nuclear Energy in Busan, Korea in April 2024.

Workshop Summary

Day 1 Opening Session

Michael Futterer
Technical Director
Generation IV International Forum (GIF)

- Michael Fütterer introduced the workshop by outlining GIF's mission: to develop advanced nuclear reactor systems that are safer, more efficient, and economically viable. He emphasized that several of the six selected Gen IV systems are now ready for demonstration.
- Michael explained the role of NECA Working Group as a platform to explore how nuclear energy can support industrial and transport applications beyond electricity, and stressed the importance of industry engagement to move from R&D to deployment. He highlighted NECA's efforts to gather data, assess market needs, and support licensing and investment frameworks.
- Dr Fütterer concluded by encouraging industry participants to share their needs to help shape GIF's future work and identify new opportunities for collaboration

Juho Korteniemi
Deputy Director General of Nuclear Energy and Fuels
Government of Finland

- Juho Korteniemi shared opening remarks on the opportunity for non-electric applications of nuclear energy in Finland.
- Mr Korteniemi emphasised the strategic importance of nuclear energy for decarbonizing the heating sector, where most needs can be met with low-temperature heat (~150°C).
- The country is advancing its first SMR pilot project in Helsinki, supported by a regulatory framework that has already been adapted to allow siting near urban areas.
- Policy priorities include investment in pilot and demonstration projects, addressing regulatory and siting requirements, and renewing the Nuclear Energy Act.
- Public engagement was highlighted as essential for successful deployment of SMRs near cities and industrial zones.
- The importance of international collaboration was stressed to share technical, regulatory, and waste management best practices, recognising that nuclear energy applications must align with both national and international standards.

Session 1: Operational experience with non-electric systems

Speakers discussed operational experience using nuclear energy for non-electric applications, including petrochemical processes in China, hydrogen production in Japan, and paper production in Norway.

Session Speakers

- Chair: Chuk Azih, Co-chair of NECA Working Group (Canada)
- Speakers from the following organisations:
  - Japan Atomic Energy Agency (Japan)
  - Institute for Energy Technology representing the Halden Reactor Project (Norway)
  - CNNC Jiangsu Nuclear Power Corporation (China)

Summary of discussion from session
Coupling nuclear reactors with industrial facilities can deliver mutual benefits but also introduces operational complexity and licensing challenges due to the interface of hazards from different industrial settings.

- The long-standing case of the Halden Reactor, which supplied 15 to 20 t/h of steam to a nearby paper mill 100s of metres away, illustrates a successful, though sometimes challenging, cogeneration/co-location relationship.
- Large-scale deployment of nuclear steam for industrial use is already occurring. The Tianwan project in China, operational since mid-2024, demonstrates the feasibility of transporting industrial-grade steam over distances exceeding 20 km from a nuclear power plant to a petrochemical park, delivering 600 t/h steam at 248°C.
- Demonstration of industrial use with HTGRs were highlighted as offering potential advantages over light-water reactor (LWR) technologies due to their inherent safety features and higher outlet temperatures. Experience with HTTR in Japan demonstrates performance and safety, and there are plans to couple the HTTR with a hydrogen plant using steam methane reforming.

Some key logistical and operational considerations were:

- Historical examples show that efficient steam utilisation and waste-heat management can be attained, however, mutual dependencies between the plants must be managed. For example, one facility's operational status (e.g., outages or water use changes) directly impacted the other.
- Due attention should be given to downstream tolerance of personnel and processes to radioactivity levels. Monitoring in the secondary and tertiary loops was noted as a requirement for coupling applications with shutdown mechanisms in place if radioactivity is detected on the applications side.
- Interfaces and regulatory boundaries are not well established, e.g. would regulator changes from any party does have undue cascading burden on the other parties. Approval frameworks should also be commensurate between the technologies involved for adequate response to changes in policies and regulatory requirements.

- Security requirements for nuclear installations are generally more stringent than requirements for end use. These may conflict with some end users' development goals especially in co-located installations. Regular evaluation of robustness of the solution for all parties is essential.
- Experiences from China, Norway, and Japan illustrate how national contexts and historical precedence influence public engagement and regulatory readiness. Policy frameworks that permit siting near cities, long-standing local partnerships, and visible project benefits (e.g., job creation, municipal heat delivery) are useful in fostering social license.
- Past and current projects highlight the importance of coordinated design and planning when integrating nuclear systems into industrial operations. This includes addressing interface hazards, redundancy planning, contractual flexibility for long-term steam supply, and public and regulatory scrutiny readiness.

Session 2: District heating and industrial heating networks

Speakers discussed the role of heat networks and the opportunity for nuclear energy, covering both district energy systems and industrial heating networks.

Session Speakers

- Chair: Aiden Peakman, Co-chair of NECA Working Group (UK)
- Speakers from the following organisations:
    - Industrial Decarbonisation Research and Innovation (UK)
    - Boltzmann Institute (Canada)

Summary of discussion from session

- Industrial clusters represent a good opportunity for integration with nuclear energy. The UK's decarbonisation strategy is focused on clustering approaches that link industrial heat demand with energy infrastructure.
- District heating can serve a significant share of building heat demand. Thermal network planning studies indicate that 60–70% of buildings could be economically connected to district energy systems. These systems are particularly well-suited to dense urban areas, where high heat demand per meter of pipe improves economics.
- Lifecycle cost analyses show that thermal networks may cost up to 50% less than full electrification strategies when accounting for electricity system expansion needs, and other externalities associated with mass electrification.
- In some jurisdictions existing heat infrastructure offers a compelling advantage over other jurisdictions that may be restricted to greenfield development of heat networks.
- Integration of nuclear heat into district or industrial networks requires strategic alignment as there are distinct complexities when compared to electricity markets. For example, local authorities often govern heat networks, while electrical networks are managed around larger polities.
- Speakers emphasized the need to match the strengths of nuclear energy (high availability, low marginal cost, baseload production) with heat demand profiles that avoid operational mismatch. Thermal storage would be more beneficial than load following using nuclear energy in the case of heat networks.
- When combined with seasonal storage or thermal buffering, nuclear CHP systems could significantly increase energy utilisation rates from approximately 33% to approximately 90% with less than a 1% additional capital cost. The ability to store thermal energy also mitigates the grid stress that accompanies mass electrification and supports more resilient local energy systems.
- Heat pump technology was noted, including that heat pump efficiency drops in colder climates when energy demands are coincidently elevated.
- Major challenges include policy uncertainty and the cautious posture of existing nuclear operators to changes in mandate. These can potentially be mitigated through early-stage planning, cross-sector engagement, and embedding CHP integration into new reactor project designs.
- Public engagement, co-location, and governance models are essential enablers. The session reinforced the importance of engaging municipalities and communities early, particularly where nuclear heat may be delivered close to urban or industrial centres.

Day 1 discussion

An interactive discussion was held to reflect on the topics covered on the first day of the workshop, which was moderated by Huang Zhang of the Institute of Nuclear Energy and New Energy Technology, Tsinghua University (China).

Summary of discussion

- Experience from past and current projects shows that close physical and functional integration between reactors and industrial facilities requires coordination between multiple industries.
- Industrial processes may demand a range of different heat qualities, impose new operational constraints, or trigger mutual dependencies that complicate reactor operations. Aligning NPP outage schedules and maintenance schedules for the industrial end user appears to be a requirement, for example.
- Industrial heat demand is diverse and application-specific. Low-temperature heat is sufficient for industries like paper production and district heating, while chemical production often requires higher temperatures. The HTR-600S project in China will use three separate heat loops to meet the needs of different petrochemical processes.
- Opportunities to deploy nuclear heat are strongly dependent on local conditions, including proximity and density of heat demand and the regional price of competing fuels.
- Safety remains a critical area for cross-sector coordination. Integration of nuclear and industrial systems must consider physical separation, containment, and real-time monitoring to mitigate radiological risks.
- Harmonisation of safety standards between nuclear regulators and industrial authorities is needed to avoid over-constraining projects or creating mismatched requirements.
- Economic assessments must go beyond levelized cost of electricity (LCOE). Participants emphasised the need for system-level evaluations that account for lifecycle impacts, thermal quality, integration costs, resilience, and externalities.
- The quality of heat affects end-use efficiency and transport losses. Tools such as thermal storage improve flexibility, allowing reactors to run continuously while decoupling delivery from demand peaks.
- Public perception and local engagement are central to project success. Clear, open communication about project benefits, risks, and safety measures builds trust. Past examples show that community support can be secured through early engagement, transparency, and a demonstration of tangible municipal benefits. Site visits, such as open days at operating nuclear facilities (e.g., Tianwan NPP), were cited as good practices for public education and confidence-building.
- Policy frameworks should explicitly recognise nuclear heat as a technical solution to climate change.
- Demonstration projects—particularly those involving heat supply, hydrogen production, and integration with existing industry—are viewed as essential for proving feasibility and unlocking market confidence.

Day 2 Opening Session

Carl Berglöf, National Nuclear New-Build Coordinator Government of Sweden

- Carl Berglöf provided opening remarks on the history and opportunity of non-electric applications of nuclear in Sweden.
- Mr Berglöf outlined Sweden's strategic vision for expanding nuclear energy to support its goal of 100% fossil-free electricity production by 2040. Sweden currently operates six light water reactors and produces 99% of its electricity from non-fossil sources. The national roadmap anticipates increasing nuclear capacity by 2,500 MW by 2035 and up to 10,000 MW by 2045.
- Policy reforms were presented, including the removal of geographic and numerical restrictions on new reactors, the introduction of a new Act, and the development of a financing framework combining state-backed loans, Contracts for Difference, and credit guarantees. Regulatory capacity is also being strengthened to support licensing.
- The remarks emphasized cogeneration opportunities, citing past and current Swedish experience with district heating from nuclear sources. Emerging reactor designs and projects supporting fossil-free steel were highlighted as promising contributors to industrial decarbonization.

Session 3: Diversity of non-electric and cogeneration applications of nuclear energy

Speakers shared analysis on the range of applications that could be supported with nuclear heat and discussed analysis and challenges that extend beyond technoeconomic considerations.

Session Speakers

- Chair: Francesco Ganda, International Atomic Energy Agency
- Speakers from the following organisations:
  - British Sugar (UK)
  - Heidelberg Materials (UK)
  - CSA Group (Canada)
  - Hatch (Canada)

Summary of discussion from session

- Industrial sectors are actively exploring nuclear energy as part of long-term decarbonisation strategies, with companies demonstrating roadmaps to make investments to reduce emissions and transition away from fossil fuels.
- Nuclear energy is increasingly viewed as a potential long-term solution to meet high thermal demands while minimising carbon intensity.
- Sugar production, cement kilns, and asphalt plants all require large volumes of low- to medium-temperature heat, often in rural or industrially clustered locations. These processes are not easily electrified due to the scale and intermittency of demand, limitations of grid infrastructure, and the physical nature of the thermal loads.
- Challenges for these industries to achieve emissions reductions were noting. In particular, the limit of energy efficiency has been achieved in some industries and acknowledged to be limited in others. Meaningful reductions in carbon emissions will require significant investment, with particular difficulty for higher temperature applications where options may be limited to hydrogen usage.
- Projects coupling hydrogen production with nuclear power are emerging but face technical, regulatory, and cost barriers. Feasibility studies are evaluating solid oxide electrolysis cells (SOEC) powered by nuclear energy for industrial hydrogen applications. Hydrogen's storage, safety, and permitting requirements (e.g., separation distances, hazardous substance thresholds) remain significant concerns.

- Existing standards often treat nuclear and hydrogen facilities separately, creating gaps at their interface. Low-temperature electrolysis (LTE) is the least complex coupling option from a siting and safety perspective, while high-temperature methods require more robust safety assessments.
- Industrial users generally prefer to purchase heat and power rather than operate a reactor themselves. While technical contamination risks are well understood and manageable, public perception remains a barrier.

Session 4: Opportunity for process industries

Speakers discussed the scale and urgency of the energy challenge in process industries including hydrogen, chemicals, and petrochemicals markets.

Session Speakers

- Chair: Chan Soo Kim, Korea Atomic Energy Research Institute (Korea)
- Speakers from the following organisations:
  - Dow Chemical (USA)
  - Hydrogen South West (UK)
  - Orlen Synthos Green Energy (Poland)

Summary of discussion from session

- Process industries face high, continuous heat and power demands. To meet decarbonisation targets without compromising reliability, advanced GenIV reactors are increasingly being considered. In both the USA and China, HTGRs are being deployed for a range of chemical and petrochemical applications.
- Successful adoption of nuclear technologies depends on their ability to align with industrial project timelines, regulatory pathways, and financial constraints.
- Participants noted that certain sectors, such as oil and gas and chemicals sectors, may be better positioned to deliver complex first-of-a-kind nuclear projects due to their experience with large-scale infrastructure and regulatory processes stretching across multiple jurisdictions. Conversely, sectors like data centers or light industry may be better suited as a customer of power.
- Identifying applications that combine low integration complexity with stakeholder competence may offer the path to early deployment.
- Hydrogen ecosystems are forming around regionally tailored industrial needs and may be able to serve a diverse range of applications including aviation, maritime, and mining applications.
- District heating systems are a strong entry point for SMRs in coal-reliant regions. In countries with widespread district heating (e.g., Poland), SMRs are being considered as replacements for aging coal-fired CHP plants.
- Government support is essential. This extends beyond financial support and includes site authorisations and policy alignment.
- The value proposition of nuclear heat depends on more than cost. Speakers emphasised that economic competitiveness is shaped not only by LCOE or fuel cost, but also by avoided emissions, thermal integration efficiency, and energy security benefits. Projects must be assessed holistically to reflect their system-level value, and externalities.
- Public-private collaboration on demonstration projects remains a critical next step to build confidence and reduce market entry risks.

Day 2 discussion.

An interactive discussion was held to reflect on the topics covered on the first day of the workshop, which was moderated by Amgad Elgowainy of Argonne National Laboratory (USA).

Summary of discussion

- There is a wide range of applications (district heating, steel, sugar, cement, asphalt, ammonia, oil and gas, mining, chemicals, and potash). Each sector has unique energy requirements, but some may represent low-hanging fruit for integration.

- Many industries are already using combined heat and power (CHP) systems to meet their needs efficiently. The inclusion of nuclear as a heat and power source is a technically viable solution. Policy stopped successful historical systems, and policy can enable new systems to come online.
- The most useful demonstration project would (1) offer a lot of learning to advance commercial readiness, (2) involve industrial end users who are familiar with managing high-risk, capital-intensive projects, and (3) represent a relatively simple technical integration such as plug-in steam to serve an industrial heat network.
- In regions where natural gas is cheap and infrastructure is entrenched, nuclear faces steep economic competition. However, in locations with carbon pricing, infrastructure limitations, or policy-driven decarbonisation goals, nuclear may offer a more attractive long-term solution.
- Industrial speakers highlighted that nuclear approvals often operate on slower or more rigid timelines than conventional industrial permitting. Projects must account for this from the outset. Hybrid permitting approaches, or leveraging existing frameworks (e.g., for combined-cycle plants), were discussed.
- Public engagement and shared local benefits are essential for social acceptance. Showing how nuclear projects benefit municipalities and local communities was noted as a useful approach.

Agenda for the Non-Electric & Cogeneration Virtual Workshop with End Users

Date: 17–18 June 2025; 13:00–16:00 CEST each day

Format: Virtual meeting hosted on Zoom. Discussion will follow Chatham House Rule

Organisers: GIF Non-Electric and Cogeneration Applications (NECA) Working Group

17 June 2025

13:00 – 13:20	***Opening Session:*** *Welcome address and keynote remarks*
Welcome Address of GIF	Michael Fuetterer, Technical Director, GIF
Opening remarks on the opportunity for non-electric applications of nuclear energy in Finland	Juho Korteniemi, Deputy Director General of Nuclear Energy and Fuels, Government of Finland (Finland)

13:20 – 14:20	***Session 1:*** *Operational experience with non-electric systems*
Chair of session:	Chuk Azih, Co-chair of NECA Working Group (Canada)
Speakers will share operational experience using nuclear energy for non-electric applications, including petrochemical processes in China and paper production in Norway.	Japan Atomic Energy Agency (Japan) Institute for Energy Technology, Halden Reactor Project (Norway) CNNC Jiangsu Nuclear Power Corporation (China)

14:20 – 15:00	***Session 2:*** *District heating and industrial heating networks*
Chair of session:	Aiden Peakman, Co-chair of NECA Working Group (UK)
Speakers will discuss the role of heat networks and the opportunity for nuclear energy, covering both district energy systems and industrial heating networks.	Industrial Decarbonisation Research and Innovation (UK) Boltzmann Institute (Canada) Steady Energy (Finland)

15:00 – 16:00 ***Discussion.***

Moderator: Huang Zhang, Institute of Nuclear Energy and New Energy Technology, Tsinghua University (China)

18 June 2025

13:00 – 13:10 Opening Session: *Day 2 opening remarks*

Opening remarks on the history and opportunity of non-electric applications of nuclear in Sweden.	Carl Berglöf, National Nuclear New-Build Coordinator, Government of Sweden (Sweden)

13:10 – 14:10 Session 3: *Diversity of non-electric and cogeneration applications of nuclear energy*

Chair of session:	Francesco Ganda, International Atomic Energy Agency
Speakers will share analysis on the range of applications that could be supported with nuclear heat, and discuss analysis and challenges that extend beyond technoeconomic considerations.	British Sugar (UK) Heidelberg Materials (UK) CSA Group (Canada) Hatch (Canada)

14:10 – 15:10 Session 4: *Opportunity for process industries*

Chair of session:	Chan Soo Kim, Korea Atomic Energy Research Institute (Korea)
Speakers will discuss the scale and urgency of the energy challenge in process industries including hydrogen and (petro)chemicals sectors.	Dow Chemical (USA) Hydrogen South West (UK) Orlen Synthos Green Energy (Poland) ExxonMobil (USA)

15:10 – 15:50 Discussion.

Moderator: Amgad Elgowainy, Argonne National Laboratory (USA)

15:50 – 16:00 Closing remarks