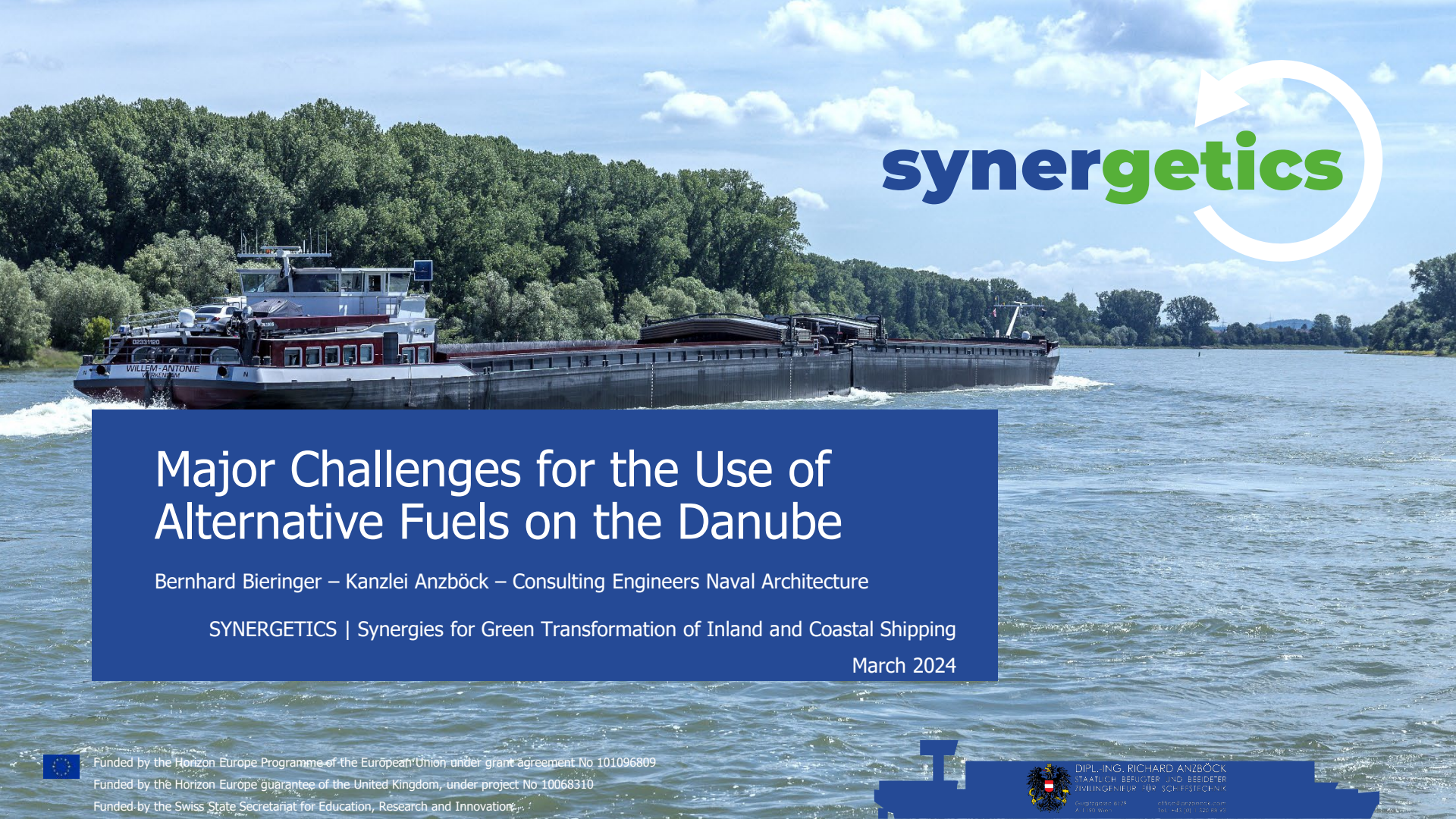

synergetics

Major Challenges for the Use of Alternative Fuels on the Danube

Bernhard Bieringer – Kanzlei Anzböck – Consulting Engineers Naval Architecture

SYNERGETICS | Synergies for Green Transformation of Inland and Coastal Shipping

March 2024

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Innovation Action SYNERGETICS

General information

Project number	101096809
Project title	Synergies for Green Transformation of Inland and Coastal Shipping
Project acronym	SYNERGETICS
Call	HORIZON-CL5-2022-D5-01
Topic	HORIZON-CL5-2022-D5-01-04
Type of action	HORIZON-IA
Project starting date	January 1st, 2023
Project duration	42 months
Total eligible costs	EUR 5 321 955.05
Maximum grant amount	EUR 4 184 312.03
Total eligible costs of APs	EUR 1 840 965.63

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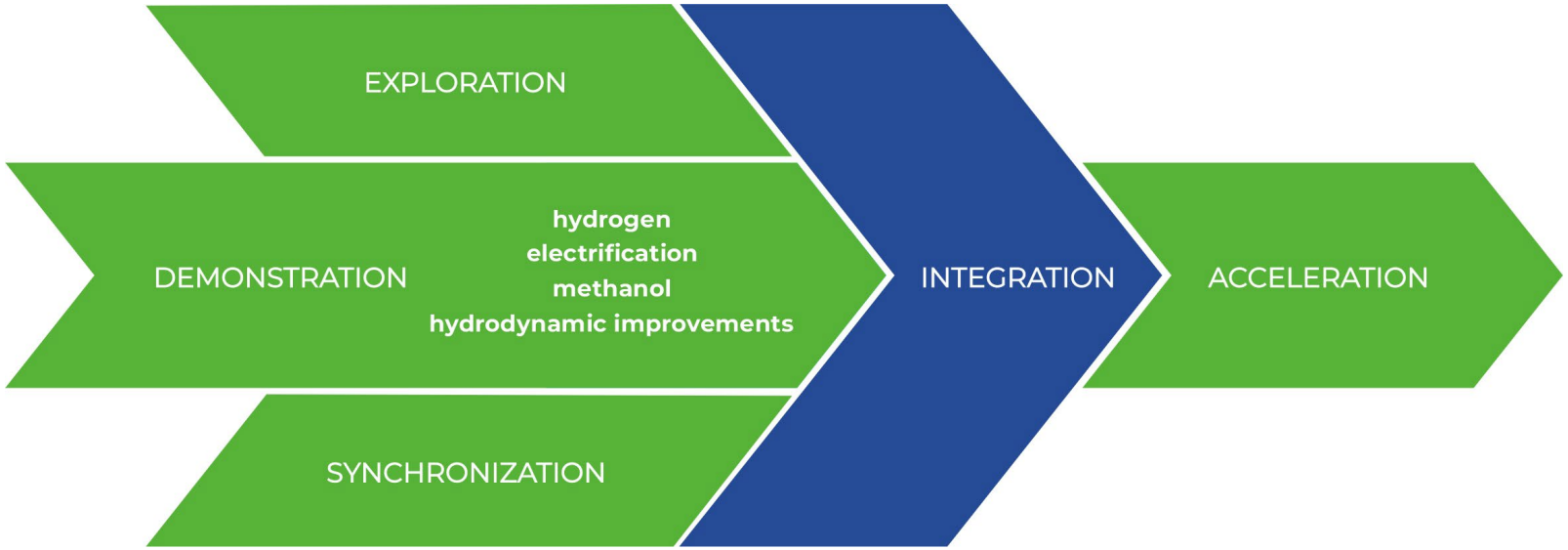
Synergies



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Full-scale Demonstrators

Image: CMB.TECH

Hydrogen – Internal Combustion Engine

Image: Mercurius Shipping

Methanol – Internal Combustion Engine

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Full-scale Demonstrators

Image: CFT

Electrification of the main propulsion plant

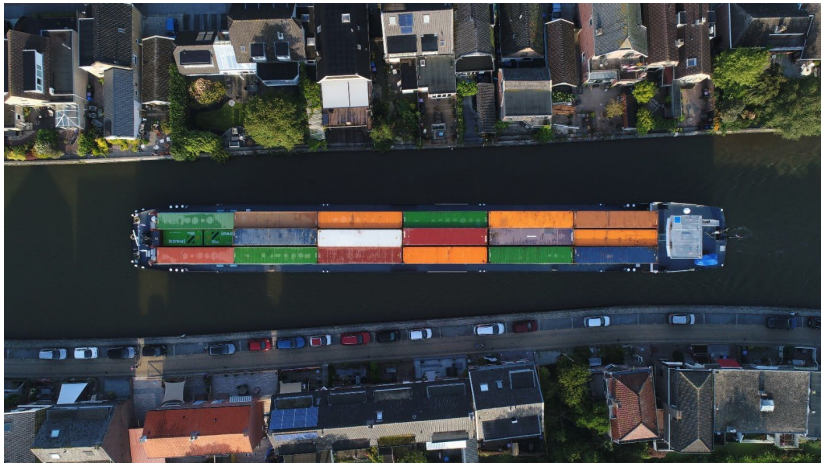

Image: Zero Emission Services

Battery-electric

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Model-scale Demonstrators

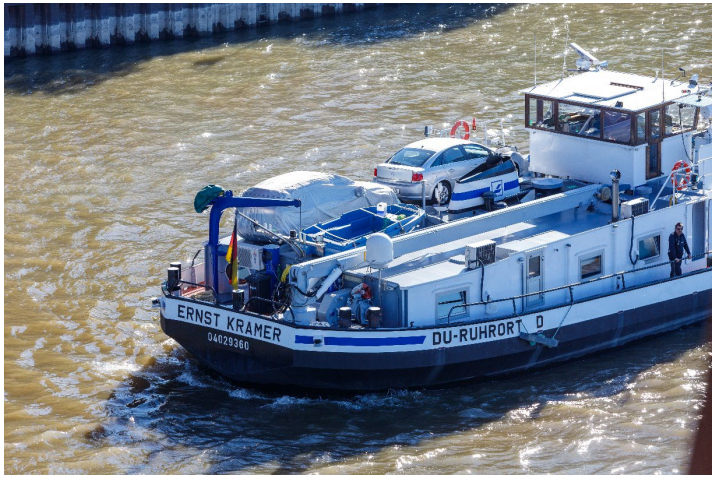

Image: DST / Benjamin Friedhoff

Aft-ship replacement

Image: via donau / Johannes Zinner

Use of digital tools and virtual assets in finding the optimal greening solution

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System Demonstrators

Image: ScandiNAOS

Comparison of a dual fuel methanol engine with a compression ignited methanol engine

Image: Future Proof Shipping

Development of power and energy management system for fuel cells and hydrogen powered ships

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Major Challenges for the Use of Alternative Fuels on the Danube

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1 **Distances**

2 **Energy content of fuels**

3 **Infrastructure**

4 **Costs**

1 - Distances

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- Rhine: approx. 800 km (Rotterdam – Basel)
- Danube: approx. 2.400 km (Black Sea – Kelheim)

- Distances of voyages on the Danube are usually significantly longer than on the Rhine
- Practical applicability of alternative fuels highly dependent on possible storage volume on board and respective infrastructure (distance between bunkering stations)

2 – Energy content

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▪ Benchmark: Diesel	42,9 MJ/kg	35,2 MJ/l	1
▪ Battery:	0,09-0,18 MJ/kg	0,18 – 0,32 MJ/l	110
▪ Methanol:	22,4 MJ/kg	17,85 MJ/l	1,97
▪ Hydrogen:	(120 MJ/kg)	(0,011 MJ/l)	(3200)
▪ Compressed (700 bar):	120 MJ/kg	5,04 MJ/l	6,98
▪ Cryogenic (-252,9° C):	120 MJ/kg	8,64 MJ/l	4,07
▪ LOHC:		6,48 MJ/l	5,43

(pure fuel without respective storage system)

Sources:
GRENDEL Factsheets (https://www.interreg-danube.eu/approved-projects/grendel/section/technological-factsheets)
https://neutrium.net/properties/specific-energy-and-energy-density-of-fuels/
https://demaco-cryogenics.com/blog/energy-density-of-hydrogen/
https://hydrogenious.net/how/#technology

3 – Infrastructure

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- Rhine: densely populated, highly industrialised along the entire river
  - Chemical industries along the Rhine make availability of alternative fuels quite probable (and also the reliability of availability), even as by-products
  - Short distances between bunkering stations possible
- Danube: lots of „space in between"
  - Hardly any chemical industry along the river, no synergies
  - Sufficiently narrow spacing of bunkering stations difficult to achieve
- General: transition from single-fuel environment (Diesel) to multi-fuel environment requires multiplication of bunkering/storage facilities

4 – Costs

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- Anecdotal evidence only
- Batteries (evidently no use case, just for illustration):
  - In order to replace the average bunkering capacity of a typical Danube pusher (60 t) batteries with a total weight of ca. 1500 t / total volume 750 m³
  - Investment costs ca. 130 Million EUR
- Hydrogen:
  - Pressurised 20’ gas container costs ca. EUR 300.000 – 500.000
  - Contains ca. 1 t of hydrogen – equal to approx. 3,4 t of Diesel
  - approx. 18 containers necessary to get equal bunkering capacity
  - Corresponds to investment costs of ca. 5,4 – 9 Million EUR

What to do?

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- Batteries: probably suitable for local passenger traffic (day cruises)
- Methanol / hydrogen: first of all hen-and-egg problem with regard to infrastructure
  - Ship-owners will not invest as long as there is no sufficient bunkering infrastructure
  - Bunkering companies will not invest as long as there are not enough vessels using alternative fuels
- Further challenges (examples)
  - Methanol: toxic, mixes with water → hazard to persons and environment
  - Hydrogen: in cryogenic form extremely cold → hazard to structural integrity of vessel in case of spillage (spontaneous embrittlement)?
  - Crew qualification

More Alternatives?

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- HVO100
  - Up to 90% reduction in greenhouse gases immediately
  - Already approved by many major engine manufacturers
  - Diesel infrastructure can be used (on-board and shoreside)
  - Availability?
    - Diesel can always be used as fall-back (HVO100 and Diesel can be blended in any proportion)
  - Synergies with transport of agricultural products?
    - Can residuals and by-products be used as a basis for HVO100?

Sources:
GRENDEL Factsheets (https://www.interreg-danube.eu/approved-projects/grendel/section/technological-factsheets)
https://www.neste.be/en/neste-my-renewable-diesel-be

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Thank You for Your Attention

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