An Industry-Government-Public-Academia Collaborative to Develop the Project Implementation Framework for Clean Energy Repurposing Projects

ROICE Initiatives Overview
Techno-Economic Study Phase 1 Results

Sep 2023
Objective: Develop a comprehensive framework for successful repurposing projects in the Gulf of Mexico
SHOWPLACE / ROICE Drivers

Over **1500 platforms still operating**; several hundreds being prepared for decommissioning - potentially candidates for repurposing for clean energy projects such as wind power, hydrogen generation, CO$_2$ sequestration

Over **13,000 mi of active natural gas pipelines** and over 15,000 mi of abandoned pipeline that could potentially be retrofitted to transport hydrogen to shore.

Opportunity to utilize end-of-life infrastructure for one to two more decades for safe, clean energy projects, jobs & revenue generation

**Lower carbon footprint** to repurpose vs new build; preserving existing positive biodiversity and environmental ecosystems impacts

**Many challenges**: structural integrity, remaining life, regulatory requirements, cost of repurposing, variable wind speeds in the GOM etc.

Requires **strong collaboration between government / industrial / academic** bodies to develop effective technical, commercial and regulatory frameworks

SHOWPLACE and ROICE will facilitate such collaboration and **generate roadmaps for successful ROICE projects**
Objective: ROICE Workgroups will develop the implementation framework for clean energy repurposing projects – currently focused on wind, hydrogen and CO₂ sequestration

Scope: Three-pronged approach – Regulatory, Commercial and Technical; Informed by ROICE techno-economic study

Deliverable: Project Implementation Framework via a set of white papers delivered by each sub-group by 2Q24

Each Workgroup Needs to Address:
- What is the current state of knowledge / processes?
- What needs to change to make ROICE Projects feasible and successful?
- Any show-stopper challenges?
- What does a roadmap for the change look like and what resources are needed?

7 ROICE Workgroups
(# of Current Members)

Regulatory Considerations (RC) Workgroups
- RC-1: Regulatory Requirements & Pathways (11)

Commercial Considerations (CC) Workgroups
- CC-1: Project Scope, Scale & Business Models (7)
- CC-2: Financing, Uncertainties & Risk Management (6)

Technical Considerations (TC) Workgroups
- TC-1: Decommissioning & Reuse (13)
- TC-2: Re-certification (7)
- TC-3: Transportation & Storage (9)

Status Update
- Workgroups kicked off; work sessions underway
- Open to more members
- Progress Review Workshop – September 29th at UH

Participants
ABS
Apache
Baker Hughes
BP
CHF
Cox Oil
DNV
Elena Keen Consulting
Endeavor Mgmt
Enterprize Energy
Genesis
GOR
Gulf Wind
Hatenboer Water
Hess
Oil States
Siemens Energy
Smart Pipe
Subsea7
Technip Energies
Technip FMC
TSB
UH
Wood PLC
WSP
Xodus
YAC
SHOWPLACE envisions extending the use of existing end-of-life oil and gas infrastructure for clean energy (ROICE) projects instead of decommissioning.

ROICE concepts being examined in initial phases include wind power generation and hydrogen generation:

- Install fixed or floating wind turbines around the oil & gas platform
- Export power to shore or use power to generate hydrogen
- Reuse the platform jacket and deck to house new topsides supporting power and/or hydrogen generation
- Hydrogen generated via desalination of seawater and electrolysis of fresh water
- Hydrogen brought to shore using new or reused pipelines

Phase 1 Work Completed:

- Levelized Cost Model developed for ROICE projects
- Levelized Cost Heat Maps developed for Wind and Hydrogen projects in the US Gulf of Mexico
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Phase 1 Work Completed
- Levelized Cost (LC) Model developed for ROICE projects in the GOM
- LC Heat Maps developed for Wind and Hydrogen projects
- Assets Shortlisted for detailed study in Phase 2

Phase 1 Research Team (SRT)
- Dr. Ram Seetharam, PI
- Yugbhai Patel, Junior, Honors Program Physics
- Younas Mohammed, Ph. D. Candidate, Geosciences
- Paulo Liu, Ph. D. Candidate, Pet Eng

Advisory Board
- American Bureau of Shipping
- AquaTerra
- Ayatis / DSIDER
- Bentley
- Blacksmith Group / PPIC
- Bureau of Economic Geology
- Center for Houston’s Future
- Elena Keen Consulting
- Endeavor Mgmt Group
- Enterprice Energy
- GE
- Grid Advisors
- Hatenboer
- Lummus Consultants
- McDermott
- Microsoft
- NEL / Proton Energy
- Noble Corp
- NREL
- Power 2 Hydrogen
- Rodi Systems
- Siemens
- Siemens Energy
- SinnPower
- Subsea 7
- Technip Energies / Genesis
- Technip FMC
- WSP
- XODUS Group
Levelized Costs for ROICE projects in the GOM

- Levelized costs for ROICE projects are a complex function of various variables – wind speed, water depth, distance to shore, project size, new build vs. repurposed.

- LC’s for repurposed wind projects in the GOM range from $82 to $231 per MWh. Equivalent new build projects have LC’s ranging from $82 to $437.

- LC’s for repurposed hydrogen projects in the GOM range from $4.76 to $8.44 per kg of hydrogen. Equivalent new build projects have LC’s ranging from $4.77 to $19.64.
Repurposing has the dual impact of reducing capex and shortening project schedule.

Most cost-effective to reuse the jacket and the deck; remaining equipment decommissioned as per normal practice. Pipelines can be repurposed to transport hydrogen to shore, although the technology for that is not fully proven for offshore applications.

Repurposing has a positive impact on LC - more pronounced for projects where platform costs form a larger fraction of total project capex - deeper water projects and smaller scale projects.

Shallow water / near-shore locations have the lowest LC for all cases - new build or repurposed, power or hydrogen projects. Repurposing improves LC by 5 to 10% for these locations.

In deeper waters, hydrogen projects & repurposing more attractive. Repurposing reduces LC up to 25% for large projects and up to 60% for small projects.

For smaller power generation project in deeper waters, repurposing highly recommended – reduces the LC by as much as half vs new build.
LC’s for offshore projects are higher than equivalent low-carbon onshore projects, and even more challenged versus high-carbon alternatives.

Federal and state incentives (up to $3 / kg of hydrogen) could make projects at the lower end of LC range competitive.

Additional LC reductions can be achieved through efficient design, technology improvements and cost reductions over time.

Where repurposing has a significant impact, overall LC is high even with repurposing. Stronger government incentives and major cost reductions will be needed to make these competitive.
Project Capex Influencers

- Project size is a major influence on project capex, as expected. Most of the costs scale with the size of the projects.

- Water depth has a strong influence on structural costs in two ways
  - Wind turbine foundations: In shallow water depths, fixed foundation costs increase with water depth; In deeper waters (> 80m) costs of floating foundations are not dependent on water depth
  - Equipment support platform: For new build projects, this is a cost that increases with water depths. For repurposed projects, this cost is not incurred, as shown in

- Distance to shore influences the two product delivery components – export cables and pipelines. For the project specs considered here, these costs do not scale with project size.

- Repurposing has an impact on structural costs through the reuse of existing oil & gas structures to house electrical support equipment and hydrogen generation equipment.

- New build projects will have to incur the cost of a new platform.

- Repurposing pipelines also has an impact on capex, avoiding the cost of a newly installed pipeline.

<table>
<thead>
<tr>
<th>Power Projects: Capex Influencers</th>
<th>Project Size</th>
<th>Water Depth</th>
<th>Distance to Shore</th>
<th>Repurposing</th>
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Hydrogen vs. Power Export

- Hydrogen project trades off power export cables and offshore substation for electrolyzers, desalination units and hydrogen pipelines.

- For new build cases, and for larger scale repurposed cases, this tradeoff only results in a ~10% increase in capex for hydrogen export projects over equivalent power export projects.

- For small scale repurposed cases, switching to hydrogen can even result in a 10 to 15% reduction in capex, assuming pipeline reuse.

- Incremental economics for hydrogen generation likely to be promising in all cases, especially with healthier federal incentives

- Levelized costs are less dependent on project size for repurposed hydrogen projects, thus enabling small scale capex investments that still have attractive returns
Conclusions

- Offshore low carbon hydrogen has a role to play in decarbonization of energy. ROICE projects (Repurposing Offshore Infrastructure for Clean Energy) can improve project economics for clean hydrogen generation.
- Challenges remain: Levelized Costs (LC) range is higher than equivalent low-carbon renewables-based onshore projects, and even more challenged versus high-carbon alternatives.
- However, projects at the lower end of the range of LC’s across the GOM have the potential to be competitive through efficient design, cost reductions and use of federal and state incentives.
- Repurposing reduces capex and shortens the schedule of implementation of ROICE projects.
- Shallow water / near-shore locations appear to have the lowest LC for all cases - new build or repurposed, power or hydrogen projects. Repurposing improves the LC by 5 to 10%.
- Further away from shore, in deeper waters, repurposing can reduce the LC by up to 25% for larger scale projects and up to 60% for smaller scale projects.
- Incremental economics on additional CAPEX for hydrogen generation is likely to be promising, with healthier federal incentives for hydrogen production.
- Unlike power projects, hydrogen projects maintain their economic feasibility in deeper waters and over a range of project sizes.
Phase 2 Plans

- LC’s estimated for all ~1500 assets in the federal waters of the GOM
- 40 assets selected with favorable LC’s (mostly near shore assets)
- 10 other assets added based on other criteria – deeper water, in different geographical areas, proximity to an available pipeline or wind lease areas etc.
- Optimized ROICE designs for these 50 locations to be developed in Phase 2
- Open to include any assets of interest to stakeholders

Top 40 Assets

<table>
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<tr>
<th>Asset Name</th>
<th>Initial Cost ($)</th>
<th>LC</th>
<th>ROICE</th>
<th>No. of Assets</th>
<th>Phase 2 Plans</th>
<th>Top 50 Asset Location</th>
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<td>LC’s</td>
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<td>Phase 2 Plans</td>
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Top 50 Asset Location

- Galveston
- Galveston-II
- Lake Charles
- Houston
- New Orleans
- Galveston
- Galveston-II
- Lake Charles
- Houston
- New Orleans

BOEM Lease Areas

Federal State Boundary

0 75 150 Km