FCH JU2 initiative:

PROJECT DEVELOPMENT ASSISTANCE FOR REGIONS

"Project Development Assistance for Cities and Regions 2020-2021": Ruse Project

Consultants: elementenergy and TREZORS

Ruse Team: Ruse Municipality | Association of Danube River Municipalities | Ruse Municipal Transport | Bulgarian River Shipping J.S.Co | University of Ruse | BGH2A | Holding Zagora *+ newcomers*

ОБЩИНА РУСЕ

Presenter: Daria Vladikova (BGH2A) d.vladikova@iees.bas.bg

OBJECTIVES

- Overall objective:
  - To support Ruse Municipality to develop the first concept for regional hydrogen deployment for transport applications;
  - To accumulate experience in the preparation of compatible projects for funding.

OBJECTIVES

❑ Specific objectives:

- To establish a core group of stakeholders representing the entire value chain

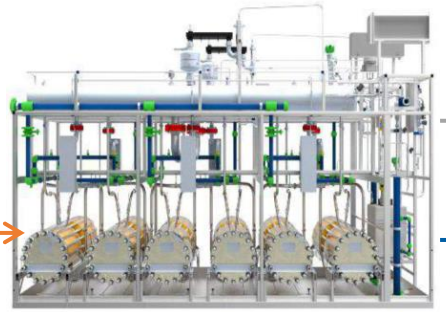
- To develop business model of hydrogen eco system appropriate for Ruse combining:
  - Hydrogen bus fleet
  - Hydrogen push boat (local retro fit)
  - Local hydrogen production by electrolysis

Technical Design

PV

P= 3,6 MWp

Electrolyzer



P= 2,4 MW (16/7)

O2

O2

Compressor
500 bars

Storage
H2 = 690kg

Technical Design

PV

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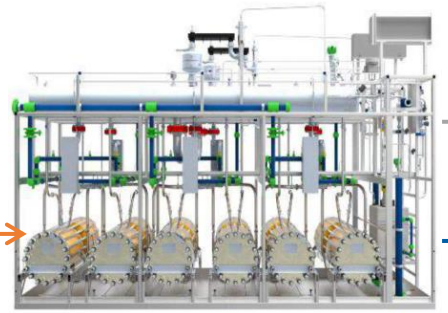

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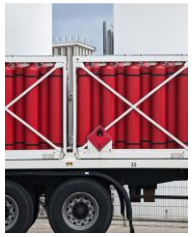
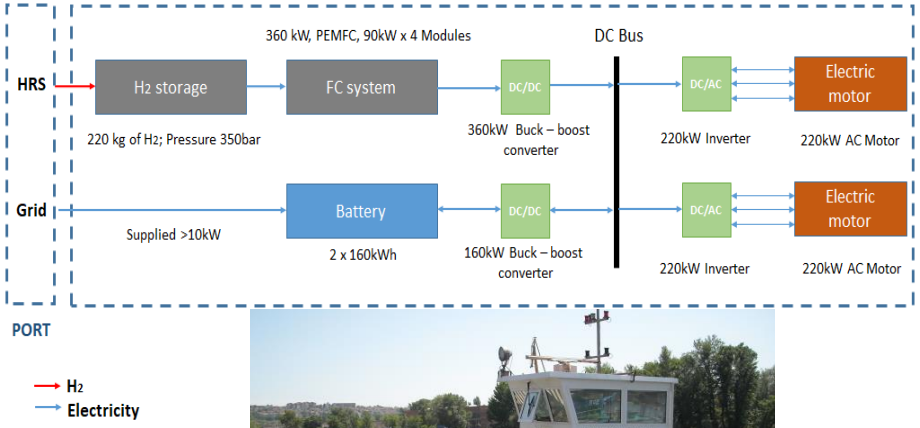




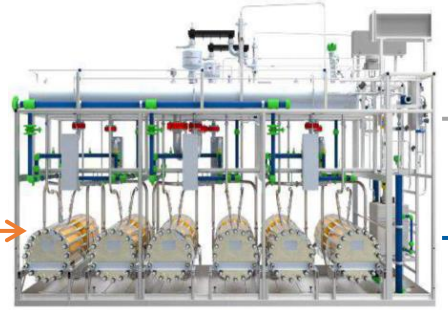
Hydrogen storage on board
220kg H2/350 bars

Technical Design

PV

P= 3,6 MWp

Electrolyzer



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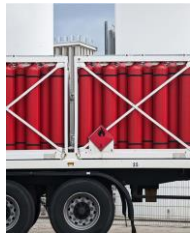
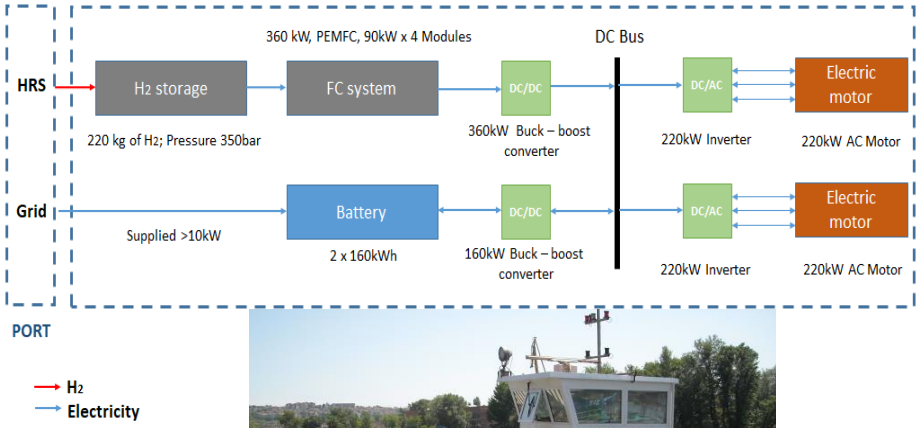




Hydrogen storage on board
220kg H2/350 bars

Dispenser
350 bars
(20 buses)

450kg H2

Costs (TCO): H2 Production

Selected conditions

Electrolysis		
Name	**Value**	**Unit**
Electrolyser efficiency	50	kWh/kg
Lifetime	80 000*	Hours
Electrolyser Installed Capacity	2423	kW
Tap water consumption	16,8	liters/kg
Working hours	16	hours/day

*Change of the stack

Capital Costs (CAPEX)				
Name	**Value**	**Unit**	**%**	**Total** (€)
Electrolyzer	1100	€/kW	37%	2670000
Hydrogen Storage	1000	€/kg	10%	691000
Hydrogen Compressor	1500	€/kg	14%	1040000
Refuelling Dispensers and Chillers	500000	€/unit	7%	500 000
Photovoltaic Equipment	500	€/kW	25%	1820000
Photovoltaic Installation	50	€/kW	3%	182000
Civil Works	400	€/m^2	3%	200000
Grid Connection	100000	€	1%	100000
Total		€	**100%**	**7200000**
Annualised total		**€/year**		**427410**

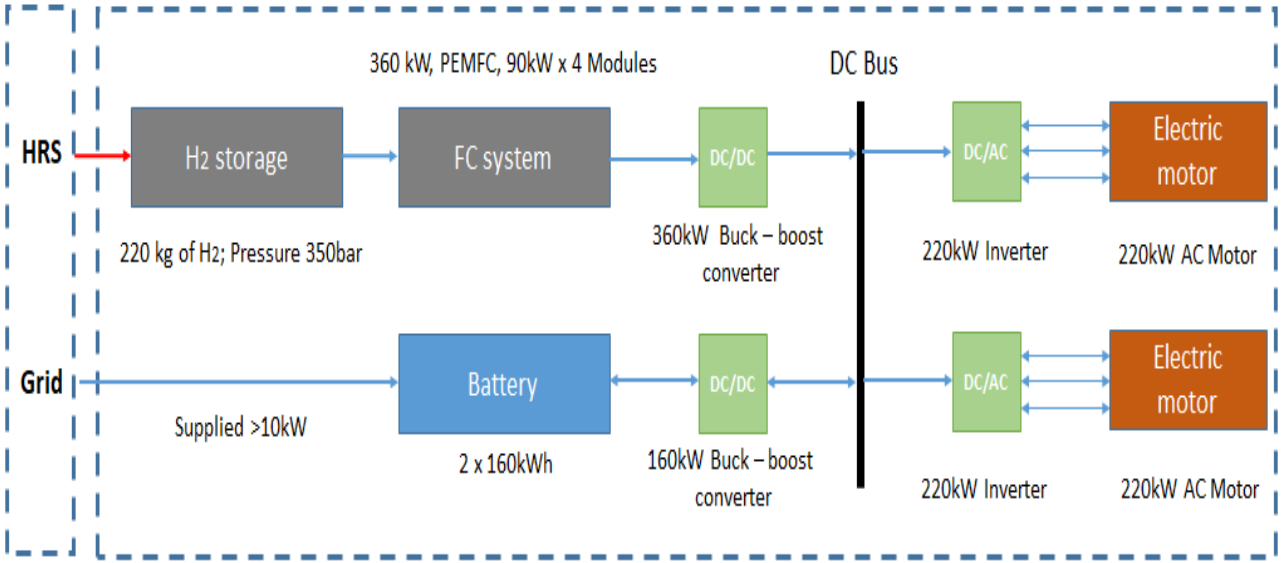
Costs (TCO): H2 Production

Annual Operational Costs (OPEX)				
Name	**Value**	**Unit**	**%**	**Total**
Electrolyser	3%	% of CAPEX p.a.	10%	80 000
Hydrogen Storage	1%	% of CAPEX p.a.	1%	6 910
Hydrogen Compressor	3%	% of CAPEX p.a.	4%	31 000
Refueling Dispensers and Chillers	3%	% of CAPEX p.a.	2%	15 000
Photovoltaics Maintenance	10	€/kWp	4%	36 400
Grid Electricity Costs	551000	€/year	68%	551 000
Labour Refuelling Station	€ 15000	per person	11%	90 000
Total			**100%**	**810 000**

Costs (TCO): H2 Production

Project	Electrolyzer capacity [MW]	H2 production [kg/day]	Levelized cost of hydrogen [€/kg]
Ruse	2400	690	**5,37**
Sofia	3899	1215	**4,13**

Costs (TCO): Pusher Retrofit



Hydrogen storage on board
220kg H2/350 bars

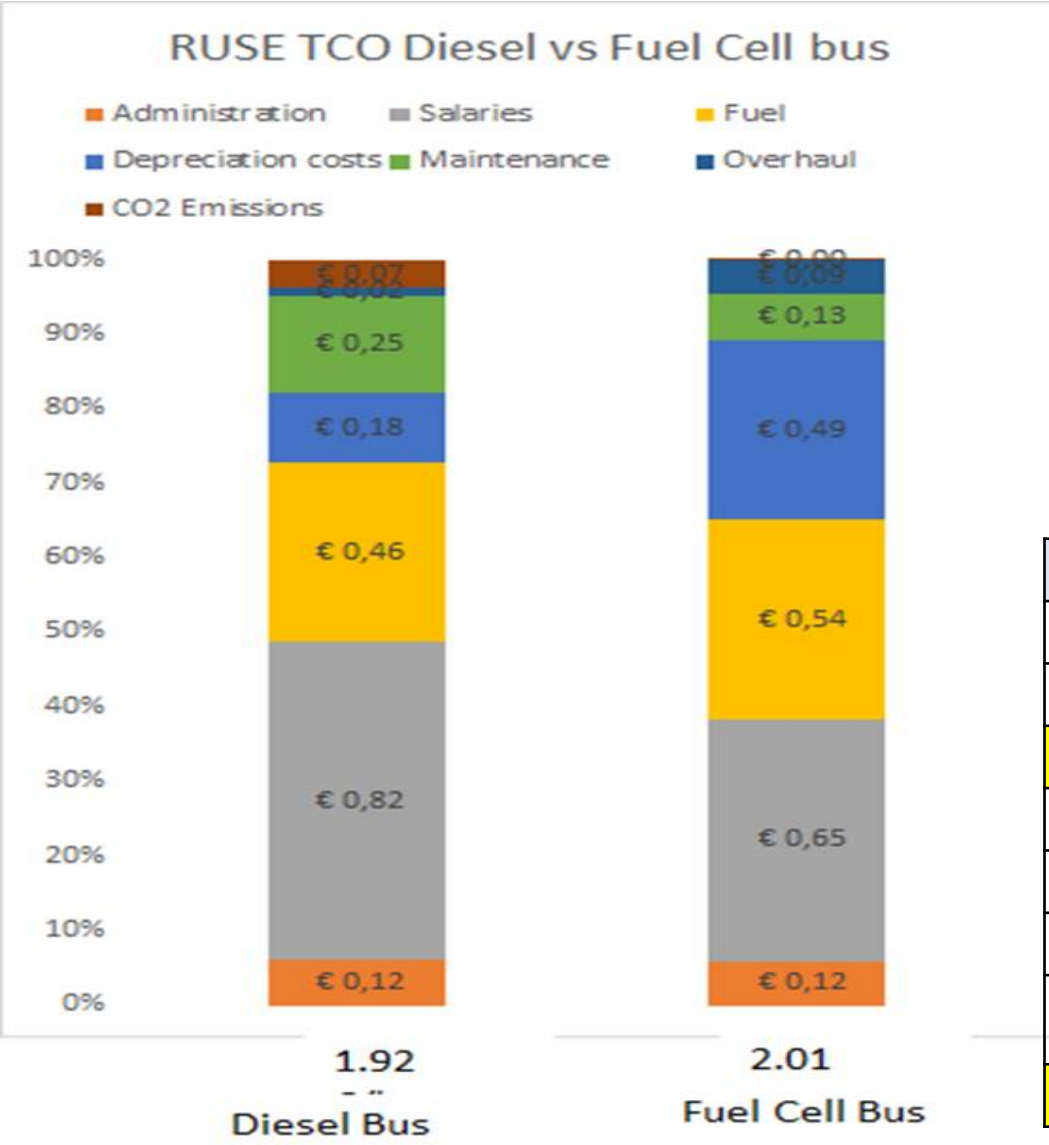
BR100A5 I (3) Z
ICE Pusher

Costs (TCO): Pusher Retrofit CAPEX

Boat technical expertise		€ 50 000
Retrofit project acceptance according to ship class company		€ 300000
Equipment dismantling	1500 h	€ 45 000
Automation (electricity, power management)		€ 300000
Painting (including preparation)		€ 120000
Class supervision (*depends on the chosen Lloyd BV*)		€ 150000
Ship safety systems		€ 490000
Fuel Cell modular system 360kW	4x 90 kW	€450 000
H2 tanks, 220 kg	2x220 kg	€440 000
Battery	2x 160kWh	€240 000
Power management and AUX		€400 000
Electric motor	2x220 kW	€ 120 000
Total for FC/battery retrofit (41%)		**€ 1640000**
Total		**€ 3985000**

Replacement of diesel with LNG propulsion is evaluated about **€ 1200000**

Costs (TCO diesel/hydrogen) - 20 Buses



Capital expense	Units	Diesel bus capex (k€/bus)	Fuel cell bus capex (k€/bus)	Total FC project cost (k€)	Total funding gap (k€)
City bus 12 m	20	200	550	11 000	7 000
Total				**11 070**	**7 070**

TCO Parameters	Diezel €/km	FC €/km
Administration	0,12	0,12
Salaries	0,82	0,65
Fuel	0,46	0,54
Depreciation Costs	0,18	0,49
Maintenance	0,25	0,13
Overhaul	0,02	0,09
CO2 emissions	0,07	
Total:	**1,92**	**2,01**

Costs (TCO): Funding Gap/Opportunities

	Infrastructure (Capex & Opex)	FC buses	Retrofitting "Voyager" (CAPEX)	PM	Total*
Total cost	€7,02m	€11,1m	€3,99m	€384k	**€22,5m**
Funding gap	€7,02m	€7,07m	€3,99m	€384k	**€18,5m**

- **Potential Funding Sources:**
  - **National**: Operational Programs; Recovery & Resilience Plan; eventually IPCEI; private
  - **European**: Horizon Europe (CH JU – Inland shipping) Interreg; TEN-T; Modernization Fund; CEF; EIB; innovation Fund;

Main Difficulties and Barriers

- To find information about companies producers of components, systems, services
- To realize a contact with such companies
- To find information about prices
- Lack of information about legislative, administrative and safety issues (lack of existing issues)
- Lack of information about homologation and certification (for retro fit)

Thanks to Elementenergy and Trezors for covering as much as possible this information gap

Project Outcomes

- **Realization of the first in Bulgaria (together with PDA for Sofia Municipality) Project** with detailed plan **for large scale hydrogen deployment** for transport applications:
  - Development of appropriate **Business Model**
  - Development of **Work Plan**
  - Identification of **technological approaches**
  - Identification and preliminary **contacts with stakeholders** through the value chain: buses (Caetano, Wrightbus, Solaris); hydrogen system (Ballard, Worthington)
  - Identification of **funding opportunities**

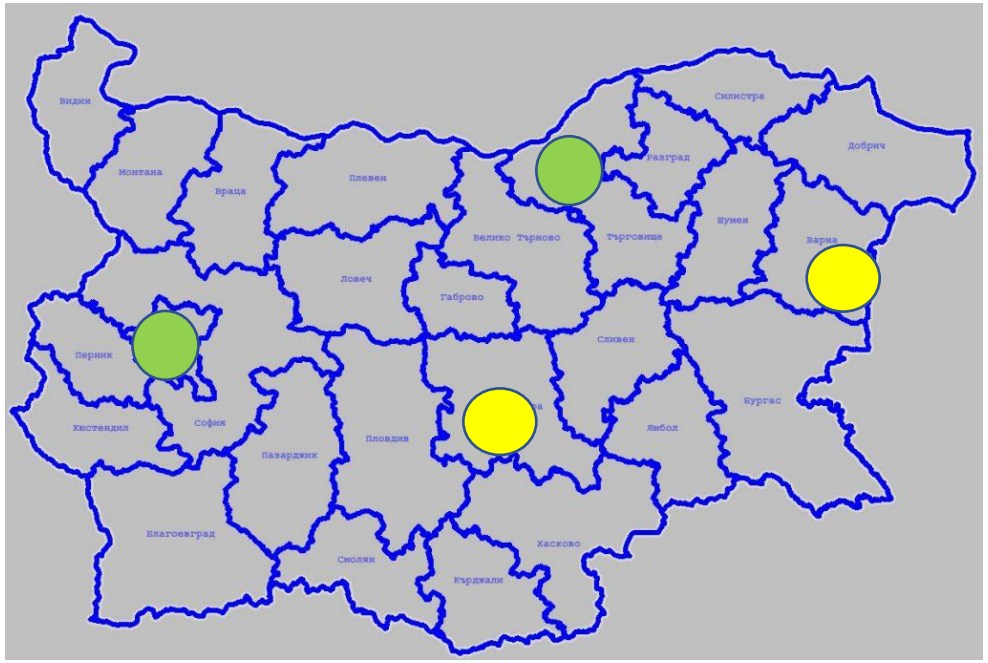
- **Attraction and Involvement of Bulgarian stakeholders**: Zagora Holding (retrofit system integration), ALMOT LTD (production of electric motors); Association of Danube River Municipalities; Ruse Municipal Transport, Bulgarian River Shipping J.S.Co ; Ruse University, BGH2A

Project Impact

- ❑ READINESS to enter in Consortium for large scale demonstration of hydrogen fuel cell propelled inland waterway vessels (FCH JU).

- ❑ **Activation of Ruse Municipality:**
  - 40 and more hydrogen buses (new Depot for 100 buses)
  - To coordinate Danube transport Hydrogen Valley (380 km longitude)
- ❑ **Deep involvement of Bulgarian River Shipping J.S.Co:**
  - 5 Danube logistic points : 2 bridges, 3 ferries
  - Combined transport: river-rail-sea
  - Land for PVs
- ❑ **Strengthening the Consortium**
  - Establishment of SME for integration of Battery/FC hybrid system (Stara Zagora)
  - Involvement of BG ship company for retro fit design
  - Involvement of BG ship yard for retro fit

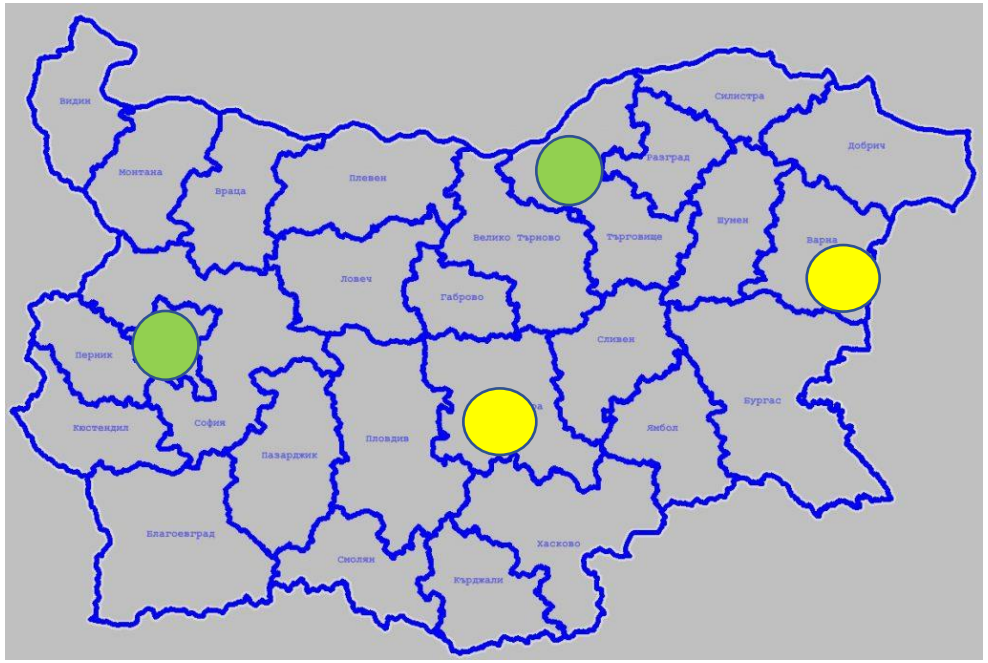
Project Impact



- **CHA Project pipeline – 2 transport projects:**
  - Bulgarian Hydrogen for Buses (BGH2B) – applicant BGH2A

Item/unit	Sofia	Burgas	Stara Zagora	Ruse	Total
Bus/No	65	20	20	35	140
Trolleybus/H2 range extender	40	8	8	8	68
Electrolyzer MW	6,3	2	2	3, 3	13,6
H2 t/y	747	224	224	368	1563

Project Impact



❑ CHA Project pipeline – 2 transport projects:

- GH4T - FC/Battery Systems for Transport – applicant Holding Zagora

Period	2022-2027	2027-2030
Retrofit trolleys	70	80
Retro fit City bus	50	190
Garbage Trucks	22	50
Heavy duty (incl. ships)	2	8
CAPEX (total)	56508 k€	
CAPEX Finding Gap	29,3%	

Acknowledgements

PROJECT DEVELOPMENT ASSISTANCE FOR REGIONS

Ruse Consortium would like to thank :

❑ **FCH JU 2** for the brilliant idea, organization and financial support

❑ **Elementenergy and Trezors** for the dedication in their assistance

❑ **and personally** to:

- **Hannah** Bryson-Jones and **Mike** Dolman from Elemmentenergy
- **Aivars** Starikovs and **Dainis** Boss from Trezors

for the personal efforts which were beyond their contract obligations.

THANK YOU