ADeKo
Alumninetzwerk Deutschland-Korea
사단법인 한국독일동문네트워크

LSTM Erlangen e.V.

Green Hydrogen

New Sustainable Energy and its Social Impact

5th until 7th October 2022

Nürnberg, Germany

ENERGIE CAMPUS NÜRNBERG

H2.B ZENTRUM WASSERSTOFF. BAYERN

German Engineering Research and Development Center LSTME Busan

Kontaktstelle für Wissens- und Technologietransfer

Welcome greetings

Program Chair and Scientific Director, Board of LSTME e.V., Greeting to Participants

As organizers with the German-Korean Society (ADEKO), the Promotion Association of the Institute for Fluid Mechanics Erlangen (LSTME) e.V. and its Korean twin institute LSTME Busan feel particularly honored to warmly welcome the participants of the DAAD Alumni Conference 2022 "Green Hydrogen - New Sustainable Energy and its Social Impact".

The DAAD (German Academic Exchange Service) is the world's largest funding organization for the international exchange of students and scientists. The motto of the DAAD is "Change by Exchange: Exchange promotes understanding between countries and individuals and helps secure the peace. New scientific findings enable us to meet global challenges".

From a now well-established tradition of cooperation and the strong trend towards innovation that is characteristic of both countries, this DAAD Alumni Conference fits seamlessly into a series of efforts that aim at establishing irreversible pillars of future political and social progress. In the sense of the DAAD`s motto, the exchange between Germany and Korea in education, alumni promotion, science and technology has proven to play the role of a key success factor. This occurs more and more with a focus on joint solutions to global challenges for Humankind.

The security and safety of energy supply is more relevant than ever as a global social and scientific challenge. The current, tragic events have finally unmasked the security of the energy supply. Its ever-present streak of a prime peace-enabling factor is now unveiled. For Humankind, safety of energy means renewable energy sources and sustainable processes.

With green hydrogen technology, this DAAD alumni event is dedicated to an energy carrier and its processing, which is said to have undeniably high potential to contribute to solving global energy challenges both from the perspective of security and of safety of supply. In this thematic field, both Korea and Germany have internationally prominent positions. This will facilitate an indepth scientific-technical exchange in a friendly and, thus, promoting atmosphere that forms the main part of our planned DAAD alumni conference. The state of the art and future unsolved problems in generation of the energy carrier Hydrogen, its storage and transport are going to be elucidated by Korean and German experts. In addition, considerations of the social impact of the hydrate technology not only from a pure point of view of energy safety but also from that of human perception in the Korean and German society promise an exciting exchange of opinions.

As German-Korean research institutions, LSTME eV and LSTME Busan, together with the co-organizer ADEKO, are pleased to contribute to the active exchange and networking between our two countries.

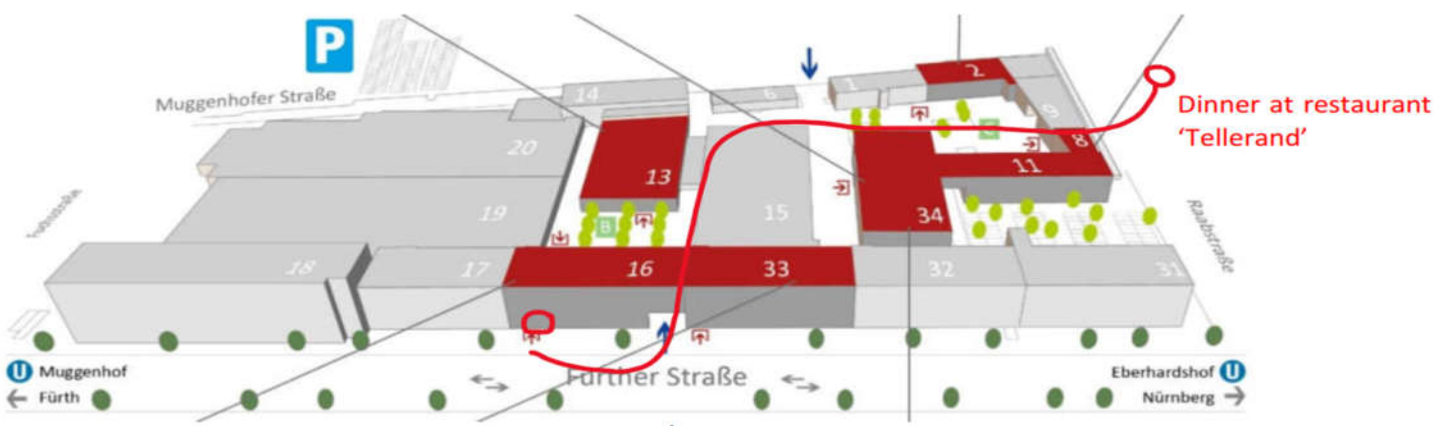
Antonio Delgado, Prof. Dr.-Ing habil.

Chair of the Board of Directors of the Promotion Association LSTM Erlangen e.V. Affiliate Institute to FAU Erlangen, Germany

Title:	**Green Hydrogen – New Sustainable Energy and its Social Impact**		
Date:	2022.10.05-2022.10.07		
Venue:	Energy Campus Nürnberg Fürther Str. 250, 90429 Nürnberg		

2022.10.05 - Wednesday

13:00-13:15	Welcome address – **Prof. Antonio Delgado (LSTME e.V.)**		15 min
13:15-15:00	Congratulatory address and presentation ADEKO – **Prof. Chun-Shik Kim (ADEKO) / Prof. Gi-Eun Kim (ADEKO)**		15 min
	Presentation Energy Campus Nürnberg – **Markus Rützel (EnCN)**		30 min
	Presentation Hydrogen Center Bayern – **Stefan Dürr (H2.B)**		30 min
	Coffee Break		30 min
15:00-17:30	Session 1: Challenges in Hydrogen Generation Chair: Dr. Benedict Prah		
	Impulse talk	**Prof. Stephan Reimelt (Bloom Energy)** Low-cost, clean hydrogen through up-to-date electrolysis as a game changer in joint European-Korean decarbonization and energy security efforts	35 min
	Short talk	**Dr. Hyo-Jin Ahn (LSTME Busan)** Green hydrogen production: Photoelectrochemical water splitting	20 min
	Break		10 min
	Impulse talk	**Dr. Peter Bouwman (Schaeffler)** Hydrogen Challenge: Think Big	35 min
	Short talk	**Dr. Gianluca Pauletto (SYPOX)** Renewable hydrogen from biogas	20 min
17:30-18:30	Break Time		
18:30-21:00	Reception and Dinner		

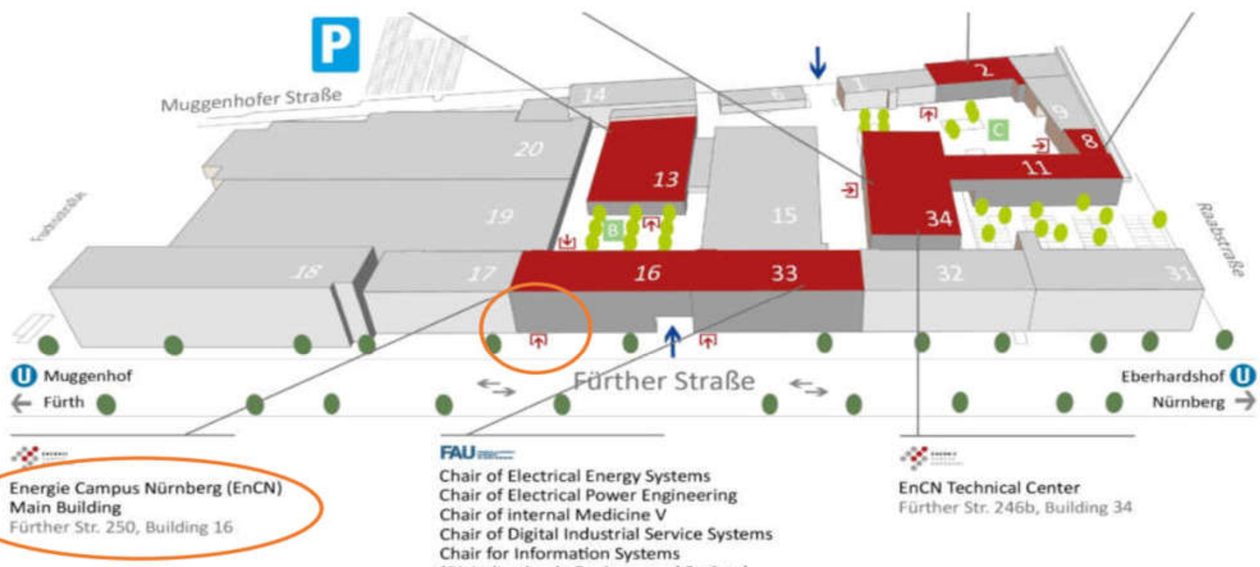


2022.10.06 – Thursday

9:00-12:00	Session 2: Challenges in Hydrogen Generation, Storage and Transport Chair: Dr. Hyo-Jin Ahn		
	Impulse talk	**Dr. Hyung Ju Kim (Green Technology Center Korea)** Strategy for promotion of Hydrogen Eco-system in Korea	35 min
	Short talk	**Dr. Berthold Melcher (Hydrogenious)** Chemical hydrogen storage and transport via LOHC. A technological insight and market outlook	20 min
	Break		10 min
	Impulse talk	**Prof. Patrik Schmuki (FAU Surface Science and Corrosion)** Photocatalytic H2-Generation Based on the Use of Single-Atoms as Catalysts	35 min
	Short talk	**Dr. Siming Wu (FAU Surface Science and Corrosion)** Maximized Photocatalytic H2 Generation Efficiency Using Minimized Amounts of Noble-Metal Single Atoms	20 min
	Break		5 min
	Impulse talk	**Dr. Sangwon Kim (KIST Europe)** Hydrogen Conversion and Energy Storage	35 min
	Short talk	**Dr. Benedict Prah (LSTME Busan)** The Clathrate Pathway to Hydrogen Storage	20 min
12:00-13:00	Lunch		
13:00-15:00	Session 3: Emerging Technologies / Novel Applications Chair: Dr. Vojislav Jovičić		
	Impulse talk	**Erik Zindel (Siemens Energy)** Hydrogen Economy: Emerging Technologies and Novel Applications	35 min
	Short talk	**Dr. Kyung-Won Suh (Hyundai Motor Company)** Hyundai Hydrogen Fuel Cell Technology	20 min
	Break		10 min
	Impulse talk	**Prof. Tim Hosenfeldt (Schaeffler)** Hydrogen for sustainable energy mobility ecosystem	35 min
	Short talk	**Dr. Ana Zbogar-Rasic (FAU LSTM Erlangen)** Hydrogen and Heat Decarbonisation - Challenges of Hydrogen Combustion	20 min
15:00-15:30	Coffee Break		
15:30-16:00	Presentation DAAD: **Dr. Holger Finken (DAAD)**		
16:00-16:10	Break		
16:10-17:30	Industry-Alumni Forum	Small group meetings between conference participants and industry representatives	
17:30-18:30	Break Time		
18:30-21:00	Network Dinner		

2022.10.07 – Friday

9:00-10:20	Session 4: Technology Assessment and Social Impact Chair: Dr. Alexander Jahn		
	Impulse talk	**Dr. Esther Stahl (Fraunhofer UMSICHT)** Origin of Hydrogen	35 min
	Break		10 min
	Impulse talk	**Jan Hildebrand (IZES gGmbH)** Public perceptions of PTX-Technologies in Energy Transition – Reflection of societal concerns and needs	35 min
10:20-10:30	Break		
10:30-12:00	Panel discussion	**Dr. Holger Finken (DAAD) and Prof. Gi-Eun Kim (ADEKO)**	
	Discussion 1: Technical Challenges and Outlook for Hydrogen Technology		40 min
	Break		10 min
	Discussion 2: Social Impact of Green Hydrogen Transition		40 min
12:00-12:05	**Closing address – Dr. Holger Finken (DAAD)**		
12:05-13:00	Lunch		
13:20-17:00	Company tour – Schaeffler Technologies AG & Co. KG Bus pickup at 13:30 behind Energy Campus building		



1 Prof. Stephan Reimelt (Bloom Energy) **Time** 35 min

Title
Low-cost, clean hydrogen through up-to-date electrolysis as a game changer in joint European-Korean decarbonization and energy security efforts

Abstract

2 Dr. Hyo-Jin Ahn (LSTME Busan) **Time** 20 min

Title

Green hydrogen production: Photoelectrochemical water splitting

Abstract

Due to the environmental pollution from the fossil energy such as fine dust pollution, global warming and water pollution, the request for clean energy has gradually increased. The green hydrogen which is produced without carbon dioxide (CO_2) have been received great attention. Until now, the water splitting (electrolysis) by the electrolyzer has been used for green hydrogen production owing to its easy system and high performance. However, the high overpotential for oxygen generation of electrode in electrolyzer is considered main draw back.

Photoelectrochemical (PEC) water splitting is a promising clean energy harvesting system that splits water into hydrogen and oxygen gases by using a solar energy with a low onset potential. The photoelectrodes in PEC system generate the electron-hole pairs (EHPs) which can be participated in water splitting reactions after absorbing the solar energy. Furthermore, photovoltages in the photoelectrode reduce the overpotentials for water splitting reaction.

Herein, we introduce not only the mechanism of the PEC system but also the real experiments of photoanode, consisting of the iron oxide (α-Fe_2O_3). Especially, we introduce the various strategies of surface treatment on hematite to achieve high performance PEC performance.

3 Dr. Peter Bouwman (Schaeffler) **Time** 35 min

Title
Hydrogen Challenge: Think Big

Abstract
Schaeffler is committed to reducing our carbon footprint and investing in hydrogen technologies to harness the power of renewable energy. This presentation will discuss the progress and prospect of the industrial hydrogen business division, delivering hardware solutions to the market in the shortest feasible timeframe. We openly share industrialization challenges, as we need to resolve these together.

4 Dr. Gianluca Pauletto (SYPOX) **Time** 20 min

Title
Renewable hydrogen from biogas

Abstract

5 Dr. Hyung Ju Kim (Green Technology Center Korea) **Time** 35 min

Title

Strategy for promotion of Hydrogen Eco-system in Korea

Abstract

Hydrogen economy has globally become one of the mainstream schemes to achieve carbon neutrality. Hydrogen economy is defined as an industrial and social system which adopts hydrogen and electricity as major energy carriers. South Korea has also focused on securing relevant political and technical infrastructure for the efficient transition from existing fossil fuel economy to hydrogen economy. First of all, South Korea was the first in the world to enact the Hydrogen Act on 4th, Feb 2020, named "Hydrogen Economy Promotion and Hydrogen Safety Management Act", to stipulate the creation of the infrastructure of hydrogen economy. Hydrogen Act consists of 8 chapters defining hydrogen economy system, fostering hydrogen-specialized enterprises, installing supply facilities, and securing safety management and penalty provisions systems. Also, South Korea has focused on developing Hydrogen Economy Roadmap and following 5th National Master Plan for New and Renewable Energy. In addition, South Korea has announced Long-term low greenhouse gas Emission Development Strategies (LEDS) and following carbon neutrality scenarios, which contributed to the introduction of 1st Hydrogen Economy Implementation Masterplan.

While South Korea has shown inspirational accomplishments in securing legal and political system to achieve hydrogen economy, it is necessary to assess the current status of hydrogen value chain in South Korea and suggest potential strategies or policies to further develop. Hence, our research aims to assess hydrogen value chain in South Korea and compare with other major countries including United States of America (USA), European Union (EU), Japan, France, Germany, China, and Australia based on lead market approach to understand the current status of Korean hydrogen value chain and identify room for improvement. In each step of hydrogen value chain (production, storage and transport, and application), we settled six different market advantages and following indicators to deeply assess each value chain considering its own characteristics. The market advantages include price, demand, transfer, export, regulation, and procurement advantage. The result demonstrates that South Korea shows the best performance in hydrogen application, followed by storage and transport, then followed by production. Regardless of higher lead market potentials of hydrogen application and hydrogen storage and transport, more intensive R&D activities are still required to enhance price competitiveness and propagate relevant innovations globally. Also, despite the high demand of domestic hydrogen production, substantial challenge is prognosed in procure renewable energy resource for it.

As it is inevitable to achieve carbon neutrality and transition into hydrogen economy, most of the countries have been competitively participating in accelerating the technology to secure related market. South Korea also has shown noticeable accomplishments in overall infrastructure including policy, law, and technology. However, since the ultimate goal of this movement is to cope with global climate change crisis, international cooperation and joint R&D should be considered as major solutions for bright future.

6 Dr. Berthold Melcher (Hydrogenious) **Time** 20 min

Title

Chemical hydrogen storage and transport via LOHC. A technological insight and market outlook

Abstract

Hydrogenious LOHC Technologies, found in 2013, develops and markets its proprietary LOHC technology. As a spin-off of FAU with now more than 160 employees, it is a living example of the innovative strength of its „Alma mater". The presentation gives an overview of current market needs for a sustainable hydrogen economy and describes the business case and technological background of the LOHC technology. Hydrogenious focusses on benzyltoluene as carrier molecule and offers the whole value chain from catalyst development to project execution and plant operation. There is a missbalance between regions with a high green hydrogen potential and industrial demand centers. Already a cost difference in hydrogen generation of 1-2 $/kg makes long distance transportation economic. Therefore a future hydrogen society needs efficient means of large scale transport and storage of this gas. Here, the LOHC technology forms a missing link, allowing a transformation of the well established and widely available hydrocarbon infrastructure into a future hydrogen transportation network. This game changer in scenario development will be briefly shown in a cost comparison from a third party study with other hydrogen carriers. The third part of the presentation focuses on accomplished small scale demonstration projects in Germany, Europe and US, current industrial scale-up activities in North-Rhine-Westphalia and the Netherlands and future international large scale transport corridors that will facilitate a hydrogen economy. In the end another motor for hydrogen development will be shown, the maritime sector, which fosters innovation with vision and strength.

7 Prof. Patrik Schmuki (FAU Surface Science and Corrosion) **Time** 35 min

Title
Photocatalytic H2-Generation Based on the Use of Single- Atoms as Catalysts

Abstract
Among all production methods for H_2, photocatalysis is certainly a most striking concept – simple, smart, clean. It relies on dispersing a "magic" powder into water and shining sunlight onto the water; this then decomposes to H_2 and O_2. The dispersed powder is neither consumed nor degraded, it is a photocatalyst.

Accordingly, photocatalytic H_2 generation has been a highly investigated topic ever since Fujjshima and Honda (Nature (1992) reported on the use of TiO_2 as a solar-illuminated photocatalyst for splitting water into H_2 and O_2. Generally, in a photocatalytic setting, a semiconductor nanoparticle suspension is illuminated, electron-hole pairs are generated in the semiconductor and react at the semiconductor surface with water to form H_2 and O_2. Nevertheless, when photogenerated electron and hole are transferred from the semiconductor nanoparticle to the aqueous electrolyte, a reasonable electron transfer rate can only be established when a noble metal co-catalyst is attached to the semiconductor. Mostly this is a Pt nanoparticle that is deposited onto the TiO_2 by various reductive treatments.

Over the years numerous efforts have been devoted to the shrinkage of the particle to enhance the utilization of the noble metal. Evidently the most extreme case of shrinkage is the use of a sole single atom (SA) of Pt. The use of such isolated atoms as a co-catalyst in photocatalysis has in recent years attracted strong interest, not only because the single atom state represents a maximized surface to volume efficiency, but also because single atom reactivity allows for unprecedented reaction pathways.

In the presentation we discuss the use of Pt dispersed and anchored as single atoms on TiO_2 nanocrystallites, powders and nanotubes as a co-catalyst in photocatalytic H_2 generation.

We discuss various trapping and stabilization approaches of SAs on photocatalysts and we report on a SA-Pt photocatalyst with a higher photocatalytic activity than observed for classic arrangements of co-catalyst on the semiconductive substrate. Moreover, we show that only a small fraction of the totally deposited Pt provides virtually all photocatalytic reactivity of a Pt decorated photocatalyst.

8 Dr. Siming Wu (FAU Surface Science and Corrosion) **Time** 20 min

Title
Maximized Photocatalytic H2 Generation Efficiency Using Minimized Amounts of Noble-Metal Single Atoms

Abstract
Functionalized semiconductors are the most used photocatalysts and/or photoelectrodes for direct solar water splitting. For an effective utilization of many semiconductors in H_2 generation they need to be functionalized with a co-catalyst. Loading SAs on semiconductors, is a most advanced form of enabling a fast transfer and efficient utilization of photocarriers with maximum atom-utilization efficiency.

In our work, we firstly show that anodic TiO_2 nanotubes present excellent harvesting features for Pt SAs even from a highly diluted Pt solution. Additionally, a saturated SA density (1.4×10^5 Pt atoms μm^{-2}) and a high turnover frequency of 1.24×10^6 h^{-1} can be accomplished with a Pt solution as dilute as 0.01 mM, which also lead to a maximized photocatalytic H_2 evolution efficiency, whereas a higher loading of Pt nanoparticles does not further increase the photocatalytic activity. Then, Pt SA anchoring on fluoride-modified TiO_2 nanosheets has been established using the same deposition method. It shows excellent photocatalytic activity with a remarkably low loading amount of Pt SAs (0.03 wt%), which is far superior to Pt nanoparticles on TiO_2 nanosheet with the same or a higher loading amount. Besides, the Pt SAs on TiO_2 nanosheets also shows excellent photocatalytic stability in long-time photocatalytic reactions. Our findings provide a rational way for the design of stable and active SA catalysts on semiconductors from very dilute Pt solutions, and Pt SAs in turn afford a unique molecular pathway for a maximized photocatalytic H_2 generation activity.

9 Dr. Sangwon Kim (KIST Europe) **Time** 35 min

Title
Hydrogen Conversion and Energy Storage

Abstract
Now we are experiencing climate change of global warming. The main culprit of global warming is the emission of greenhouse gases from the use of fossil fuels. For this reason, efforts are being made worldwide to convert energy sources to renewable energy and hydrogen energy and to achieve carbon neutrality. Renewable energies such as wind and solar power and solar energy are affected by weather and seasons. In order to overcome these limitations and achieve complete energy conversion, a safe and reliable energy storage device is required. As a method of storing surplus renewable energy, there are a method of storing it in the form of electricity and a method of converting it into hydrogen and storing it. As a large-scale energy storage device for linking renewable energy generation and power grids, an eco-friendly redox flow battery with no fire risk is mentioned as a promising candidate. In order to store hydrogen in the form of hydrogen, the water electrolysis method that decomposes water is considered the most environmentally friendly and should be pursued. In particular, hydrogen produced through water electrolysis is called green hydrogen. The Korean government and companies are recognizing the importance of the hydrogen economy and establishing strategies. Korea's hydrogen economy roadmap was published in January 2019. The roadmap aims to produce 6.2 million fuel cell electric vehicles by 2040 and supply more than 1,200 hydrogen charging stations. November 2021. Under this plan, the country will provide 27.9 million MT/year of clean hydrogen by 2050 in green or blue hydrogen excluding gray hydrogen. Hydrogen technology can be categorized into hydrogen production, storage, delivery and use.

This presentation aims to increase researchers' interest and understanding of related research through an overall introduction and explanation of Korea's hydrogen technology and development roadmap, and thereby expand opportunities for future cooperative research.

10 Dr. Benedict Prah (LSTME Busan) **Time** 20 min

Title
The Clathrate Pathway to Hydrogen Storage

Abstract

Hydrogen is considered a promising and innovative clean solution to achieving carbon neutrality in the present climate crisis. In fact, the global demand for hydrogen has been constantly growing with a yearly growth rate of 6.07% and is projected to increase by 80 million tonnes by 2050 (Bundesministerium für Wirtschaft und Energie, 2015). One of the challenges associated with establishing a hydrogen-based economy is the development of energy-efficient hydrogen storage technology with fast and easy charging and discharge rate. Clathrate hydrates of hydrogen offer a novel approach for long-term storage of large quantities of hydrogen at moderate temperature and pressure conditions.

Clathrate hydrates are a solid network of cavities whose frameworks are connected by hydrogen bonded water molecules and stabilized by low molecular weight guest gas molecules (such as CH_4, CO_2, H_2 C_2H_6,); without the gas molecule, the crystal lattice structure would collapse. The main advantage of hydrogen storage in clathrate hydrates is that the storage of H_2 in clathrate hydrates can be applied anywhere, ideally close to the location of H_2 production as only water is needed for its formation. Presently, research is focused on the optimization of formation conditions and cage occupancy of hydrogen gas and thus the storage capacity of clathrate hydrogen hydrate. Potentially, hydrogen hydrates could store hydrogen up to a maximum theoretical capacity of about 5.4% by weight in cavities.

This work presents the fundamental morphology and properties of hydrogen hydrate, and its H_2 storage application and reviews its performance in relation to other storage approaches. While far from being optimized, hydrogen storage in clathrate hydrate may be competitive with the other approaches, due to low energy consumption for charge and discharge, safety, cost-effectiveness and favourable environmental characteristics.

11 Erik Zindel (Siemens Energy) **Time** 35 min

Title
Hydrogen Economy: Emerging Technologies and Novel Applications

Abstract
In order to limit global warming to below 1.5-2 °C above pre-industrial levels, a significant transformation of how energy is being produced, transported, stored and consumed is required. This includes a "defossilization" of our economy and a full elimination of greenhouse gas emissions across all economy sectors and all countries by the mid of the century.
Sector coupling is the key methodology to enable an economy-wide decarbonization across the different economy sectors and describes a closer integration between the energy sector (with access to carbon-neutral renewable energy) and all other sectors in the economy to allow the provision of carbon-neutral energy to all energy-consuming processes in agriculture, industry, mobility, residential and commercial buildings. This sector coupling is usually described as being executed in three phases: Increased widespread electrification, use of hydrogen, and the use of hydrogen derivatives such as e-ammonia or e-fuels where hydrogen limitations kick in. Hydrogen will therefore become a major energy vector in the future and will be one of the key energy technologies that will shape the future of energy.

The presentation covers the main aspects and technologies of decarbonization and sector coupling, followed by a description of some of the most important technologies of the hydrogen economy, especially concentrating on those which are in the portfolio of Siemens Energy. Among these are: PEM Electrolysis, Hydrogen Compression, Power-to-X applications, Energy System Design and Green Energy Certification.
In addition, and to complete the whole decarbonization as well in the energy sector itself, hydrogen fueled gas turbines and combined cycle power plants are required for a deep decarbonization of the power system, where renewable energy will provide the backbone of all energy consumed, and the combined and simple cycle power plants will provide the residual load for periods of low renewable energy production (dark doldrums, i.e. dark wind still periods) as well as provision of decarbonized heat (cogeneration) during residual heat times, enabling large scale and seasonal storage of renewable electricity.
The presentation will conclude with a summary and an outlook on the H2 Academy, a training curriculum currently being developed by Siemens Energy to train its own employees on hydrogen topics, which will also be marketed externally in 2023.

12 Dr. Kyung-Won Suh (Hyundai Motor Company) **Time** 20 min

Title
Hyundai Hydrogen Fuel Cell Technology

Abstract
According to the IPCC (Intergovernmental Panel on Climate Change) report published last year, we must stop carbon emissions from rising further starting from today if we are to maintain the temperature increase level at 1.5℃, as promised in the Paris Agreement. Not only has the public a heightened sense of emergency, but governments worldwide are taking action by implementing regulations and legislations, green technologies and renewable energy sources are gaining more traction, accelerating investments in related areas and their growth. Based on this consensus, starting with major countries, nations across the globe are announcing their commitment to carbon neutrality, as well as their concrete plans to achieve it, taking into consideration their key industries and other criteria.

In order to achieve carbon neutrality, we must reduce our dependence on carbon-based energy. The expansion of power generation based on renewable energy sources is being considered as a key factor in achieving this goal. However, the intermittency of renewable energy sources and regional differences create an imbalance in energy demand and supply, which requires a solution.

In this context, hydrogen is gaining traction as it is easier to store in large quantities over extended periods of time than other energy sources. We can take advantage of this property to use the surplus power from renewables for electrolysis and store energy in the form of hydrogen, which in turn will be transformed into electricity using fuel cells, ultimately resolving the imbalance in renewable energy demand/supply. Hydrogen can also mitigate regional differences, as it is a form of energy that can be transported over long distances through tube trailers and pipelines.

Hydrogen is widely known as a power source in the mobility area, but it should be recognized as a clean energy solution. Building a clean hydrogen society revolving around hydrogen energy supposes the existence of a value chain that spreads across a country's key industries, from the production of energy to its storage, transportation, supply, and utilization. This means it cannot be realized through the efforts of one company or institution alone. Therefore, exchanging extensive experience and networking will help German and Korean companies and institutes leading hydrogen society.

13 Prof. Tim Hosenfeldt (Schaeffler) **Time** 35 min

Title
Hydrogen for a sustainable energy mobility ecosystem

Abstract
CO_2-neutral mobility requires the provision of CO2-neutral energy and thus a transformation of the energy chain from fossil fuels to renewable energy sources. Supported by the German and European hydrogen strategies, the demand for green electricity and hydrogen will increase accordingly. There are several ideas for future mobility, in dependence of the vehicle weight or driving distance. Hydrogen is one essential way for a CO_2-neutral and sustainable energy mobility ecosystem and makes it an integrative part of the sustainability efforts. This comprises the conversion of regeneratively generated electricity into green hydrogen as a carrier for fuel cell electric vehicles.. Defossilization of the energy chain requires increased industrialization of components for electrolysers and metallic bipolar plates, strategic components of fuel cells. For new and innovative hydrogen products, the selected materials need to fulfil the increased requirements and stand in balance of efficiency, costs, availability, and sustainability at the same time. Exemplarily, electrochemical cells need to be mechanically stable, reduced in both the CO_2 footprint and in costs by significantly reducing the precious metal share. Therefore, an efficient use of precious materials with high costs and CO_2 footprint is essential. Material and surface technology as well as electrochemistry is highly important for the hydrogen product portfolio and will be the key technologies for a sustainable and CO_2-neutral mobility regardless of the powertrain concept.

14 Ana Zbogar-Rasic (FAU LSTM Erlangen) **Time** 20 min

Title

Hydrogen and Heat Decarbonisation: Challenges of Hydrogen Combustion

Abstract

Global efforts to decarbonise energy systems have been so far largely focussed on reducing emissions in the electricity sector, while less progress has been made in reducing emissions associated with heat. However, the heating in residential sector and in industry accounts for more than 50% of the EU energy consumption and leads to approx. 30% of the energy-related CO_2 emissions. Residential heating in EU is dominated by fossil fuels, while the ratio of renewable energy within district heating in Europe varies between ca. 70% in Sweden and less than 2% in the UK. On the other hand, more than 80% of houses in the UK and the Netherlands use in-house gas boilers. To reach the 1.5 °C -target, natural gas consumption in buildings in EU has to be reduced for 42% by 2030 in comparison to 2015.

Hydrogen is a promising, zero-carbon alternative to natural gas. It could play a role in some of the routes for heat decarbonisation, as it can help in achieving internationally set climate goals. It benefits are that it can be produced from a range of resources and technologies, it can be stored for long periods, transported in a stable way, and used within existing infrastructures. However, as a complete transition to hydrogen would require production of huge quantities of green hydrogen and a significant supply chain adjustment, literature indicates that combination of electricity driven heating (i.e. heat pumps) and hydrogen would help keep energy supply and demand in balance.

As a fuel, hydrogen has different physical and chemical characteristics compared to natural gas. Hydrogen flame is approximately eight times faster compared to methane flame, thus is the flame stabilisation one of the key topics to consider when designing a hydrogen burner. While up to 20% hydrogen-addition to the existing gas network would not demand significant changes of devices already in use, the addition of higher amounts of hydrogen would require new burner head designs. Currently, market does not offer a reliable 100 %-hydrogen burner for household heating, although such burners are claimed to be under testing.

In the scope of this work, activities of LSTM-FAU in hydrogen combustion are presented: development of a volumetric ceramic (porous) burner and an additive manufactured micro-jet burner suitable for hydrogen combustion, numerical analysis of hydrogen jet flames and numerical analysis of a thermal oil boiler integrated with a hydrogen burner.

.

15 Dr. Holger Finken (DAAD) **Time** 35 min

Title
A New DAAD Programme: ERA Fellowships Green Hydrogen

Abstract
ERA Fellowships Green Hydrogen, a new DAAD special programme funded by the German Federal Ministry of Education and Research (BMBF), is to accompany the National Hydrogen Strategy of BMBF in the context of the European Agenda Process on Green Hydrogen. The latter is a pilot initiative of the European Research Area (ERA). The programme is intended to identify and develop young experts in the field for research and teaching, in universities and both public and private research institutes in Germany, ERA countries and beyond. Simultaneously, current fellows as well as alumni shall be integrated into international expert networks.

The programme will commence with a consultation process between experts from the existing agenda process network in 2022 and early 2023. DAAD alumni with suitable expertise will be integrated into the networks in this phase. The consultation process shall create four working groups for the four areas of the agenda process:

- Production
- Transport and infrastructure
- Market stimulation
- Cross-cutting topics: regulations, socio-economic and legal environment

About 200 fellowships of 1-24 months length shall be awarded between 2023 and 2025. Master students, PhD students and postdocs will be given the opportunity to study and do research on cutting-edge problems of green hydrogen, to integrate into the four working groups, and to network between themselves. Financial support will be made available for

- Periods of study and/or research in ERA countries (outgoers) or Germany (incomers)
- Internships
- Summer schools
- Conference travel

DAAD alumni with expertise and current research in green hydrogen shall be included in the programme network on a global basis.

16 Dr. Esther Stahl (Fraunhofer UMSICHT) **Time** 35 min

Title
Origins of Hydrogen

Abstract
The presentation gives an introduction over current utilization and needs of hydrogen, historical use and future applications. In addition, an overview over principles of hydrogen generation and different "colors" of hydrogen is given. Potential transformation pathways towards green hydrogen are discussed.

Hydrogen is one of the central building blocks for a successful energy and raw materials transition. Produced CO_2 -free, it is an energy carrier and storage medium for renewable electricity, a key raw material for defossilized industrial processes, and an important emission-free fuel in the mobility sector. There is no alternative to the production and use of hydrogen to significantly reduce greenhouse gas emissions on the way to climate neutrality by 2045. This requires adapted regulations, new or adapted technologies, and new business models. Even though the general feasibility of hydrogen technologies has been demonstrated in many areas, broad and large-scale application in real-world environments as well as in new smaller, decentralized applications is often yet to come. This is a huge challenge because it is a holistic transformation. At the same time, it is a great opportunity for companies, policymakers and society to actively shape this transformation and open up new technologies and applications.

In the production of hydrogen, a fundamental distinction can be made between the thermochemical conversion of hydrocarbons (especially methane) and water splitting (electrolysis), with the thermochemical processes and in particular the steam reforming of natural gas predominating. In 2019, 69 million tons of hydrogen were produced from natural gas worldwide. This corresponds to 59% of the total hydrogen production[1] . Another process is the water gas shift reaction to reduce the CO content in syngas while producing hydrogen. Finally, hydrogen can be produced electrochemically by splitting water. Water electrolysis is the most important process here.

To achieve national and European climate targets, the production and use of CO_2 -free hydrogen, in particular green hydrogen, is being targeted. Nevertheless, it is clear that the development of the corresponding electrolyzer capacity can only take place gradually. In order to achieve a fast and cost-efficient market ramp-up, the necessity of using gray (from natural gas), blue (natural gas + CCS) and turquoise hydrogen (pyrolysis of natural gas and C storage) as transitional solutions is formulated. On the other hand, however, lock-in effects should be avoided, which arise when new infrastructures are built for the production of blue hydrogen in particular, which would delay a long-term transformation to hydrogen from renewable energy sources. The question of which hydrogen sources to take on the path to fully green hydrogen is still open in this context.

17 Jan Hildebrand (IZES gGmbH) **Time** 35 min

Title
Public perceptions of PTX-Technologies in Energy Transition – Reflection of societal concerns and needs

Abstract

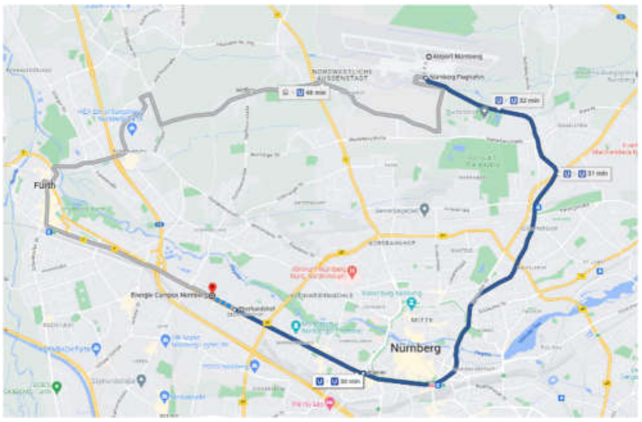
The change to a hydrogen (H2) based economy by using different power-to-x technologies are seen to be a promising pathway for a sustainable transition of the energy system in industrialized countries. Power-to-x technologies offer a solution to how sustainable energy is transformed into hydrogen or synthetic gas which respectively can be transferred into the different sectors of application like mobility, industry, or chemical products. Besides technological and economical challenges, the public acceptance of power-to-x technologies and products is one key success factor for the further diffusion towards a sustainable hydrogen-based economy.

The presentation provides an overview on relevant acceptance levels and factors in this context and focuses on the public acceptance of power-to-x pathways in Germany. Therefore, key findings of recent studies are presented. Following an environmental psychological research concept, relevant factors influencing public acceptance such as social and personal norms, environmental awareness as well as openness to innovation, are analyzed. Additionally, as recent protests for more sustainability led by young people have increasingly occurred, one presented study addresses the perspective of the younger generation and compares their perceptions to those of an elder generation. For this purpose, a representative sample of youth (16-25 years old) and adult (>25-years old) people were surveyed with an online questionnaire.

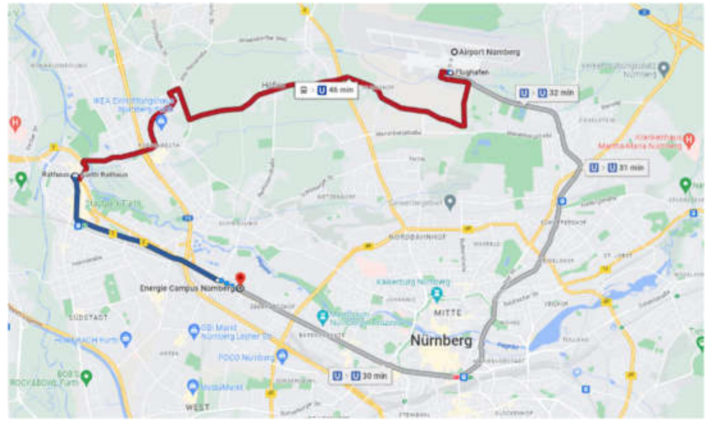
Results show on the one hand a relatively low degree of existing knowledge towards H2 and power-to-x technologies, on the other hand, a rather positive estimation about their potential for decarbonization. These findings indicate that people see the principal potential of H2 and power-to-x technologies for supporting the energy transition, as the perceived ecological impact in a sense of reducing CO_2 emissions turns out to be the strongest significant predictor for acceptance. For the future development of a hydrogen economy, these positive expectations mean on the one hand a very good starting situation, and on the other hand there is a corresponding obligation to meet these expectations and to be evaluated by them.

Guide to reach conference location from Nürnberg airport and Nürnberg central station

From Nürnberg airport to Conference Location - Energie Campus Nürnberg



Subway Option



City Bus and Subway

Subway Option

08:12 **Airport Nürnberg**
Flughafenstraße 100, 90411 Nürnberg, Deutschland

08:12 **Nürnberg Flughafen**

U2 Nürnberg Röthenbach
16 min (10 Zwischenstopps)

08:14 Nürnberg Ziegelstein
08:16 Herrnhütte
08:18 Nordostbahnhof
08:19 Schoppershof
08:20 Rennweg
08:22 Rathenauplatz
08:23 Wöhrder Wiese
08:25 Nürnberg Hbf
08:26 Opernhaus

Betreiber: VGN

08:28 / 08:33 **Plärrer**

U1 Fürth Hardhöhe
5 min (4 Zwischenstopps)

08:34 Gostenhof
08:35 Bärenschanze
08:36 Maximilianstr.

Betreiber: VGN

08:38 **Eberhardshof**

Zu Fuß
ca. 4 min,350 m

08:42 **Energie Campus Nürnberg**
Fürther Str. 250, 90429 Nürnberg, Deutschland

City Bus and Subway

08:11 **Airport Nürnberg**
Flughafenstraße 100, 90411 Nürnberg, Deutschland

Zu Fuß
ca. 1 min,27 m

08:12 **Flughafen**

33 Fürth Hauptbahnhof
28 min (20 Zwischenstopps)

08:13 Nürnberg Cargo-Zentrum
08:15 Nürnberg Flughafenstr.
08:16 Nürnberg Am Bäumling
08:17 Nürnberg Lohe
08:18 Nürnberg Almoshof Schule
08:19 Nürnberg Almoshof
08:20 Nürnberg Johann-Sperl-Str.
08:23 Nürnberg Am Wegfeld
08:25 Nürnberg Wehrenreuthweg
08:26 Nürnberg Seeweg
08:27 Nürnberg Höfles Ost
08:28 Nürnberg Höfles West
08:30 Ronhof Jenaer Str.
08:31 Poppenreuth Erfurter Ring
08:32 Ronhof Steingartenweg
08:33 Dieselstr
08:34 Hans-Vogel-Straße
08:35 Poppenreuther Brücke
08:37 Fürth Poppenreuther Str.

Betreiber: VGN

08:40 **Fürth Rathaus**

Zu Fuß
ca. 1 min

08:47 **Rathaus**

U1 Nürnberg Langwasser Süd
6 min (4 Zwischenstopps)

08:48 Fürth (Bayern), Hauptbahnhof
08:50 Jakobinenstr.
08:51 Stadtgrenze

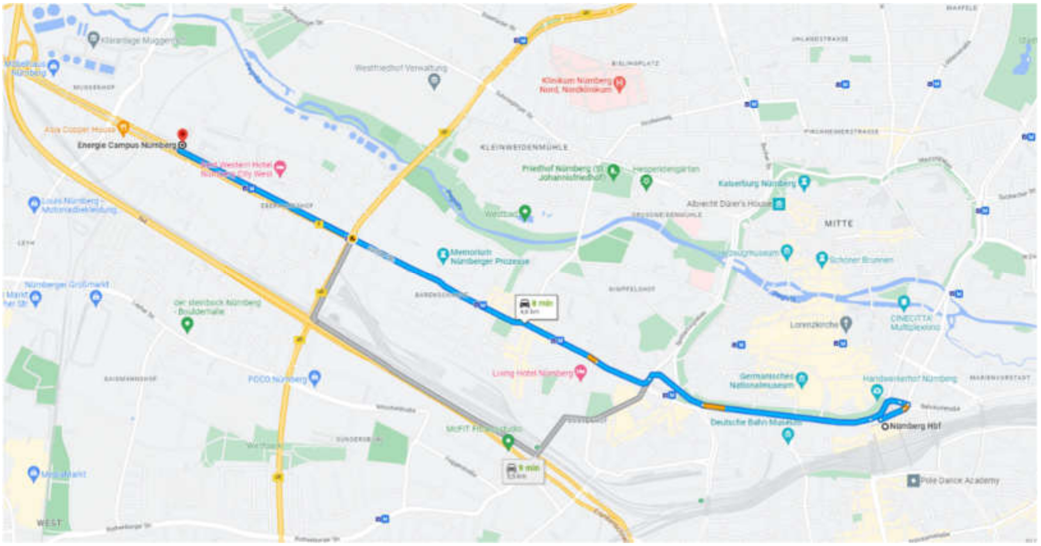
Betreiber: VGN

08:53 **Muggenhof**

Zu Fuß
ca. 4 min,350 m

08:57 **Energie Campus Nürnberg**
Fürther Str. 250, 90429 Nürnberg, Deutschland

From Nürnberg central station to Conference Location - Energie Campus Nürnberg



Subway Option 1

08:08 **Nürnberg Hauptbahnhof**
Bahnhofspl., 90443 Nürnberg, Deutschland

08:08 **Nürnberg Hbf**

U1 Fürth Hardhöhe
10 min (7 Zwischenstopps)

08:10 Lorenzkirche
08:11 Weißer Turm
08:13 Plärrer
08:14 Gostenhof
08:15 Bärenschanze
08:16 Maximilianstr.

Betreiber: VGN

08:18 **Eberhardshof**

Zu Fuß
ca. 4 min,350 m

08:22 **Energie Campus Nürnberg**
Fürther Str. 250, 90429 Nürnberg, Deutschland

Subway Option 2

08:05 **Nürnberg Hauptbahnhof**
Bahnhofspl., 90443 Nürnberg, Deutschland

08:05 **Nürnberg Hbf**

RE10 (58208) Würzburg Hbf
5 min (ohne Zwischenhalt)
Betreiber: DB Regio AG Bayern

08:10 **Fürth(Bay)Hbf**

Zu Fuß
ca. 1 min

08:13 **Fürth (Bayern), Hauptbahnhof**

U1 Nürnberg Langwasser Süd
5 min (3 Zwischenstopps)

08:15 Jakobinenstr.
08:16 Stadtgrenze

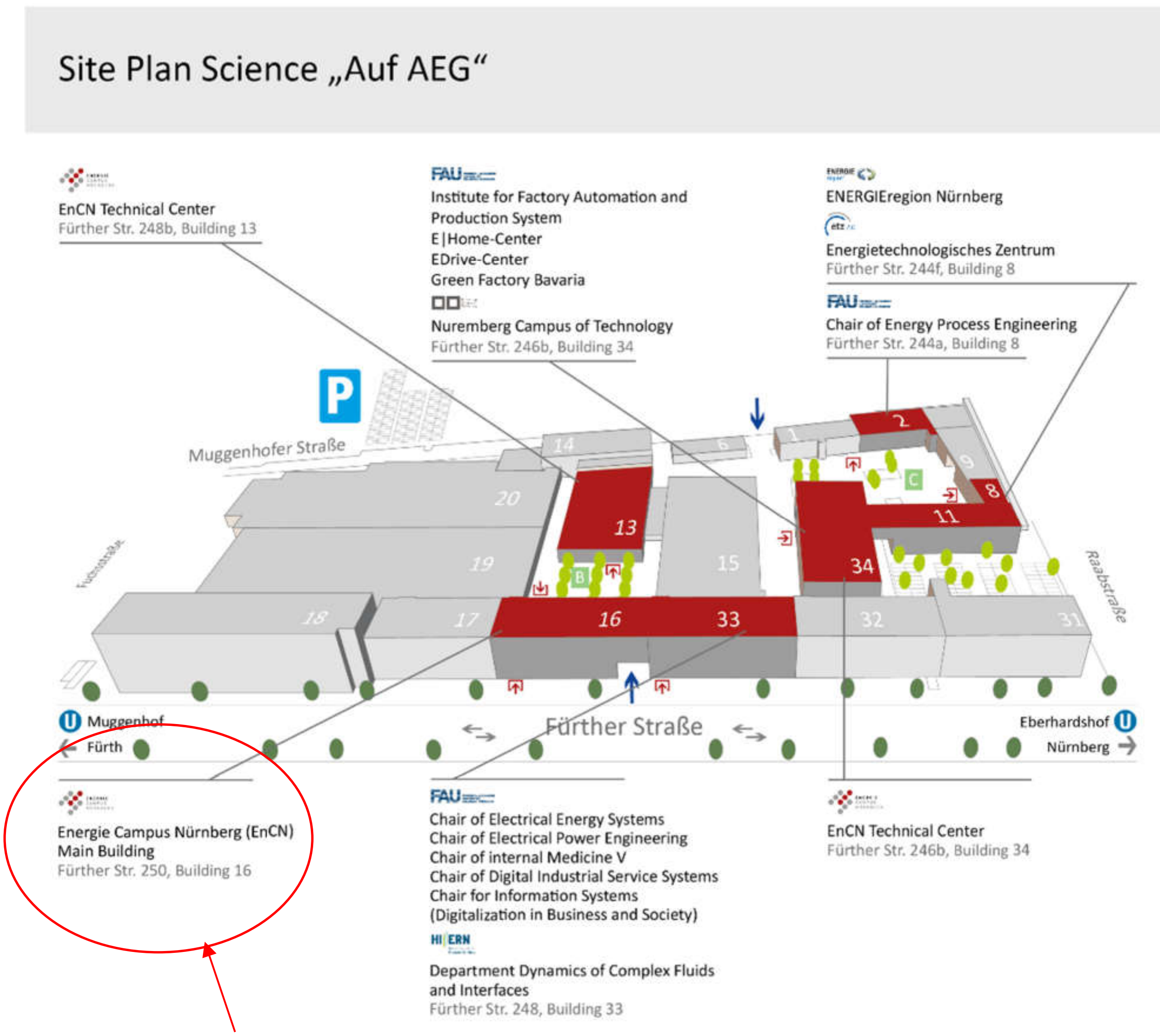
Betreiber: VGN

08:18 **Muggenhof**

Zu Fuß
ca. 4 min,350 m

08:22 **Energie Campus Nürnberg**
Fürther Str. 250, 90429 Nürnberg, Deutschland

Location – Energie Campus Nürnberg



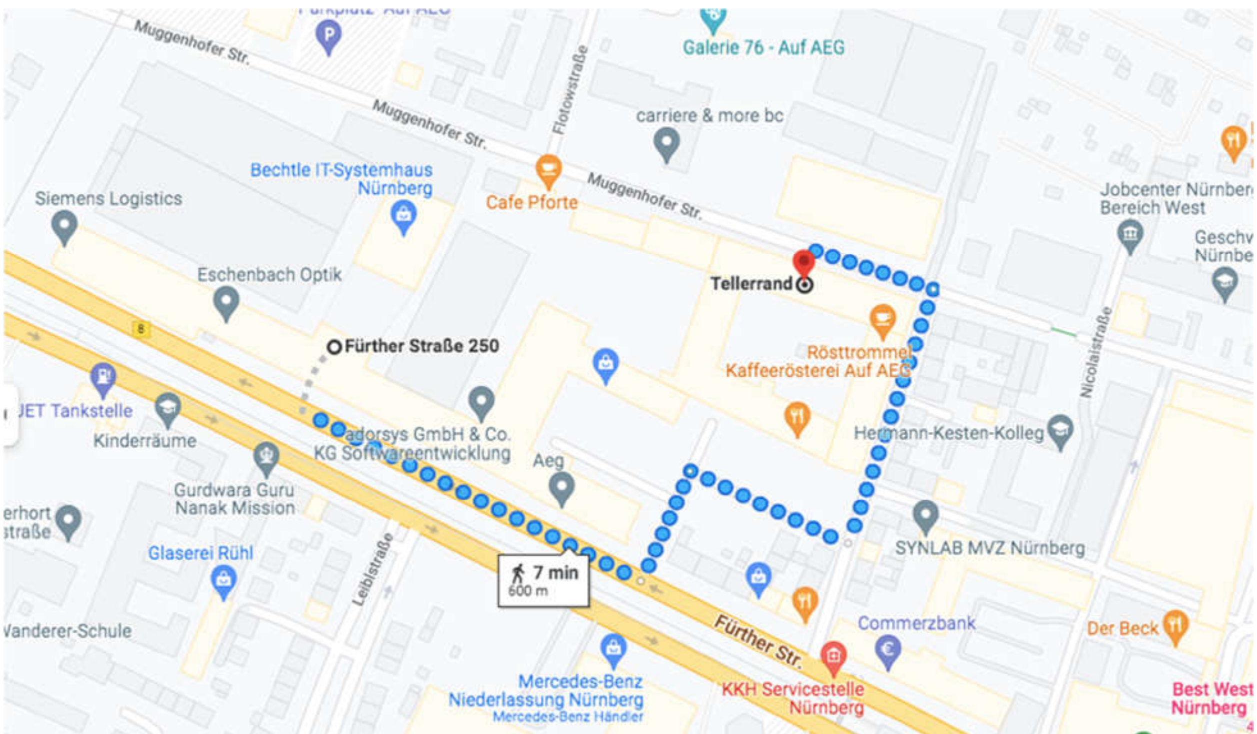
Conference Location

Location – Cafeteria (Lunch)

EUREST Deutschland GmbH
Fürther Straße 246 | 90429 Nürnberg

Location – Restaurant Tellerrand (Dinner)

TELLERRAND



Tellerrand

Fürther Str. 244d | 90429 Nürnberg

Company Tour - Schaeffler Technologies AG & Co. KG

Information for the company tour

- 1:30 pm Bus pick up behind Energie Campus Nürnberg, Fürther Str. 250, 90429 Nürnberg Company Tour at Schaeffler Technologies AG & Co. KG, Industriestraße 1-3, 91074 Herzogenaurach, in groups of 8 participants.
- Please bring your identification card/passport.
- The company tour will last until around 4 pm. Afterwards Schaeffler Technologies AG & Co. KG will offer coffee and cake.
- Bus transport back at around 4:30 pm to Energie Campus Nürnberg, Fürther Str. 250, 90429 Nürnberg.