The need to use nuclear energy for the energy transition to Hydrogen in iron and steel industry (05)

In the opinion of the author of this website, and in view of the world situation of iron and steelmaking industries, cement, transport, etc.etc.., the objectives of the Dubai (UAE) climate summit, COP 28 and the transition to an energy based fundamentally on hydrogen and eliminating the carbon footprint, they cannot be achieved without employment, in Europe and on a global scale, with the exception of very few countries such as the Nordic countries and some African countries, of nuclear energy for the production the of electrical energy necessary for obtaining by electrolysis hydrogen in large quantity. At least until said hydrogen can be obtained through other non-polluting alternative procedures.

Since the alternative energies proposed up to now, wind and solar, including hydraulic energy, will be absolutely insufficient to stop and reverse climate change on a global scale.

For this reason, it is essential to stop the delay the matter and use the nuclear energy, in its safest form, in a generalized way. Since between two bad options ,one of which is fatal and irreversible, the lesser bad must be chosen. Furthermore, failure to do so will bring enormously negative economic and social consequences for the world population as a whole.

I.Ibarrondo 20.06.2023

Department of Energy

At COP28, Countries Launch Declaration to Triple Nuclear Energy Capacity by 2050, Recognizing the Key Role of Nuclear Energy in Reaching Net Zero

December 1, 2023

Declaration Recognizes the Key Role of Nuclear Energy in Keeping Within Reach the Goal of Limiting Temperature Rise to 1.5 Degrees Celsius

Declaration to Triple Nuclear Energy
02 December 2023

Recognizing the key role of nuclear energy in achieving global net-zero greenhouse gas emissions / carbon neutrality by or around mid-century and in keeping a 1.5°C limit on temperature rise within reach and achieving Sustainable Development Goal 7;

Recognizing the importance of the applications of nuclear science and technology that contribute to monitoring climate change and tackling its impacts, and emphasizing the work of the International Atomic Energy Agency (IAEA) in this regard;

Recognizing that nuclear energy is already the second-largest source of clean dispatchable baseload power, with benefits for energy security;

Recognizing that analyses from the OECD Nuclear Energy Agency and World Nuclear Association show that global installed nuclear energy capacity must triple by 2050 in order to reach global net-zero emissions by the same year;

Recognizing that analysis from the Intergovernmental Panel on Climate Change shows nuclear energy approximately tripling its global installed electrical capacity from 2020 to 2050 in the average 1.5°C scenario;

Recognizing that analysis from the International Energy Agency shows nuclear power more than doubling from 2020 to 2050 in global net-zero emissions by 2050 scenarios and shows that decreasing nuclear power would make reaching net zero more difficult and costly;

Recognizing that new nuclear technologies could occupy a small land footprint and can be sited where needed, partner well with renewable energy sources, and have additional flexibilities that support decarbonization beyond the power sector, including hard-to-abate industrial sectors;

Recognizing the IAEA's activities in supporting its Member States, upon request, to include nuclear power in their national energy planning in a sustainable way that adheres to the highest standards of safety, security, and safeguards and its "Atoms4NetZero" initiative as an opportunity for stakeholders to exchange expertise;

Recognizing the importance of financing for the additional nuclear power capacity needed to keep a 1.5°C limit on temperature rise within reach;

Recognizing the need for high-level political engagement to spur further action on nuclear power;

https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key

Protecting and growing our use of nuclear technologies are important ways to dramatically reduce greenhouse gases and help us make meaningful progress to address climate change.

Nuclear power plants produce no greenhouse gas emissions during operation**, and over the course of its life-cycle, nuclear produces about the same amount of carbon dioxide-equivalent emissions per unit of electricity as wind, and one-third of the emissions per unit of electricity when compared with** solar.

Nuclear power is emerging as an answer to fill the gap as states transition away from coal, oil and natural gas to reduce greenhouse gas emissions and stave off the worst effects of a warming planet.

The mining and enrichment of uranium; the manufacturing, transport and reprocessing of nuclear fuel rods and waste; the building and dismantling of the reactors. At every step, nuclear energy produces greenhouse gas (GHG).

https://www.npr.org/2022/01/18/1073726137/the-us-is-divided-over-whether-nuclear-power-is-part-of-the-green-energy-future

VIDEOS:

COP28: Leaders Announce Nuclear Energy Summit for 2024

https://www.iaea.org/newscenter/multimedia/videos/cop28-leaders-announce-nuclear-energy-summit-for-2024

COP28: IAEA Statement on Nuclear Power Backed by Dozens of Countries

https://www.iaea.org/newscenter/multimedia/videos/cop28-iaea-statement-on-nuclear-power-backed-by-dozens-of-countries

COP 28: Jump Starting the Global Deployment of New Nuclear Energy

https://www.youtube.com/watch?v=jwBhSDvcQt4

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22 Countries Pledge to Triple Nuclear Capacity in Push to Cut Fossil Fuels

The group, including Britain, France and the United States, said the agreement was critical to meeting nations' climate commitments.

https://www.nytimes.com/2023/12/02/climate/cop28-nuclear-power.html

Crucial role of nuclear energy in fighting climate change cannot be overstated: Rosatom Director General

https://greenfue.com/crucial-role-of-nuclear-energy-in-fighting-climate-change-cannot-be-overstated-rosatom-director-general/

Related Topic: Hydrogen

https://world-nuclear-news.org/TagSection?tagid=1067

ArcelorMittal invests $25 million in breakthrough nuclear power innovator TerraPower. 03.11.2022

ArcelorMittal (the 'Company') today announces it has invested $25 million in nuclear innovation company TerraPower through its XCarb® Innovation Fund. The investment is part of an $830 million equity raise TerraPower has concluded, which is the largest private raise among advanced nuclear companies.

https://corporate.arcelormittal.com/media/press-releases/arcelormittal-invests-25-million-in-breakthrough-nuclear-power-innovator-terrapower

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The Future of Nuclear Energy in a Carbon-Constrained World
AN INTERDISCIPLINARY MIT STUDY, Pages 1-275.

MIT Energy Initiative

https://energy.mit.edu/wp-content/uploads/2018/09/The-Future-of-Nuclear-Energy-in-a-Carbon-Constrained-World.pdf

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The future of nuclear power

Scarlett Evans

1. **Analysis February 15, 2022**

Nuclear power is increasing the world over, with International Energy Agency (IEA) figures showing global energy generation from nuclear sites grew 3.5% in 2021 compared with 2020 levels, recovering from a drop of almost 4% seen as a result of the pandemic. Yet the IEA has also said that current levels are not on track to help reach global decarbonisation targets, and that a doubling in annual capacity will be needed if this goal is to be achieved.

While there has been recent debate over just how green nuclear power is, several nations have already made it a key part of their future energy landscape, with the World Nuclear Association estimating that there are 55 new nuclear reactors under construction around the world. While the majority are planned in Asian countries, nations on almost every

continent have such sites in the pipeline, with a total capacity of about 100GW on the horizon for nuclear power projects.

So what are some of the sites set to come online in the next few years? We take a look.

https://www.power-technology.com/analysis/nuclear-projects-future-olkiluoto-hinkley-point/

Study of a nuclear energy supplied steelmaking system for near-term application.

Xing L. Yan *, Seiji Kasahara, Yukio Tachibana, Kazuhiko Kunitomi

Japan Atomic Energy Agency, Nuclear Hydrogen and Heat Application Research Center, 4002 Narita-cho, Oarai-Machi, Ibaraki-ken 311-1394, Japan.

Energy 39 (2012) 154-165

Conventional steelmaking processes involve intensive fossil fuel consumption and CO2 emission. The system resulting from this study ties a steelmaking plant to a nuclear plant. The latter supplies the former all energy and feedstock with the exception of iron ore. The actual design takes on a multi- disciplinary approach: The nuclear plant employs a proven next-generation technology of fission reactor with 950 C outlet temperature to produce electricity and heat. The plant construction saving and high efficiency keep the cogeneration cost down. The steelmaking plant employs conventional furnaces but substitutes hydrogen and oxygen for hydrocarbons as reactant and fuel. Water decomposition through an experimentally-demonstrated thermochemical process manufactures the feedstock gases required. Through essential safety features, particular a fully-passive nuclear safety, the design achieves
physical proximity and yet operational independence of the two plants to facilitate inter-plant energy transmission. Calculated energy and material balance of the integrated system yields slightly over 1000 t steel per 1 MWt yr nuclear thermal energy. The steel cost is estimated competitive. The CO2 emission amounts to 1% of conventional processes. The sustainable performance, economical potential, robust safety, and use of verified

technological bases attract near-term deployment of this nuclear steelmaking system.

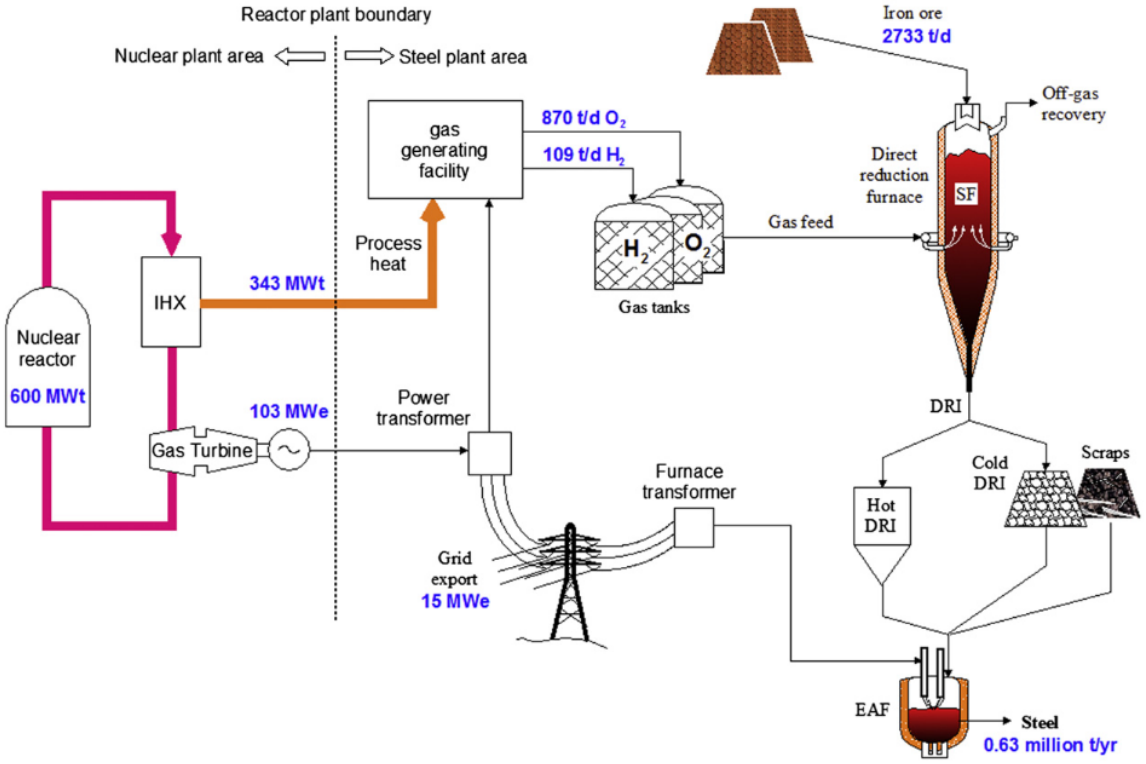

Fig. 1. Schematic of GTHTR300C nuclear steelmaking system based on a unit of nuclear reactor.

BrucePower

13.10.2023

Steel industry needs more clean nuclear energy to achieve decarbonization goals, new report shows

Canada’s steel industry is one of the greenest in the world, thanks to carbon-free electricity generated by nuclear power, including the strong baseload supply from Bruce Power. And as Canadian steelmakers look to further decarbonize their processes over the coming

years, the demand for clean electricity is demonstrating the need for clean, reliable, affordable nuclear power.

A report released today, Greening Steel: How nuclear energy and electrification can power the future of steel, shows that on average, Canadian steelmakers expect to see a 430 per cent increase in electricity demand by 2050 as they transition to processes powered by electricity and expand operations. The report, jointly produced by the Bruce Power Centre for New Nuclear & Net Zero Partnerships at the Nuclear Innovation Institute and the Canadian Steel Producers Association (CSPA), report highlights the increased demand from the Canadian steel sector for clean electricity in the decades ahead and demonstrates how nuclear can meet this demand.

“Nuclear can provide the clean, reliable, and affordable electricity supply to power a transition to widespread green steelmaking, starting in Ontario and across Canada as provincial grid operators look at adding and expanding nuclear in their supply mix,” said Pat Dalzell, Executive Director, Corporate Affairs at Bruce Power.

“As the generator of 30 per cent of Ontario’s carbon-free electricity, and through the successful completion of our Major Component Replacement projects and continued asset optimization, Bruce Power is committed to providing the long-term supply of clean power needed to further decarbonize Canada’s steel industry, and other sectors. **This report further proves there is no path to net zero without nuclear.”**

https://www.brucepower.com/

https://www.brucepower.com/2023/10/12/steel-industry-needs-more-clean-nuclear-energy-to-achieve-decarbonization-goals-new-report-shows/

2023 Bruce Power Annual Review and Energy Report (download)

https://www.brucepower.com/2023annualreview/

Nuclear Power in a Clean Energy System

Iea (International Energy Agency)

May 2019

Nuclear power and hydropower form the backbone of low-carbon electricity generation. Together, they provide three-quarters of global low-carbon generation. Over the past 50 years, the use of nuclear power has reduced CO2 emissions by over 60 gigatonnes – nearly two years' worth of global energy-related emissions. However, in advanced economies, nuclear power has begun to fade, with plants closing and little new investment made, just when the world requires more low-carbon electricity. This report focuses on the role of nuclear power in advanced economies and the factors that put nuclear power at risk of future decline. It is shown that, without action, nuclear power in advanced economies could fall by two thirds by 2040.The implications of such a "nuclear fade case" for costs, emissions and electricity security using two World Energy Outlook scenarios are examined in the New Policies Scenario and the Sustainable Development Scenario. Achieving the pace of CO2 emissions reductions in line with the Paris Agreement is already a huge challenge, as shown in the Sustainable Development Scenario. It requires large increases in efficiency and renewables investment, as well as an increase in nuclear power. This report identifies the even greater challenges of attempting to follow this path with much less nuclear power. It recommends several possible government actions that aim to ensure existing nuclear power plants can operate as long as they are safe, support new nuclear construction and encourage new nuclear technologies to be developed.

https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

Full report

Nuclear Power in a Clean Energy System pp. 1- 103

Dr Fatih Birol

Executive Director

International Energy Agency

Download from :

https://iea.blob.core.windows.net/assets/ad5a93ce-3a7f-461d-a441-8a05b7601887/Nuclear_Power_in_a_Clean_Energy_System.pdf

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Nuclear Energy: A critical pillar of a carbon-free future

GE Stem power

Producing dependable, cleaner power is a global priority

As the world continues to decarbonize the energy sector and strives to attain net-zero greenhouse gases to combat the threat of a warming planet, producing dependable, cleaner power is a global priority. As the most dependable source of carbon-free power generation providing around-the-clock energy supply without interruption, nuclear energy is an important part of the power generation landscape, and it is a critical pillar in the transformation to a carbon-free future.

https://www.ge.com/steam-power/nuclear-turbine-island/carbon-free-future

Download nuclear energy white paper:

NUCLEAR ENERGY:

A critical pillar of a carbon-free future

https://www.ge.com/content/dam/gepower-new/global/en_US/downloads/steam-new-site/nuclear-steam/nuclear-energy-carbon-free-future-white-paper.pdf

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What are Small Modular Reactors (SMRs)?

Joanne Liou, IAEA Office of Public Information and Communication

04.11.2021

Small modular reactors (SMRs) are advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit, which is about one-third of the generating capacity of traditional nuclear power reactors. SMRs, which can produce a large amount of low-carbon electricity, are:

- **Small** – physically a fraction of the size of a conventional nuclear power reactor.
- **Modular –** making it possible for systems and components to be factory-assembled and transported as a unit to a location for installation.
- **Reactors –** harnessing nuclear fission to generate heat to produce energy.

Learn more about nuclear fission and energy.

See :

Advantages of SMRs

What is the status of SMRs?

SMRs and sustainable development

What is the role of the IAEA?

https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs

Decarbonizing Steel Production with Nuclear Hydrogen

Mariia Platonova

Steel production accounts for more than seven per cent of global carbon dioxide (CO2) emissions. That percentage is set to soar in the coming decades, along with a rising demand for steel, which is vital for sectors ranging from energy and transport to construction and consumer appliances. However, nuclear energy could help put steel production on a path to net zero.

About two billion tonnes of steel are produced annually around the world. According to the International Energy Agency, steel demand is projected to rise by more than a third by 2050, mainly in developing countries. A growing number of global companies are looking for ways to decarbonize the energy-intensive industrial processes of this sector.

The steel industry largely depends on coking coal to power blast furnaces, which turn iron ore into steel, a process that emits large quantities of CO2. However, it is possible to create steel using a method called direct reduction of iron, in which hydrogen reacts with iron ore without melting and emits water vapour and no CO2.

¨Several countries around the world are exploring and testing the use of nuclear energy to produce clean hydrogen, including for use in the production of steel¨.

Aline des Cloizeaux, Director, Division of Nuclear Power IAEA

“The amount of hydrogen needed to create green steel is staggering. Traditionally, fossil fuels have been used to generate almost all hydrogen, therefore finding the necessary amount of decarbonized hydrogen is going to be one of the biggest challenges,” said Francesco Ganda, Technical Lead for Non-Electric Applications at the IAEA.

“Nuclear hydrogen production, with zero emissions, can really be a game changer for the sector, as nuclear power has the potential to provide sufficient heat and electricity 24/7 to produce the required amount of hydrogen. This could help to make huge strides in the clean energy transition.”

Nuclear power reactors coupled with a hydrogen production plant can efficiently produce both energy and hydrogen as a cogeneration system, fitted with components for either electrolysis or thermochemical processes. Electrolysis is the process of inducing water molecules to split using a direct electric current, producing both hydrogen and oxygen.

https://www.iaea.org/bulletin/decarbonizing-steel-production-with-nuclear-hydrogen

Nuclear power is absolutely needed to reach worldwide climate goals, the head of the International Energy Agency (IEA) Fatih Birol said

"Without the support of nuclear power, we have no chance to reach our climate targets on time," Birol told reporters ahead of the Nuclear Energy Summit in Brussels.

"Renewables will play a major role in terms of electricity, especially solar, supported by wind and hydro power. But we also need nuclear power, especially in those countries where we do not have a major renewable potential."

https://www.reuters.com/business/environment/nuclear-power-absolutely-needed-reach-climate-goals-ieas-birol-says-2024-03-21/?utm_campaign=IEA+newsletters&utm_medium=Email&utm_source=SendGrid

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Canadian Nuclear Safety Commission:

Small modular reactors:

On this page

https://nuclearsafety.gc.ca/eng/reactors/research-reactors/other-reactor-facilities/small-modular-reactors.cfm

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Clean hydrogen could help clean up steel industry

21.02.2024

As hydrogen production increases worldwide, some see clean hydrogen as a game-changer when it comes to decarbonizing the steel industry.

Steel production is one of the “hard-to-abate” sectors of industry, which are responsible for about 30 percent of global carbon emissions. These industries are tough to decarbonize because the technologies either do not yet exist or are considered uneconomical.

The issue: The two billion tons of steel produced annually worldwide is responsible for more than 7 percent of carbon emissions. That number is expected to rise substantially in

the coming years as the demand for steel increases due to growing transportation, construction, consumer appliances, and energy needs.

Meanwhile, about 95 percent of hydrogen production in the United States is powered by fossil fuels, according to the Department of Energy.

Hydrogen is produced using electrolysis, which separates hydrogen from the oxygen in water. The process can be done at low temperatures (less than 100°C) or at high temperatures (between 700°C and 800°C) with steam, which requires less electricity.

The solution? The International Atomic Energy Agency has been studying the use of nuclear for hydrogen energy production for several years. The process is expensive, but the price tag is getting easier to swallow as fossil fuel costs rise and global supply becomes less secure.

An IAEA study found nuclear production of hydrogen to be competitive once natural gas prices rise above $20 per million BTUs—which it currently is.

“Nuclear hydrogen production, with zero emissions, can really be a game-changer for the [steel] sector, as nuclear power has the potential to provide sufficient heat and electricity 24/7 to produce the required amount of hydrogen,” said Francesco Ganda, technical lead for nonelectric applications at the IAEA.

“This could help make huge strides in the clean energy transition.”

https://www.ans.org/

https://www.ans.org/news/article-5797/clean-hydrogen-could-help-clean-up-steel-industry/

Office of
NUCLEAR ENERGY

4 Key Benefits of Advanced Small Modular Reactors

28.May 2020

Welcome to the future of nuclear energy.

Within the next 10 years, advanced small modular reactors (SMRs) could change the way we think about reliable, clean and affordable nuclear power.

Instead of going big, scientists and engineers went small developing mini reactors that are roughly a third of the size of a typical nuclear power plant.

That means America's largest clean energy source

could be coming to a market near you—making nuclear more scalable and flexible than ever before.

Here's how they work. : with video and infographic explains how small modular reactors work.

https://www.energy.gov/ne/articles/4-key-benefits-advanced-small-modular-reactors

And a look at these four key benefits to advanced small modular reactors:

SMRs Require Less Prep Time

SMRs Provide More Options

SMRs Are Flexible

SMRs Attract New Business Opportunities

More information :

Advanced Small Modular Reactors (SMRs)

https://www.energy.gov/ne/advanced-small-modular-reactors-smrs

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Steel maker considers use of NuScale SMRs at its mills

16.05.2023

NuScale Power has signed a memorandum of understanding (MoU) with North American steel manufacturer Nucor Corporation to explore the deployment of NuScale's VOYGR small modular nuclear reactor (SMR) power plants at Nucor's scrap-based Electric Arc Furnace (EAF) steel mills.

STEEL NEWS

5/16/2023 - Nucor Corp. and nuclear power plant developer NuScale Power Corp. have signed a framework agreement under which they'll study the possibility of powering Nucor's electric arc furnaces with NuScale's small modular reactors.

Nucor and NuScale said Tuesday that as part of memorandum of understanding between the two, they'll evaluate site suitability, transmission interconnection capabilities and capital costs of building NuScale plants near Nucor's electric arc furnaces. Additionally, they'll study the potential to use Nucor's Econiq net-zero steel in NuScale projects.

"Nucor is committed to supporting the development of transformative technologies that will deploy safe, reliable, affordable, 24/7, base-load carbon-free power, like NuScale's VOYGR small modular reactor plants," said Nucor chairman and chief executive Leon Topalian.

https://www.aist.org/news/steel-news/2023/may/15-19-may-2023/nucor-once-served-the-nuclear-industry-now,-the-in

https://nucor.com/greenhouse-gas-reduction-target-strategy

HATCH

Powering tomorrow's steel mills with nuclear energy

By Raf Hirmiz, Ph.D. | March 23, 2023

As the iron and steel industry moves to decarbonize its processes, a significant amount of carbon-free energy will be required, and nuclear technology is well positioned to be a part of the solution. By becoming an integral part of the steel mill, nuclear technology can be used to provide electricity, steam, and hydrogen, while also powering other GHG-reducing technologies.

An overview of new decarbonization technologies

Many major steelmakers have identified ***direct reduced iron (DRI)*** as a pathway to significantly reduce GHG emissions. DRI utilizes natural gas—and hydrogen as an even lower emission alternative—to directly reduce iron ore without the need for melting. This pathway reduces overall GHG emissions when compared to the blast furnace route, and presents opportunities to further reduce emissions through hydrogen for DRI, electrical steel making, and carbon capture. The supply of emission-free hydrogen for decarbonized ironmaking is often constrained by the amount of clean electrical power for electrolysis.

Traditionally, **basic oxygen furnace** steelmaking is utilized downstream of blast furnaces, in which oxygen is blown through molten iron to produce steel. While minimal electricity is currently required for this process, various DRI-based steelmaking pathways all require significant amounts of electrical energy. This includes the ubiquitous ***electric arc furnace***

(EAF) steelmaking process, as well as the ***Hatch CRISP+ DRI*** melting process, and the ***Hatch CRISP*** direct steelmaking process, which both use ***electric smelting furnace*** (ESF) technology. As such, access to large amounts of reliable, emission-free electrical power is urgently needed to help decarbonize the iron and steel industry.

Small Modular Reactors (SMRs) have been identified as one of the key technologies to aid in the global GHG challenge, with key advantages in reliability, flexibility of location, and scalability.

https://www.hatch.com/About-Us/Publications/Blogs/2023/03/Powering-tomorrows-steel-mills-with-nuclear-energy

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NUWARD™, le SMR développé par EDF pour un monde bas-carbone

Notre conviction est que les petits réacteurs modulaires (SMR) sont appelés à jouer un rôle crucial dans la lutte mondiale contre les effets du réchauffement climatique.

Dans un contexte où de nombreux pays renforcent leurs objectifs de décarbonation afin d'atteindre la neutralité carbone en 2050, **NUWARD™** offre une solution durable pour un accès rapide à une électricité pilotable, compétitive et bas-carbone.

Caractéristiques et principaux avantages

NUWARD™ est une centrale SMR de 340MWe comprenant deux réacteurs indépendants de 170MWe chacun, hébergés dans un bâtiment nucléaire unique permettant ainsi l'utilisation d'équipements mutualisés.

NUWARD™ allie technologies éprouvées et innovation pour gagner en constructibilité, compétitivité opérationnelle et performance environnementale :

- Un réacteur à eau pressurisé de Génération III+ **entièrement intégré**, satisfaisant aux normes de sûreté les plus élevées
- Un design centré sur **la standardisation, la construction modulaire et la simplicité** pour une production de masse en usine, flexible en phase de construction et d'exploitation, conforme aux standards de sûreté de l'Agence internationale de l'énergie atomique (IAEA) et de l'Association des autorités de sûreté nucléaire des pays d'Europe de l'Ouest (WENRA).
- Un design pensé pour favoriser **le suivi de charge** et **adapté aux usages non électrogènes**
- Une solution **complémentaire aux énergies renouvelables** qui vise **le remplacement des centrales à charbon** autour de 300-400 MWe de puissance, **l'approvisionnement en électricité des communes isolées et des sites industriels énergivores**, ainsi que les réseaux aux capacités trop limitées pour les centrales électriques de forte puissance.

https://www.edf.fr/groupe-edf/produire-une-energie-respectueuse-du-climat/lenergie-nucleaire/nous-preparons-le-nucleaire-de-demain/le-projet-smr-nuwardtm/le-projet

https://www.naval-group.com/fr/expertises

https://fr.wikipedia.org/wiki/NUWARD_(r%C3%A9acteur)

See Video

https://www.edf.fr/groupe-edf/produire-une-energie-respectueuse-du-climat/lenergie-nucleaire/nous-preparons-le-nucleaire-de-demain/le-projet-smr-nuwardtm/le-projet

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Midwest Nuclear-based Net-Zero Carbon Steelmaking Demonstration

Steve Chalk, Seth W Snyde

INL/MIS-21-63341-Revision-0

July 2021

Idaho National Laboratory Idaho Falls, Idaho 83415

http://www.inl.gov

https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_47596.pdf

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