



NET ZERO

INNOVATION HUB FOR DATA CENTERS

www.netzerodatacenters.com



Whitepaper

Contents

- **Summary**
- **The Hub at a glance**
- **Key challenges**
- **Value proposition**
- **Collaborative principles**
- **Our Net Zero scope**
- **What we do and what we don't**
- **Case 1: Heat recovery innovation project**
- **Case 2: Grid support and energy storage**
- **Organisation**
- **Comparison to other initiatives**
- **Location**
- **Contact**
- **Appendix**

Summary

A Net Zero Innovation Hub to accelerate the European data center industry towards a net zero future

Data centers are a cornerstone of the modern, knowledge-based society. Therefore they must also be part of the solution for a zero carbon economy.

The Net Zero Innovation Hub for Data Centers addresses three key opportunities in the effort to speed up the industry's race towards net zero.

Demands and expectations for a net zero industry

Data centers are facing increased public scrutiny and political awareness. More demands and legislation is expected over the coming years, that will influence the development and operation of data centers dramatically.

Systemic solutions to 'wicked' challenges

The need for a rapid societal transition into a zero carbon economy also concern data centers. But the industry faces challenges that cannot be solved by individual corporations alone. Lowering energy consumption, increasing efficiency, heat reuse and grid balancing, back up energy supply, security issues all require a systemic approach to be solved and secure a bright future for data centers in Europe.

A melting pot for innovative, scalable and rapid solutions

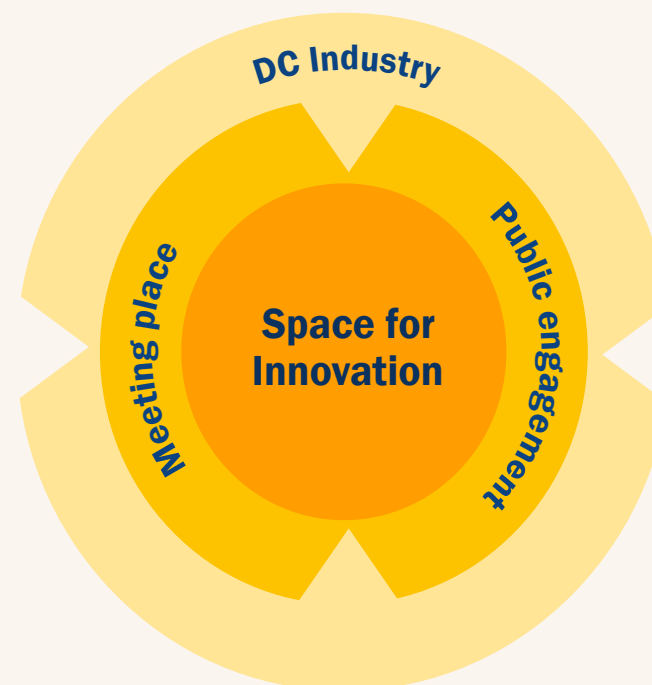
The Hub offers a joint setup for European data center operators and suppliers to address key challenges in a systematized methodology, scale the solutions to the whole industry, and present them to the public. Thereby facilitating a faster way to net zero for the industry.

The Hub at a glance

The three pillars of the Hub

The Net Zero Innovation Hub For Data Centers addresses key sectoral challenges in concrete innovation projects, and establishes a stronger link between operators and suppliers and the intergovernmental level, acting as a gateway for innovation and public advocacy in Europe.

In short, flipping the mindset across industries and inviting adversaries to become partners.



Space for innovation

The Hub will set up innovation programs together with academic partners and industry start-ups, by identifying concrete challenges and facilitate calls and innovation projects to deliver solutions. The Hub will oversee separate entity work packages and help qualify and connect the projects being carried out autonomously, while also assisting in securing EU and national funding.

Projects will be based on shared guidelines, such as:

- Clear problem definition
- Speed to market - rapid project development
- Shared risks and rewards between owners

A pan-European meeting place for industry partners

Fostering knowledge sharing in a concrete, physical setup allows the best practice to flow freely between collaborators and members. The physical meeting space provides the backbone office for the Hub and the essential common, neutral meeting ground for industry partners, public officials and the public at large.

Activities include:

- Repeating events for members
- Public debates and demonstrations of new solutions
- Office hub – members will have access to a number of office spaces to promote cross sector collaboration

Platform for public engagement

The Hub will work towards creating a stronger link between data center operators and the greater public – thereby lowering risks and frictions in the construction and development phase through securing a higher legitimacy and acknowledgement of data centers in the public and on policy level.

Activities include:

- Collect and develop break-through knowledge and distribute to members,
- Monitor EU policy initiatives and coming trends.
- Work together with relevant industry associations

Key challenges

Internal and external drivers for a joint, systemic pan-european data center innovation approach

The Data center industry faces increasing internal and external demands, that can hardly be solved individually.

Internal drivers

- Increasing regulatory demands and public scrutiny
- Sustainability policies and ESG reporting
- Cost reduction in lowering energy consumption
- Overall lowering of OPEX and CAPEX expenditures
- Infrastructure security



External drivers

- Energy crisis throughout Europe
- Rising electricity prices
- Increasing public awareness ecological and geographical footprint
- Energy consumption
- Energy efficiency
- Energy storage
- Heat reuse
- Grid balancing

What is in it for our partners?

The journey towards net zero data centers begins with solving the complex challenges in specified project domains, to support the whole data center industry, securing future opportunities in the market. The Hub offers a three-fold value proposition to the partners:



1. Faster to Net Zero

An accelerator for the industry to speed up decarbonization - by engaging and collaborating with vital stakeholders through public-private collaboration and partnerships.



2. Pan-European Cross-sector collaboration

A European wide initiative, harvesting experiences throughout the region, and developing scalable solutions.



3. Influencing policy agendas on energy efficiency & sustainability

Establishing close ties to European partners to tap into knowledge and policy development but also influence the debate and solutions proposed.

Collaborative principles

The principles for collaboration is the base for a succesful partnership

The Hubs strategic outset is based on OECD's principles for succesful partnerships; bringing all relevant partners together; with equal rights in the forum; equal ownership to overall agenda; and a local approach to concrete projects and solutions. This is translated into three principles for collabration based on best practice and insights from leading hubs.

1. Net zero innovation first

All projects and collaboration must aim to reduce emmissions and accelerate the path towards net zero data centers.

2. Set common long-term objectives

Secure mutual interests which are aligned by identifying common objectives and goals in all partnerships from the start.

3. Centralize strategic partnerships, localize project partnerships

Projects that are shared by all members will be run out of the Hub, other more specified projects will be led by members or local partners, with the Hub acting as a gateway to knowledge, network and sparring.

The principles are deployed across the development model as illustrated.



Four examples of potential collaboration projects in the Net Zero Innovation Hub

Innovation, development and test of...

- **Data Centers' interaction with public infrastructure**
This could be reuse of excess heat from datacenters or grid balancing arrangements or energy storage solutions.
- **Environmentally friendly solutions**
This could be with respect to noise emissions and air pollution from data centers.
- **Arrangements where the data center interacts with public activities. Could data centers be regenerative?**
This could be use of surrounding green areas for i.e. grassing sheep or development of data center designs where public activities can be allowed very close to the actual data center construction (i.e. near waste to energy plants).
- **Internal data center solutions that contributes to a more efficient operation.**
This could be optimization algorithms between internal air flow, chilled water temperature and condensing temperature on chillers

What we don't do:

- **Vendor specific testing, marketing or advertising towards operators.**
- **Innovation, development and test of individual technical components, our suppliers do that.**
- **Direct lobbying activities**



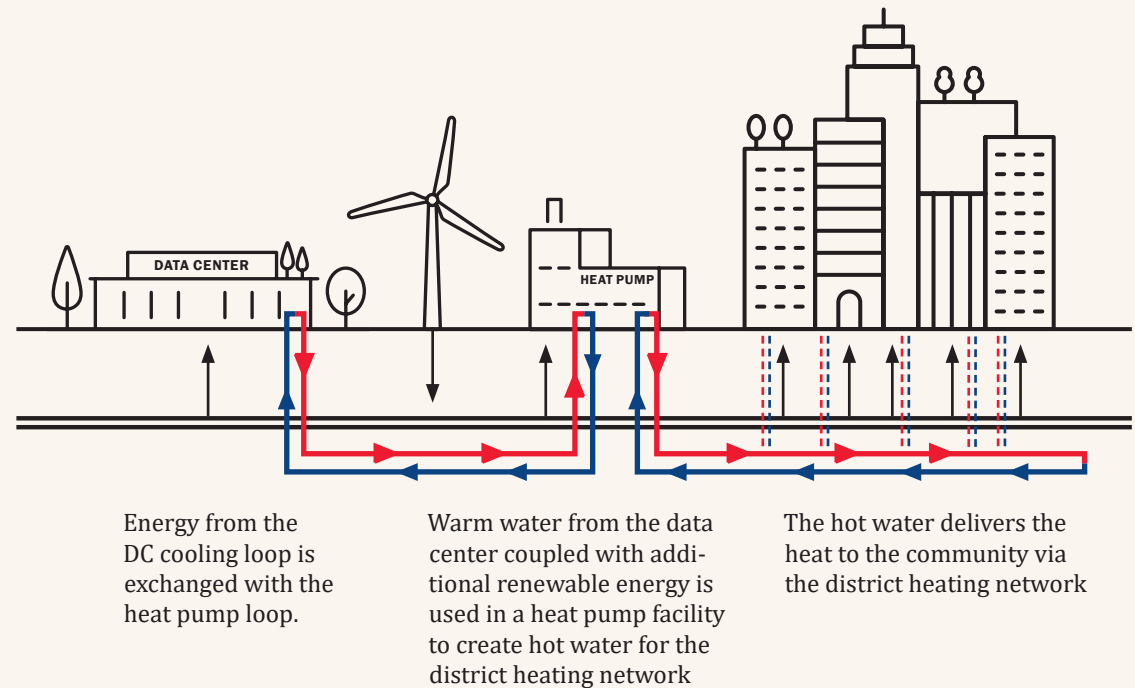
Case 1

Heat recovery innovation project

Heat Recovery and grid balancing pose significant challenges to data centers across Europe. A first program in the Hub could address this issue in the following manner:

Why:

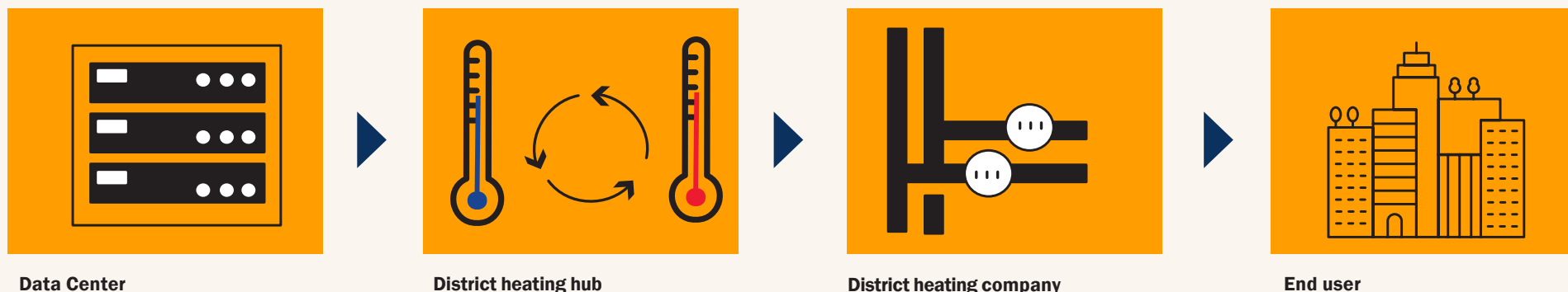
- Taps directly into any Net Zero strategy
- The tax on excess heat based on electricity has been lifted in beginning of 2022 in Denmark.
- The EU Taxonomy urges companies to report their environmentally sustainable economic activities. Energy is a scarce commodity.
- The data center sector in the European Union is expected to undergo new and rigorous directives (EED) and potentially regulations intended to reduce their carbon emissions. A directive for reuse of heat from DCs is launched as of september 2022.



Participants

- | | |
|-----------------------------------|-----------------------------|
| • Net Zero Innovation Hub members | • Energy planning companies |
| • District Heating Networks | • Balance Responsible Party |
| • National Energy Department | • Universities |

Case 1: Heat recovery innovation project



(Some) Key questions to be addressed:

- How to implement reuse of excess heat into the design of new and existing DC's if reliability is not to be compromised?
- Can load shifting go hand in hand with heat reuse?
- Is reuse of excess heat a sound investment?
- Standard conditions between a DC and a district heating company ?
- How to optimise DC and district heating efficiencies?
- What to look for during DC site selection to exploit reuse of heat ?
- Should a DC choose to deliver low temperature excess heat or produce high temperature district heating ?
- A screening tool to evaluate the business case for reuse of heat from a data centre ?

Funding

- Regional Funds
- EC – could be under the recently launched call for: “Synergies between Data Centers and Energy Systems”
- National Energy departments
- Net Zero Innovation Hub

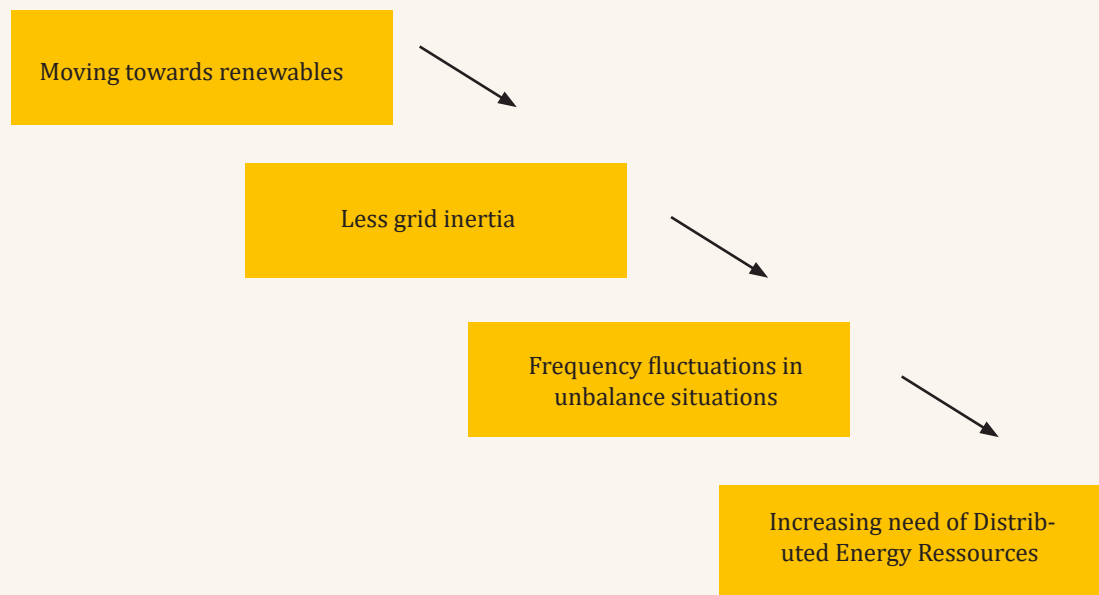
Case 2

Grid support and energy storage through optimisation of ancillary services

The number of data centers are increasing and will continue to do so in the coming years, as well as the need for grid services. What if we could utilize the energy storage in data centers for building the new electric world?

Why:

- A major challenge for continued adoption of Renewable power is grid stability. Grid support features are bringing data center storage capacity in play as part of the solution.
- Grid support has a high financial value. Projections suggest that future data centers will reduce their TCO with 30% by participating in grid support programs.
- Regulation is being considered to incentivize grid support.
- Grid support programs are relevant for small and large data centers.



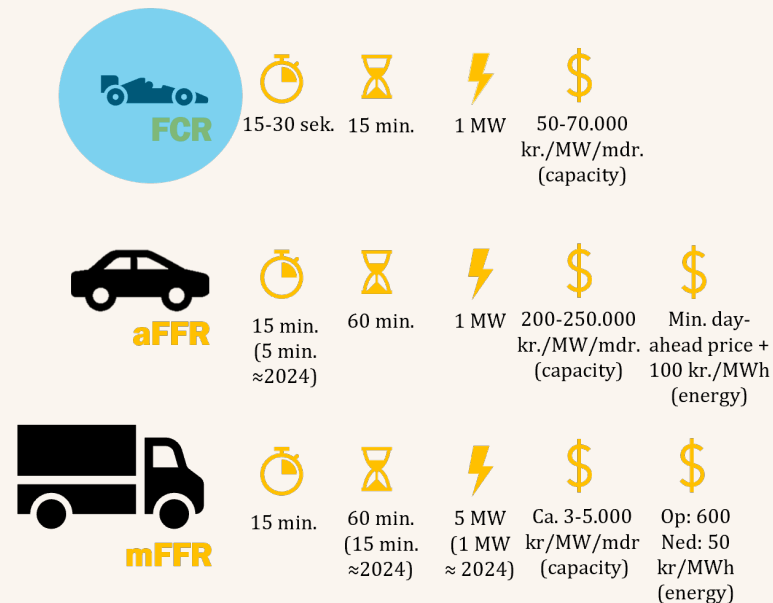
Participants

- | | |
|--|-------------------------------|
| • Net Zero Innovation Hub members | • Balance responsible parties |
| • Energinet, Fingrid, Statnett and Svenska | • Universities |
| • Energy planning companies | • Battery producers |

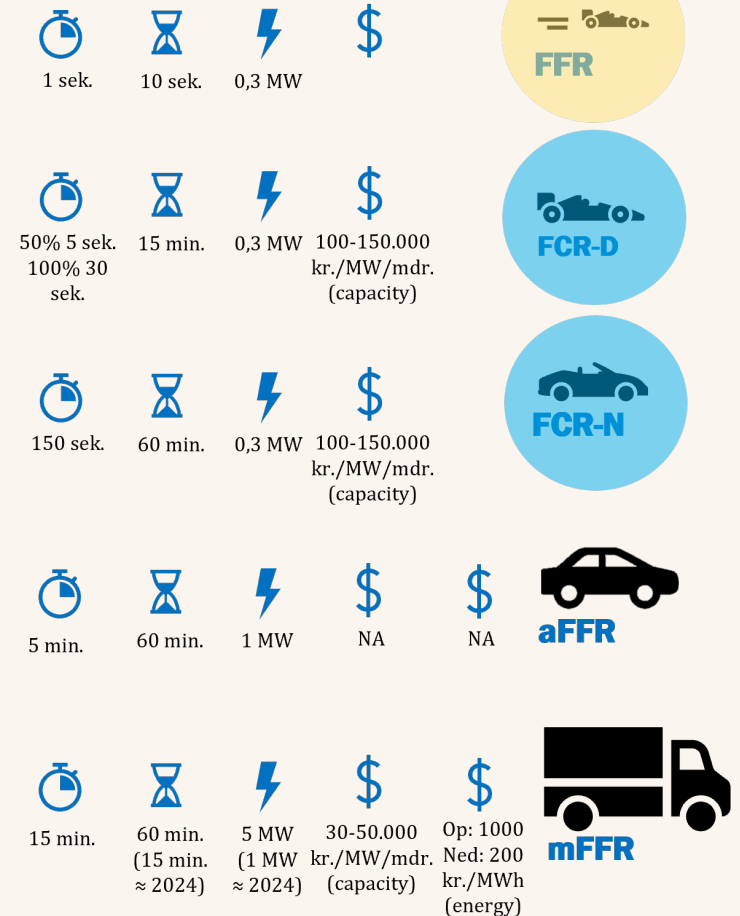
Case 2: Grid support and energy storage



Present situation



Stage 2



(Some) Key questions to be addressed:

- Standardization of grid support services?
- How to setup the country/European market place? Players, split of roles and value creating/benefit harvest
- How can data centers maximize their participation while keeping their resilience in good shape?
- How do we ensure cyber security, when connecting it all?
- How do we streamline the design, setup and approval process of a data center with grid support participation?
- Mapping of technology gaps for grid support

Funding

- Regional funds
- European Commission – could be under the recently launched call “Synergies between Data Centres and Energy Systems”
- National Energy department
- Net Zero Innovation Hub

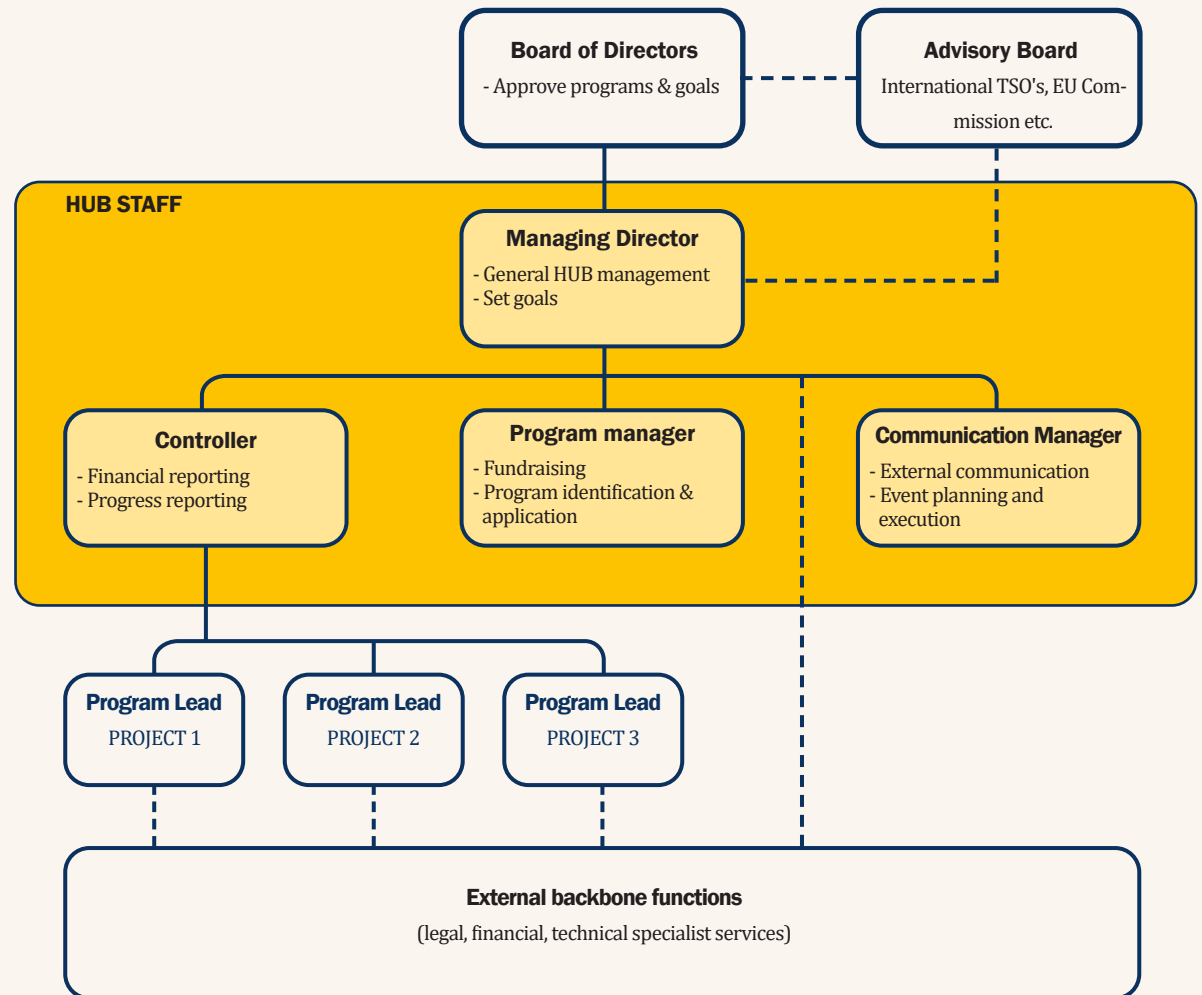
Organisation

Board of Directors and Governance structure

The Hub will be governed by the Board of Directors, supported by an international Advisory Board. The financial model rests on external funders and members, who elect the Board of Directors. The Board meets four times yearly (six times in first year), and sets out the strategic frame for the Hub, reviews the yearly roadmap, approves projects and initiatives, communication plan, budget etc.

Hub organisation

- Initially the Hub will set off as a small, agile organisation holding a Program manager, a Controller and a Communication manager, reporting to the Managing director.
- The Program manager will be responsible for program identification and fundraising. Each Program is on a daily basis controlled and lead by a Program Lead, who is responsible for coordination of the participants in each program.
- All Program leads will report to the Program controller.
- The majority of Program leads and program participants should be recruited from HUB members whenever possible. If programs cannot be manned form HUB members, then staff will be hired on program specific contracts.
- The Communication manager will be responsible for all external communication and event planning.
- External backbone functions will be brought on an hourly basis when needed.



How do we differentiate?

Broad, non-political focus

The Net Zero Innovation HUB focus is broad and addresses besides internal data center infrastructure, the innovation and development between the data center and the surrounding infrastructure, society and municipality. We do this on a technical and non-political level.

Not only for specialists

Other innovation centers like OCP and ICE focus on development and improvement within the data center infrastructure with communication primarily focused towards data center specialists or to promote a country specific

Meeting place for cross sector collaboration

The Net Zero Innovation HUB is beside its innovation activities a platform for meeting and communication to a broad range of different stakeholder groups in and out side of the traditional data center societies.

Location

Why Denmark?

Denmark has been chosen as a "launch location" for the hub. The goal is to scale the hub with projects all across Europe, encouraging cross-sector collaboration with European partners.

By launching in Denmark, the Net Zero Hub will benefit from Denmark's ideal conditions which include:

- Denmark's national green ambitions is to reduce CO2 emissions by 70% by 2030, and a target of 100% green electricity already by 2027
- Denmark have some of the world's most sustainable companies
- EU potential - tap into political landscape of energy crisis and need to lower consumption
- Stable infrastructure and energy grid
- Connected to both European and Nordics energy grid
- Proven track record of successful public-private partnerships
- General openness towards data center investments



A perfect place to start up and to collaborate with all European countries

Summary

Faster to net zero together by creating a melting pot for innovative, scalable and rapid solutions.

Together we can meet key challenges towards net zero data centers by minimising organisational risks.

Sharing knowledge and promoting a joint vision, where we can accelerate the speed of innovation.



Get in touch

Henrik Hansen
CEO
Danish Data Center Industry
Mobile: +45 4013 4474
E-mail: hh@datacenterindustrien.dk

Net Zero across the complete value chain

We define a net zero data center according to the GHG protocol where we include scope 1, 2 and 3 emissions in the following manner:



We do not just focus on direct emissions due to energy consumption from operations but wish to work with improvements in the entire value chain.

As an example, embodied carbon is often neglected. But as the primary energy in many countries gets less carbon intense, then the indirect emissions in i.e. building materials and solar panels ect. become important to address.

Appendix

Appendix A - Roadmap projects

Appendix B - Legal setup

Appendix A

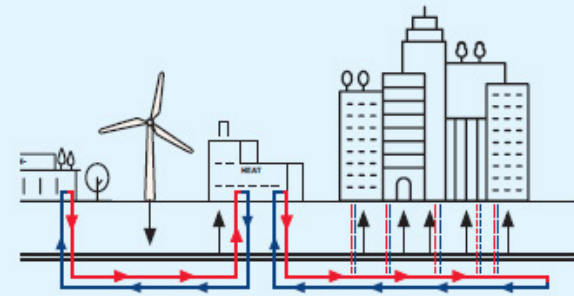
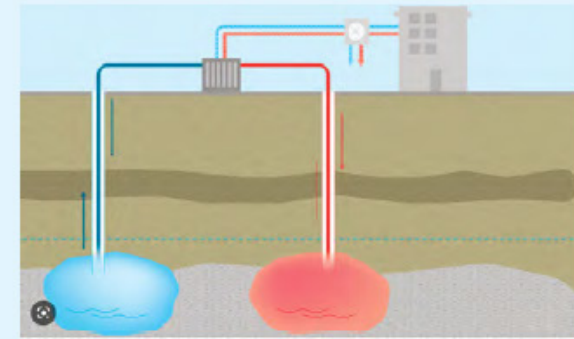
Roadmap project possibilities

The suggested roadmap is developed from a series of standalone project opportunities referring to either **Decarbonization** or **Grid Support** initiatives.

Each project opportunity has been initially rated according to the following categories:

- Impact and scalability estimation
- Cost benefit considerations
- Timeframe
- Funding possibilities

with a 0 (bad) to 5 (best) grade based on our initial knowledge and without any detailed investigations.



Decarbonization Initiatives

Reuse of heat

#D1 Schemes for implementation of reuse of excess heat in relation to district heating systems

- Mapping of the potential for reuse of heat in relation to existing and future DCs
- Mapping of economical and technical barriers
- Comparison of different operational models with respect to operational risk and economic benefit
- Definition of a best practice model for investment, maintenance and operation



Clean Power Generation

#D2 Use of the electrical DC infrastructure for export of power in combination with load shifting

- Mapping of the physical and economical potential in existing and future DCs
- Economical and technical barriers within different types of DCs



Clean Power Generation

#D3 Alternatives to conventional Gensets

- Technical and economical potential for use of natural gas turbines in future facilities
- Carbon-neutral synthetic fuels instead of diesel – a drop in alternative to obtain clean power and avoid emissions?
- Use of Waste Vegetable Oils (WVO) as fuel in combination with exhaust cleaning on Gensets

- 4 Impact and scalability estimation
- 5 Cost benefit considerations
- 4 Timeframe
- 4 Funding possibilities

- 3 Impact and scalability estimation
- 5 Cost benefit considerations
- 4 Timeframe
- 4 Funding possibilities

- 5 Impact and scalability estimation
- 5 Cost benefit considerations
- 4 Timeframe
- 2 Funding possibilities

The initially rated project opportunities within category 2:

Grid Support Initiatives

#G1 Mapping of Load Shifting Possibilities and limitations for DCs

The project should map possibilities for planned load shifting seen from both the DC and the grid side.

The mapping should result in a guideline for what to be expected with respect to time needed to plan and execute a load transfer, how often it is possible to realize, associated cost and expected time period in which it is possible to operate in a load shifted mode.

- 5 Impact and scalability estimation
- 5 Cost benefit considerations
- 5 Timeframe
- 4 Funding possibilities

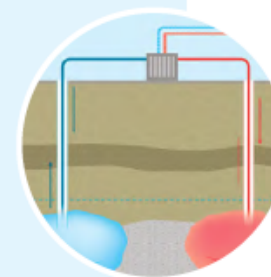
NET ZERO INNOVATION HUB

#G2 Short term forecasts of central data center electricity consumption (hour ahead, day ahead, average demand curve)



- 5 Impact and scalability estimation
- 3 Cost benefit considerations
- 3 Timeframe
- 2 Funding possibilities

#G3 Grid balancing - short term/long term (FCR/FFR) with DC UPS and gensets



- 5 Impact and scalability estimation
- 5 Cost benefit considerations
- 3 Timeframe
- 4 Funding possibilities

#G4 Thermal cold storage for DCs in combination with Smart Grid schemes – ATEs, pond, PCM or traditional storage?

- 3 Impact and scalability estimation
- 3 Cost benefit considerations
- 5 Timeframe
- 4 Funding possibilities

The best rating projects within the Decarbonization and Grid support initiatives

Best rating projects

PROJECT #1

Decarbonization

#D1 Schemes for implementation of reuse of excess heat in relation to district heating systems

Reuse of excess heat from DCs represents a huge potential, especially in connection to district heating networks where large amounts of heat can be reused and distributed. Future immersed cooling will probably reduce or even remove the need for use of heat pumps in order to utilize the

excess heat and make reuse even more attractive. It is therefore important to help reduce barriers for future implementation of excess heat reuse in connection to district heating systems or other large heat-intensive industries. This is the motivation for assigning #D1 as roadmap project no. 1.

PROJECT #2

Decarbonization

#D2 Use of the electrical DC infrastructure for export of power in combination with load shifting

#D3 Alternatives to conventional Gensets

Grid Support Initiatives

#G1 Mapping of Load Shifting Possibilities and limitations for DCs

Clean power generation is crucial if DC backup systems (beside UPS) should play a considerable role in active power generating grid support, as DC provided power must be green or at least as green as the alternative to be considered a genuine alternative.

This is the motivation for combining project possibility #D2, #D3 and #G1 across the two initiative groups and define them as a combined roadmap project no. 2.

#D3 will investigate how green power can be produced cost effectively relative to the benefit achieved from grid support. #G1 will map to which extent grid support is possible and #D2 will focus on possible technical infrastructure barriers.

Schemes for implementation of reuse of excess heat in relation to district heating systems and other large heat-intensive industries

Project #1

Project description

Work packages

WP#1 Initial screening of potentials and test of project assumptions.

The initial work package will provide basis for the detailed project definition and funding applications and will test that the assumed potentials and cost benefit considerations are realistic.

WP#2 Detailed project definition and funding

Based on "WP#1 findings a detailed project definition will be finalized and funding applications will be issued based on documentation and findings from WP#1.

WP#3 Mapping of the potential for reuse of heat in relation to existing and future DCs

With funding in place, WP#3 will for 3 European countries map the potential for reuse of heat for both existing and planned future DCs. This work will provide data that can be extrapolated and provide estimates for reuse of heat across Europe.

WP#4 Mapping of economical and technical barriers

The work package will run almost parallel timewise to WP#3 and will for selected locations found with a heat reuse

potential perform a "deep dive" in order to map economical and technical barriers dependent on location, size and type of DC and surrounding heat-intensive industries and district heating networks. A total number of 20 "deep dive" studies should be performed.

WP#5 Comparison of different operational models with respect to operational risk and economical benefit

Based on the learnings from WK#4 different models for establishing and operation of an installation for reuse are defined and compared in order to identify patterns across the selected cases with respect to mitigation of operational and economical risk.

WP#6 Definition of a best practice model for investment, maintenance and operation

The final work package should focus on definition of a best practice model for setting up the legal and technical framework between the DC and its user. This will enable future projects with a solid platform that will mitigate risk and speed up the planning and negotiation process and hopefully drive and spread the installations for reuse of excess heat from data centers.



Schemes for implementation of reuse of excess heat in relation to district heating systems and other large heat-intensive industries

Project #1

Cost benefit considerations

There are multiple driving factors for both supplier and end user that indicate that investment in reuse of excess heat is an attractive investment.

The primary driving factors are:

- Taps directly into any Net Zero strategy
- The EU Taxonomy urges companies to report their environmentally sustainable economic activities
- Energy is a scarce commodity
- The data center sector in the European Union is expected to undergo new and rigorous directives (Fit for 55) and potentially regulations intended to reduce their carbon emissions.
- A directive for reuse of heat from DCs is launched as of September 2022.

In other words, reuse of heat could very easily become a must have for future data centers but there should also be an attractive case for existing DCs. We know that district heating companies are installing air to water heat pumps in large scales and the efficiency of water to water heat pumps receiving excess heat from a

data center will, due to a higher efficiency, be even more attractive for district heating companies.

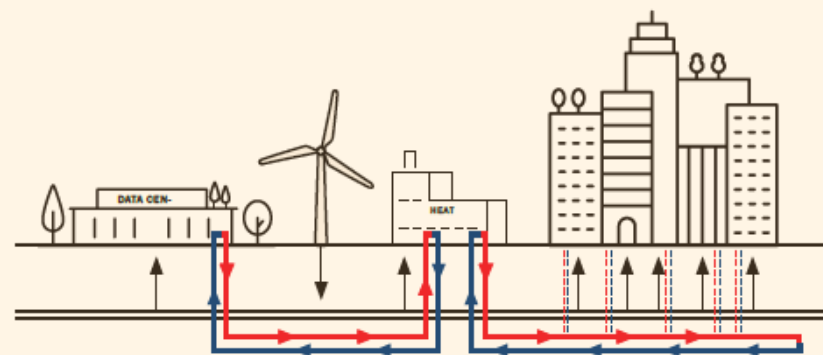
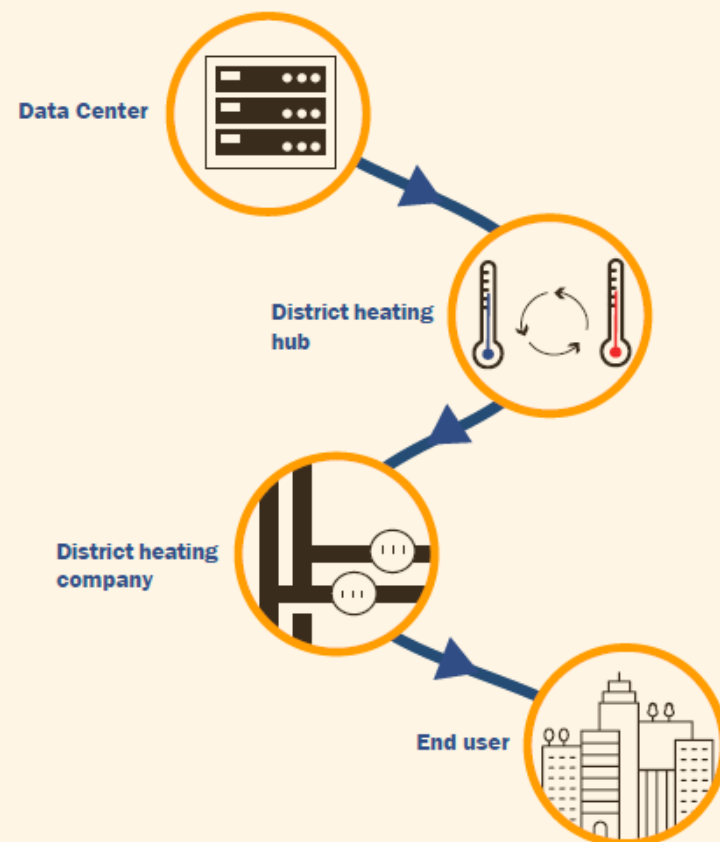
Taking in account that the project will be beneficial for the entire DC industry, the estimated direct project (before external funding) cost of EUR 600,000.- seems attractive. The project duration is around 2 years.

Participants

- Net Zero Innovation Hub members
- District Heating Networks
- National Energy Department
- Danish National Cluster for Energy
- Energy planning companies
- Euroheat & Power Association
- Universities

Funding

- Calls under EU Horizon program
- Innovation Fund Denmark
- Net Zero Innovation Hub



Project #2

Project description

Work packages

WP#1 Initial mapping of load shifting possibilities and test of project assumptions. The initial work package will provide basis for the detailed project definition and funding applications and will test that the assumed potentials and cost benefit considerations are realistic.

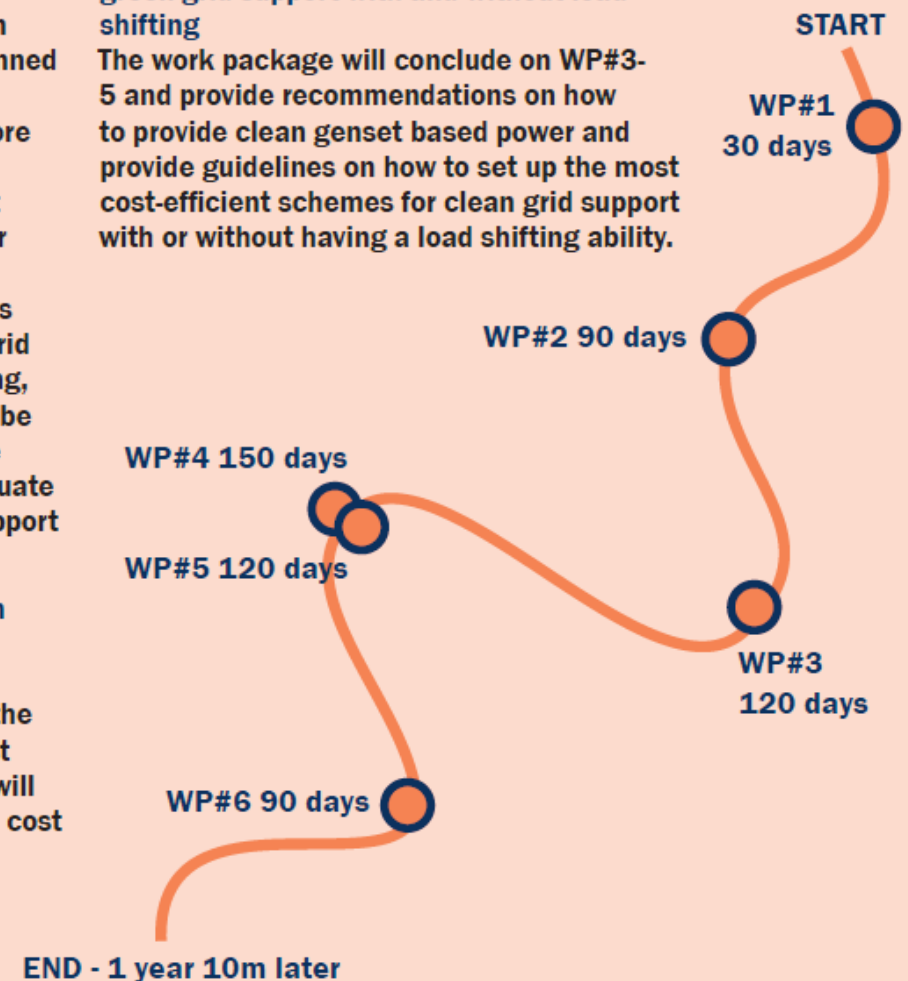
WP#2 Detailed project definition and funding Based on “WP#1 findings, a detailed project definition will be finalized and funding applications will be issued based on documentation and findings from WP#1.

WP#3 Alternative green fuel options The work package is as such a decoupled investigation focusing on evaluation of alternative fuel option for existing and new gensets. WP#3 will investigate and map alternative fuel options, fuel cost and connected maintenance cost incl. possible cost on existing and new gensets to be converted into alternative fuel options. The final output from the work package will be an overview of possible fuel options/ technologies and the associated cost benefit evaluation.

WP#4 Detailed mapping of load shifting potentials and barriers Load shifting in combination with a clean power generation at DCs open up for planned grid support with the possibility to offer support with high capacities. It is therefore important to get a clear picture of the extent to which it is possible, in different types of DCs, to provide the possibility for load shifting. WP#4 should map this for hyperscale and colo DCs of different sizes and location across Europe and across grid balancing parties. Along with the mapping, possible restrictions and barriers should be addressed. WP#4 will lastly estimate the combined economical potential and evaluate on the importance of this type of grid support seen from the balancing parties.

WP#5 Technical infrastructure barriers in relation to grid support Physical and administrative barriers for grid support seen from both the DC and the grid balancing party will be mapped. Best practices to overcome possible barriers will be developed and evaluated along with a cost benefit calculation for the alternatives.

WP#6 Evaluation of the possibility to provide green grid support with and without load shifting The work package will conclude on WP#3-5 and provide recommendations on how to provide clean genset based power and provide guidelines on how to set up the most cost-efficient schemes for clean grid support with or without having a load shifting ability.



Project #2

Cost benefit considerations

Even if load shifting is not an option, use of existing gensets powered by clean fuels will make it possible to establish planned grid support corresponding to the total capacity of a DC. With load shifting the available capacity impact on the grid is doubled.

Gensets and required electrical infrastructure are already present in almost all DCs, therefore the major cost impact is caused by the cost of converting gensets to alternative fuels and the additional cost for clean fuels.

As conversion to clean fuels is starting to be real alternatives and prices for being able to provide grid support are quite attractive, the initial conditions for a sound business case are very likely.

The estimated direct project cost (before external funding) is EUR 650,000.- and the estimated project durance is 1½ to 2 years.

Participants

- Net Zero Innovation Hub members
- Colo and Hyperscale providers
- Genset manufactures
- UPS manufactures
- Danish National Cluster for Energy
- Fuel companies
- Energy planning companies
- European TSO association
- Universities

Funding

- Calls under EU Horizon program
- Innovation Fund Denmark
- Net Zero Innovation Hub
- Danish National Energy Agency

