Insularity and Connectivity:
Hybrid and Electric Vessels for Short Distances

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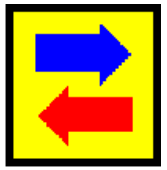
Contents

- The Problem
- The International Status
- The ELEMED and the Greek Potential
- Funding & Financing
- The Policy
- Conclusions



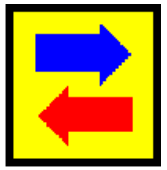
Battery Propulsion

Battery only:

- All power through batteries
- Charging externally when not sailing
- Usually, lithium ion
- Aim at high capacity (total energy)

Hybrid Systems:

- Coexistence of Diesel engines, electrical engines and batteries
- Ability to change source during voyage
- Excess power stored in battery and deliver when needed
- Aim at maximum power

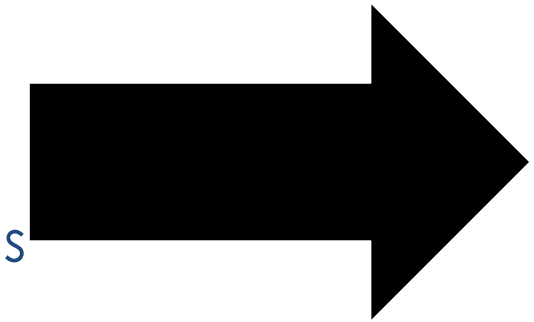


New Technology?

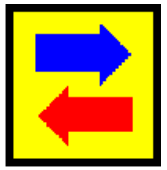
- 1839: first electric ship (7m, 3kn)
- 1880-1920: «golden age» of electric vessels
- Gradually replaced by gasoline and then Diesel engines

Recent Years:

- Rapid development of lithium batteries and cost reduction
- Need to reduce air emissions
- Search for efficient propulsion alternatives

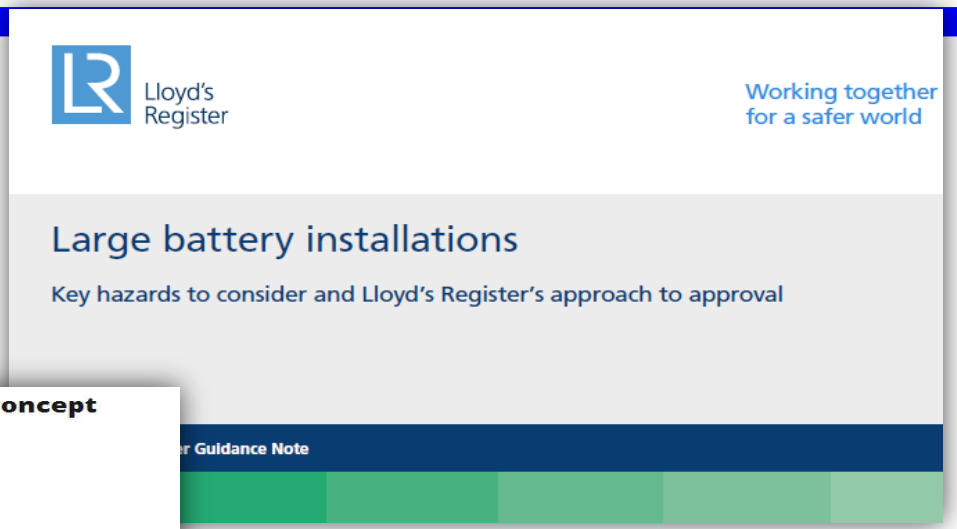


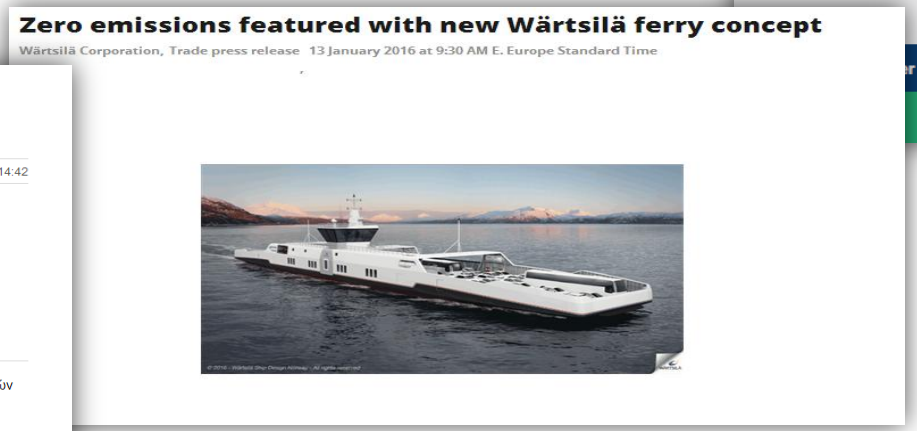
Gradual reintroduction of batteries as propulsion alternative



New technology ?

LR issues guidance on battery installations, covering the **hazards** associated with them and LR's approach to **approving** them. This guidance is generic and applies to all **electric and hybrid** configurations, since batteries can be used in any marine application





Engine Manufacturers including Wartsila have already developed new technology & **concept designs** for zero emissions

NTUA has already developed extensive **research** on new technologies and ships **electrification**

Operating

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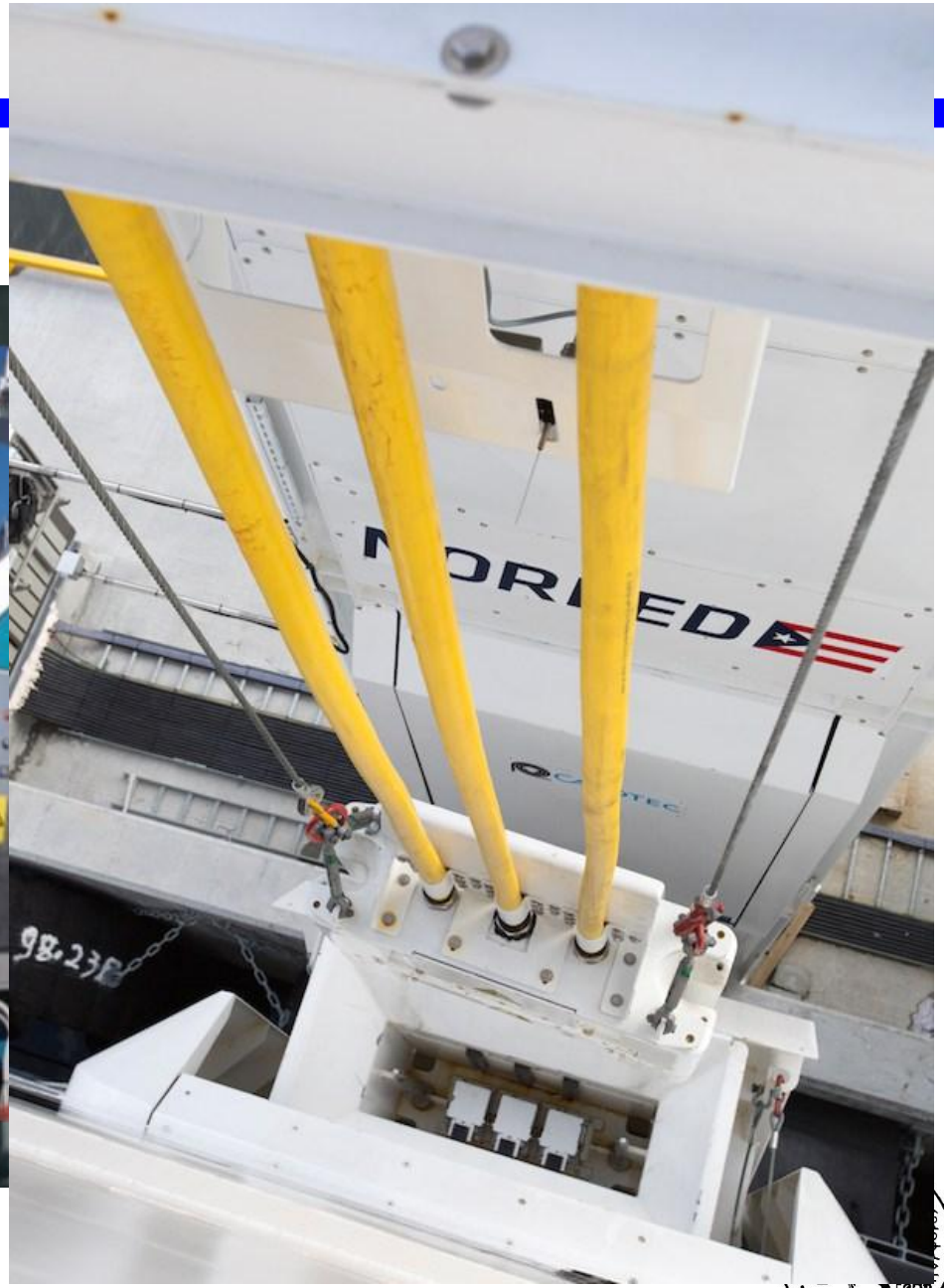
Operating



Operating

(Source: TECHSOL MARINE)

Peter Fraser Hybrid Ferry

- Hybrid electric-diesel and battery propulsion for the specific needs of the tricky waters of the St-Lawrence River in Québec, Canada
- Built in 2013
- Length 33.6 m, Gross tonnage 292 t
- 70 Passengers, 12 Cars
- Motor power 4 X 220 kW
- Battery 364 kWh, 542 Ah
- Speed 8.5 knots
- 4 x 220kW 364kWh 542Ah

Hybrid Passenger Vessels

Frequent port calls: emissions and noise

(Source: Scandlines)

MV Hallaig: Calmac's first Hybrid Ferry

Courtesy Lloyd's Register (HLSA)

the **world's first** sea-going roll-on roll-off vehicle and passenger **diesel-electric hybrid** ferry

incorporates a **low-carbon hybrid system** of **diesel electric** and **lithium ion battery** power

developed under the Low Emission Hybrid Ferries Project

more than **£20m** of Scottish **government investment**

created **175 jobs** and **20 apprenticeship** positions for the local community

Being Retrofitted

(Source: Gee's Bend Ferries)

- **Gee's Bend Ferry** in Camden Alabama
- Retrofit for full electric operation
- 4 x 100kW propulsion motors and drives
- 2 battery banks (~120 - 190kWh total)
- 2 new electric HPU (1 each for steering and auxiliaries) New propulsion controls
- 1.45 nm crossing, 5 round trips per day, charge at either side

New Project

(Source Becker Marine)

- **BECKER MARINE Proposed Ferry**
- 75m ferry, 480 pax and 58 cars
- Gas fuelled main engine + battery pack
- Two fully independent systems supplying two engine rooms
- LNG trailer storage tanks (x2) located in gastight garage which will be exchanged every 3 days

Svitzer ECOtugs

Barrow Isl., Australia

Courtesy Lloyd's Register (HLSA)

Four new LR classed **ECOtugs** –hybrid vessels that operate **exclusively on battery power**, while maintaining full **manoeuvrability**

33m long, 13m beam diesel-electric tugs with an impressive
75t bollard pull
electrical deck equipment
low-reflection paint
double wall fuel tanks
solar panel water heating
on-board water recycling

perfectly suitable for operations in one of Australia's most **environmentally sensitive** regions

technology that reduces **noise and light emissions** thus minimise the impact that the tug operations have on **sea life**

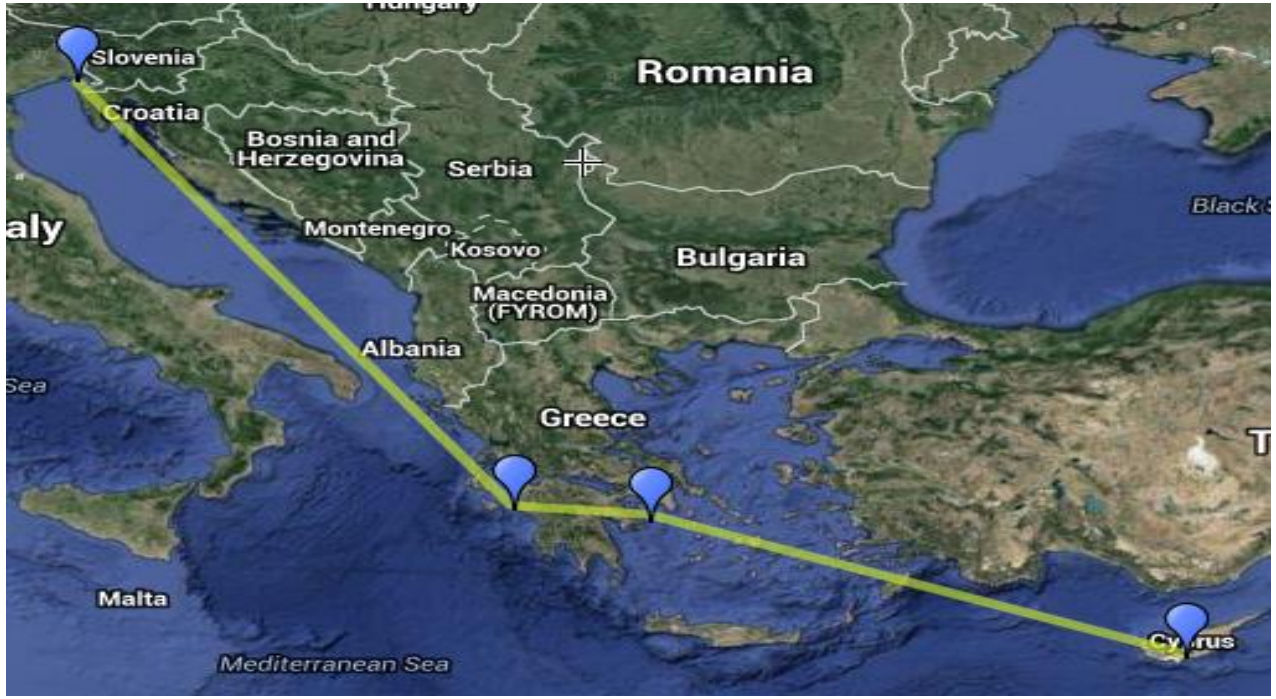
Other

- Special type vessels (eg., supply vessels, tugs, ‘sightseeing vessels’)

And not Only…

- Floating moving dock/passageway (SeaWalk™)

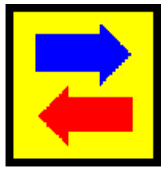
ELEMED and the Greek Potential



ELEMED – **EL**ectrification of the **E**ast **MED** Corridor through the extensive use of Cold Ironing and the introduction of electricity as a propulsion alternative

Societal & Environmental Benefits

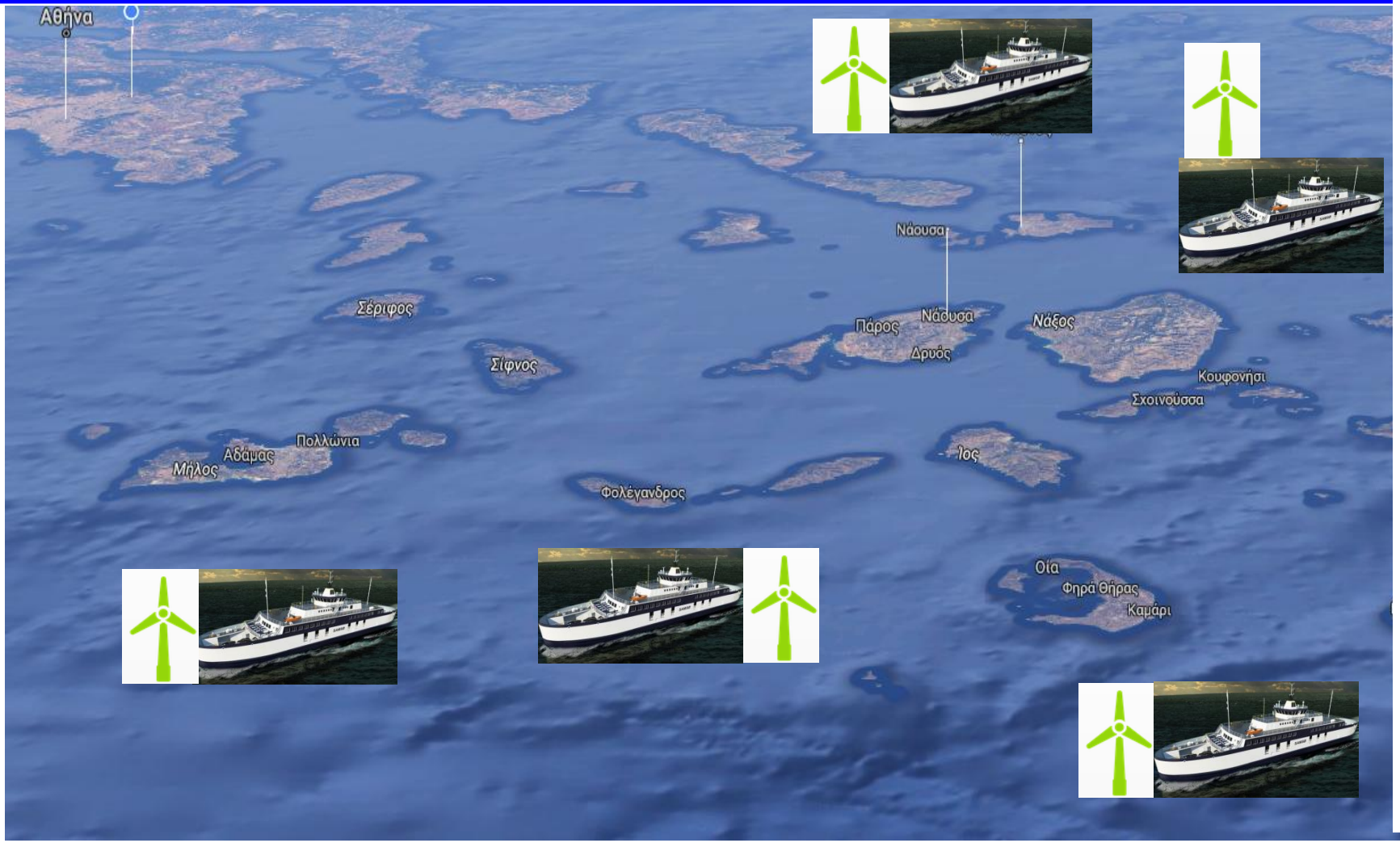
- Substantial benefits to public health and the environment
- Reduction of air emissions in the ports and the usually densely populated surrounding areas
- Reduction of noise and vibrations from ships at berth
- Upgrading of the quality of life with prospective growth in other sectors: trade, tourism
- Alignment with EU directive for SOx emissions (2020) and potential upcoming directives for NOx emissions
- Sustainable solution for compliance with the recent historical international agreement for climate change that sets medium- (2020) and long- (2050) targets for the end of the fossil fuel era and redirection to clean energy sources (Paris Agreement 2015 – COP21)
- **Sustainable connectivity for islands in archipelago states**



Financial & Operational Benefits

- Exploitation of low-carbon electric energy generated by inland power stations
- Promoting commercial implementation & port competitiveness
- Preparing ports for use of alternative energy sources, Ports connection to Smartgrid
- Preparing ports for accommodation electric/hybrid ships
- **Boosting sustainable shipping with emphasis in short and mid-range mobility**
- Introducing zero emission solutions and blending the renewable energy with the shipping sector
- **Revival of the local ships construction activity, especially for smaller ships (such as open type ferries for smaller local connections), which is the only *non-dead shipbuilding* activity in Greece**
- Enhancing employment in the wider shipping industry
- Boosting growth by accelerating technology uptake
- **Making island mobility more sustainable**

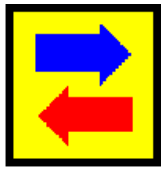
The Greek Potential



- Dense inter-island connections
- Combine renewable sources and transportation
- Maximum positive societal benefit
- Opportunity to involve local communities

The Greek Potential – Realistic Applications

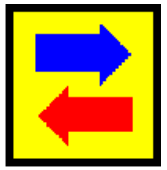
- Greek small distance connections Γραμμές και πλοία πορθμείων.xlsx
- Intra-Cyclades connections
- Intra-Dodekanissa connections
- Intra-Ionian connections
- e.g. Pollonia-Kimolos (hybrid)
- e.g. Kylini – Zakynthos
- e.g. Piraeus – Islands in the Saronic Gulf
- etc.



Possible Categories (Greek Legislation)

- Δ – Waterways of Shortsea Shipping (Πλόες Μικρής Ακτοπλοίας)
- Ε – Waterways of Restricted Length (Πλόες Περιορισμένης Έκτασης)
- ΣΤ – Regional Waterways (Τοπικοί πλόες)
- Ζ – Waterways in Protected Areas (Πλόες εντός Προστατευμένων Περιοχών)

* Categories ΣΤ and Ζ may be served by “open-type” vessels, as well.



General characteristics of vessels serving routes ΣΤ & Ζ

- L (Length) : 60 – 100 m
- B (Beam) : 14 – 20 m
- T (Draft) : 1,7 – 2,7 m
- Vservice : 6.5 – 8.5 kn
- Passengers : 300 – 600 prs
- Cars : 100 – 200
- Trucks : 20 – 50
- Most of them Double-Ended
- Year Built : 2000-2016

Ship's Main Machinery consists of:

- 2 or 4 Main Diesel Engines of 300 kW – 600 kW each
- 2 or 4 Azipod Thrusters
- 2 or 3 Electric Generators of total power 200 kVA – 400 kVA
- 1 Emergency Generator 50 – 80 kVA

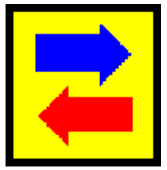
Electric Retrofit Case

INSTALLATION OF :

- ADEQUATE No. OF BATTERIES ACCORDING TO OPERATIONAL PROFILE
- ELECTRIC MOTORS DRIVING THRUSTERS
- BATTERY MANAGEMENT SYSTEM
- VENTILATION UNITS OF BATTERY SPACE
- SUITABLE RETROFIT OF THE SHIP ELECTRICAL NETWORK

REMOVAL OF :

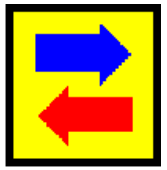
- MAIN DIESEL ENGINES
- ELECTRIC GENERATORS
- FUEL TANKS
- FUEL PUMPS & RELATED GEAR



Ro/Pax “Spyridon S”

- Loa = 105.5 m
- Lwl = 89.7 m
- B = 18.1m
- D = 3.9 m
- T = 2.7 m
- Vs = 6.5 kn
- Double-Ended

- Route : Perama – Salamina



MAIN MACHINERY

- M.E. : 4 x CATERPILLAR C18 599 BHP@1800 RPM
- 4 x VETH-Z DRIVE @ 599HP
- GEN. : 2 x CUMMINS 110 KVA
  1 x CATERPILLAR 88 KVA

Ro/Pax “Spyridon S”

AFTER TAKING INTO CONSIDERATION :

- I.M.O. rules (S.O.L.A.S. , MAR.POL.)
- Greek-flag state rules
- Classification rules
- Desired Operational Profile for max. 9 trips/day
- Available Battery solutions in the Market
- Vessel’s Stability
- Battery’s Specs for max. Life Cycles

RESULTS :

- Installed Energy : 1.34 MWh
- 756 Battery Modules (Valence U27-36XP)
- Weight : 14.74 tn
- Volume : 8.9 m^3

Ro/Pax "Spyridon S"

Total Installation Cost = 2.367.399 €

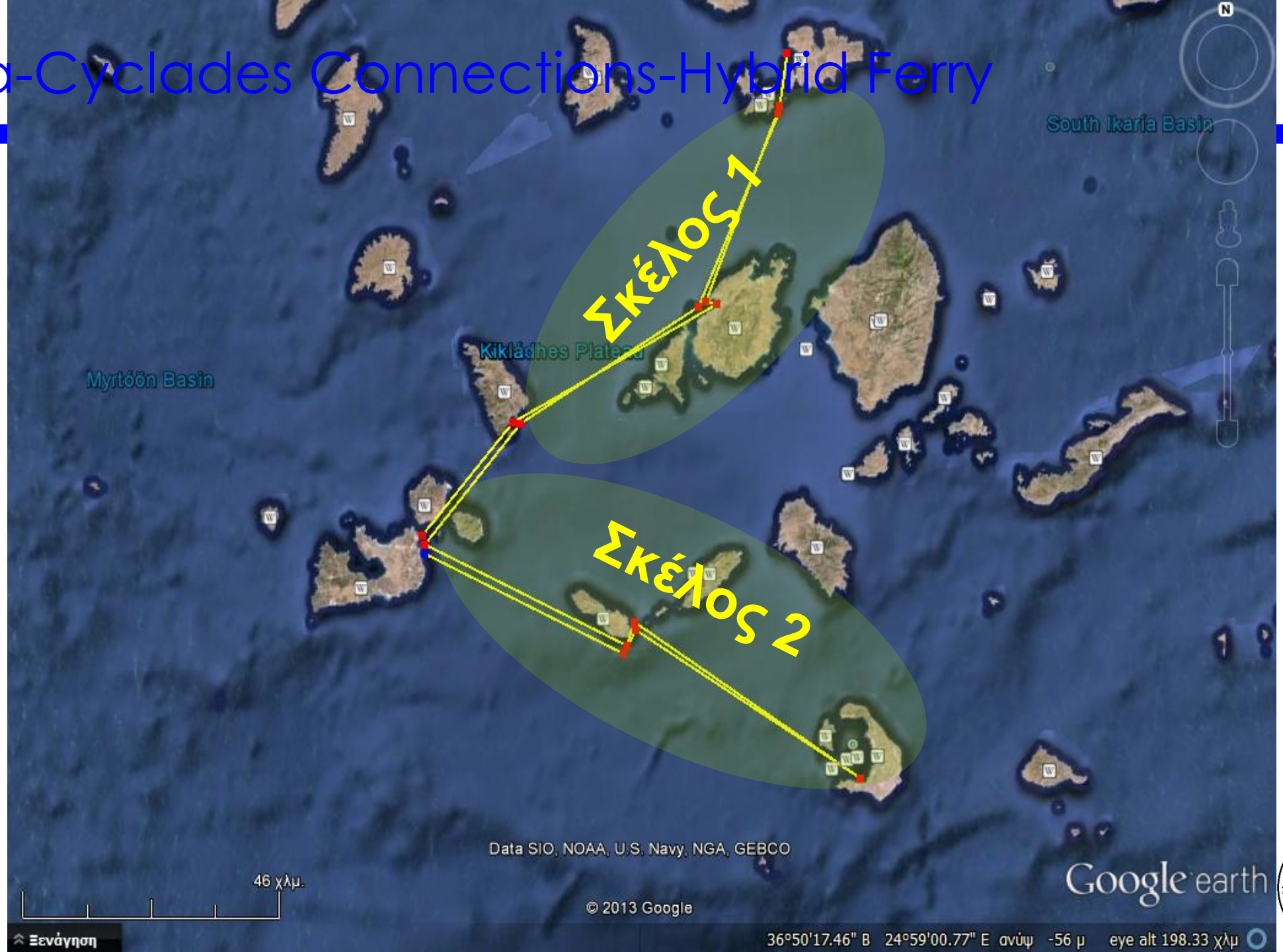
- Including purchase of:
  - Battery Modules
  - Battery Management System
  - Battery Inverters
  - Motor Drives
  - Electric Motors
- And sale of existing:
  - Main Engines
  - Electric Generators

Savings from operating on Batteries:

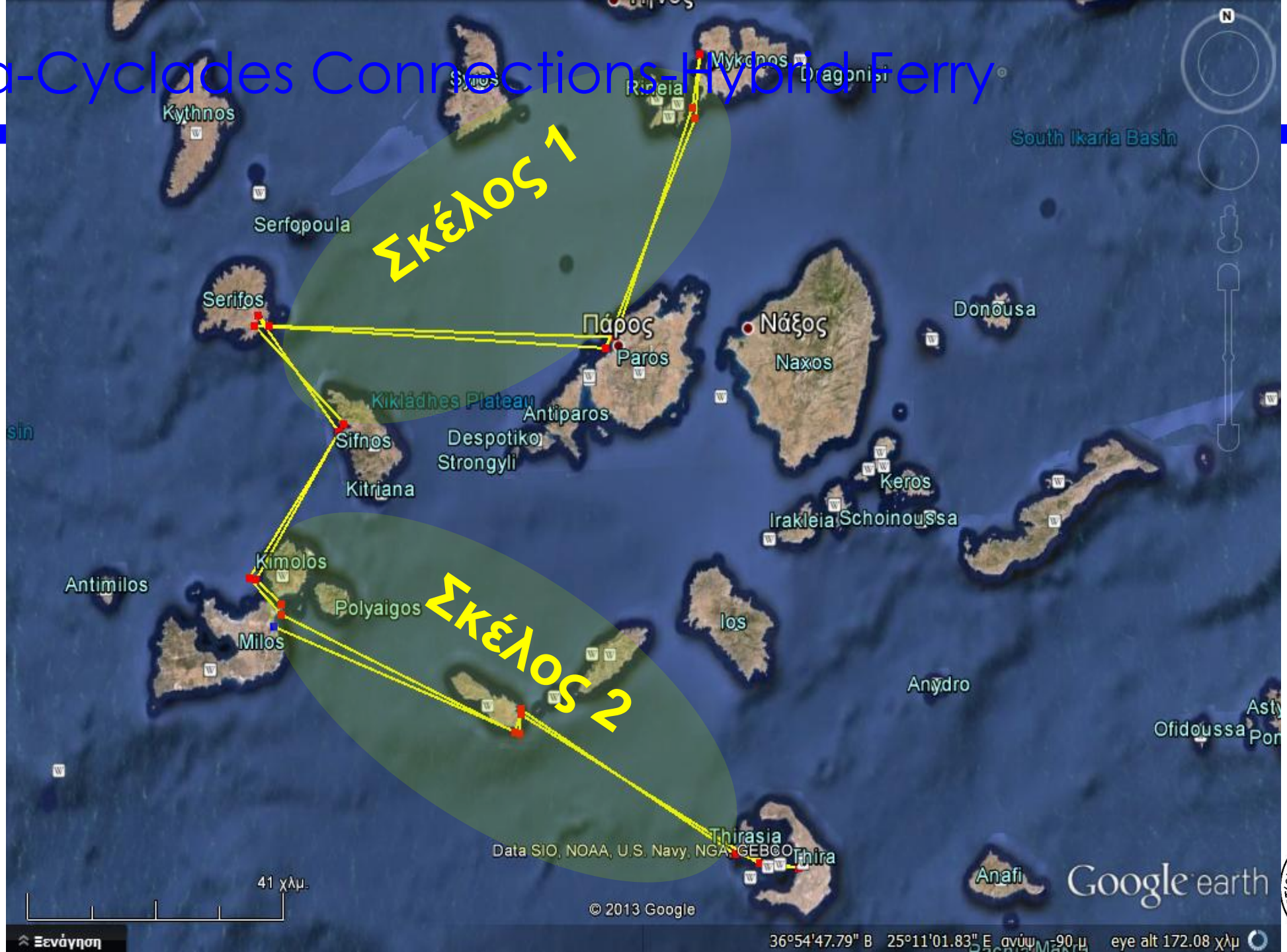
- From Fuel Consumption = 22.370 €/year

  (assuming oil price growing rate = 3.5% /year & electricity price growing rate = 1% /year)
- From O & M expenses = 11.492 €/year
- *Rough* Profit in 7 year period operation : 308.000 €

Intra-Cyclades Connections-Hybrid Ferry



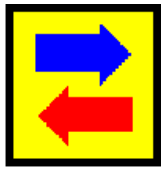
Intra-Cyclades Connections-Hybrid Ferry



Intra-Cyclades Connections-Hybrid Ferry

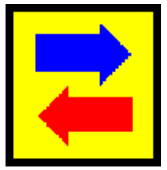
Requirements

- Port infrastructure
- Island connection to electrical grid or own sources
- (Smart grid integration in ports)
- Exploit synergies between energy and transport
- (Possibly) a different island connection network (hub & spoke)
- Further exploit renewable energy sources for clean energy and for *additional* electricity requirements
- *Funding or financing the investments*
- *Regulatory requirements*



Funding & Financing

- National Development Programmes (ΕΠΑΝΕΚ, etc.)
  - Now more market focused but still including the element of research/innovation
  - Bureaucracy/Administrative nightmare
  - Limited budget
- H2020
  - Large consortia
  - Research focused (TRL mainly 2-7)
  - Not really for *actual* applications
  - Academia/industry/end user collaboration
  - Does not usually fund major hardware items

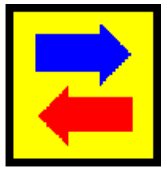


Funding & Financing

- EASME/COSME, SME Funding
- EIB
  - Green Shipping Scheme
  - Green Shipping Programme
  - SME financing (EIAH)
- EFSI (Juncker Plan)
- Connecting Europe Facility (TRL 7 or 8)
  - MoS
  - Innovation etc.
  - Energy (PCI)

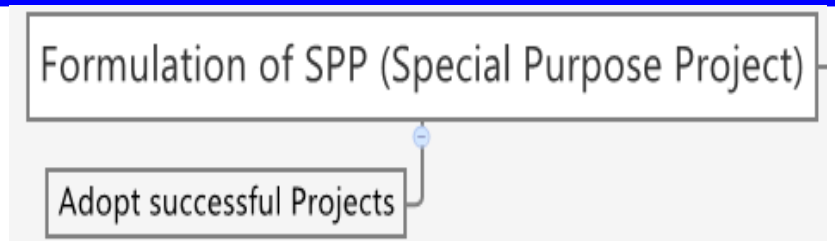
Funding & Financing

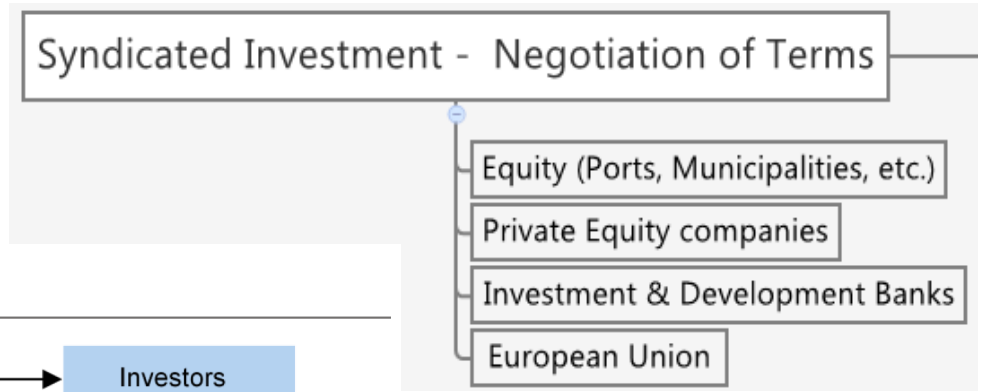
- Connecting Europe Facilty (CEF) (*not suitable*)
  - Will pay for pilot activities
  - Works, studies or work with study
  - Up to 20, 30, 50 or 85% of eligible costs
  - Can include significant items of hardware
  - Cannot include any research
  - *Small* focused consortia / *Large* investments
  - TRL 7 or 8



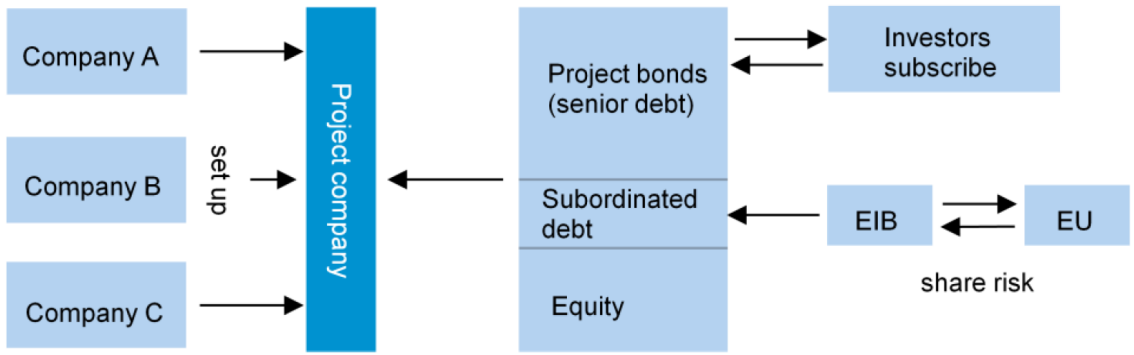
Innovative/Alternative Financing

- Project Bond Initiative
- PPP's
- Innovative Financing/PDA
- Crowd Funding
- Blending Equity, Funding, Private and Public Financing
- Involve Local Communities





Project Bond Initiative



Sources: European Commission, EIB, DB Research schematic interpretation

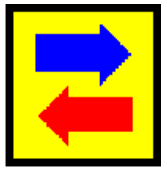
Regulatory and Policy Requirements

- *Regulatory*
  - Regulatory framework update
  - Open minded regulation
  - Electricity as an alternative fuel

- *Policy*
  - Ship investment (general attitude towards vehicles)
  - Vessel as infrastructure (?)
  - Redefinition of MoS / Derrogation for insular regions (?)

Conclusions

- Possible? • YES!
- Potential? • YES!
- Easy? • YES technically! • NO financially!
- Need? • Regulatory upgrade (GR)
  • Policy upgrade (EU)



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Thank You !