

# REPURPOSING OFFSHORE INFRASTRUCTURE FOR CLEAN ENERGY *(ROICE)*



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



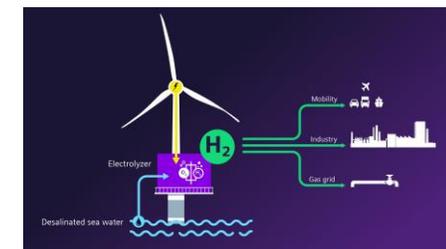
Division of Energy and Innovation  
UNIVERSITY OF HOUSTON

## ROICE Initiatives Overview Techno-Economic Study Phase 1 Results

Sep 2023



Courtesy: Endeavor Management



Courtesy: Siemens Gamesa

# UH Energy ROICE Initiatives

## ROICE:

# REPURPOSING OFFSHORE INFRASTRUCTURE FOR CLEAN ENERGY



## SHOWPLACE Techno-Economic Study

Techno-Economic  
Framework For  
Repurposing in GOM

Initially Focused on Wind  
and Hydrogen

Advisory Agreement  
(30+ Companies)

Federal and State Funding

Led by UH Energy

## ROICE Workgroups

Project Implementation  
Framework For Repurposing in  
GOM

Initially Focused on Clean Energy  
and Carbon Storage

Open to All Stakeholders  
(30+ participants)

Self Funded Participation

Coordinated by UH Energy

**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<sub>2</sub> 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.

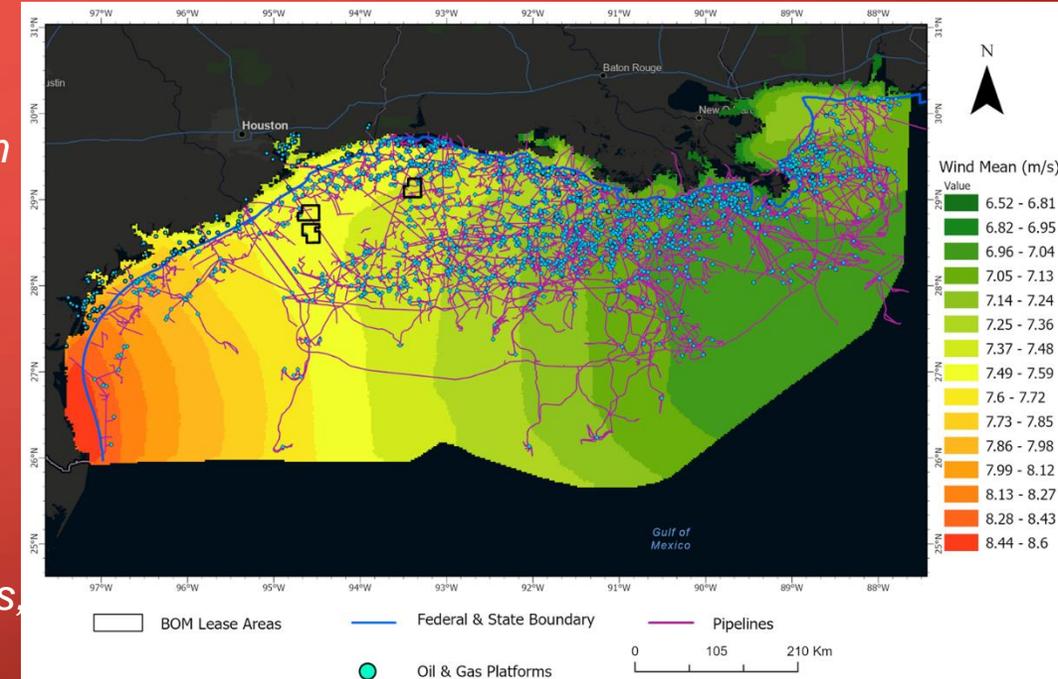
Opportunity to **utilize end-of-life infrastructure for one to two more decades for safe, clean energy projects, jobs & revenue generation**

**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**



Mean Wind Speed (m/s)

# ROICE Workgroups – Project Implementation Framework

**Objective:** ROICE Workgroups will develop the implementation framework for clean energy repurposing projects – currently focused on wind, hydrogen and CO<sub>2</sub> 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)
- RC-2: Financial Assurance & Decommissioning (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 29<sup>th</sup> at UH

## Participants

ABS  
Apache  
Baker Hughes  
BP  
CHF  
Cox Oil  
DNV  
Elena Keen Consulting  
Endeavor Mgmt  
Enterprize Energy  
Genesis  
GORI  
Gulf Wind  
Hatenboer Water  
Hess  
Oil States  
Siemens Energy  
Smart Pipe  
Subsea7  
Technip Energies  
Technip FMC  
TSB  
UH  
Wood PLC  
WSP  
Xodus  
YAC

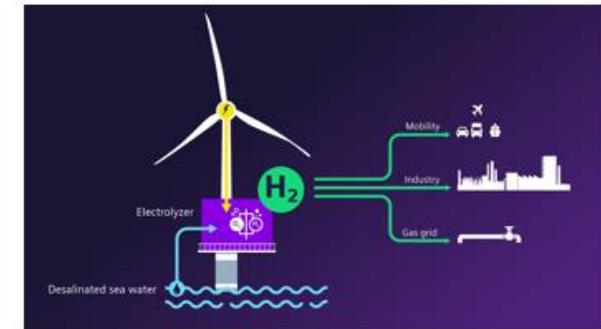


# The SHOWPLACE Concept

- ❑ 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



Courtesy: Endeavor Management



Courtesy: Siemens Gamesa

# ROICE Techno-Economic Study

- ❑ Envisions extending the use of existing end-of-life oil and gas infrastructure for clean energy (ROICE) projects instead of decommissioning.
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  - ❑ Hydrogen brought to shore using new or reused pipelines
- ❑ 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)

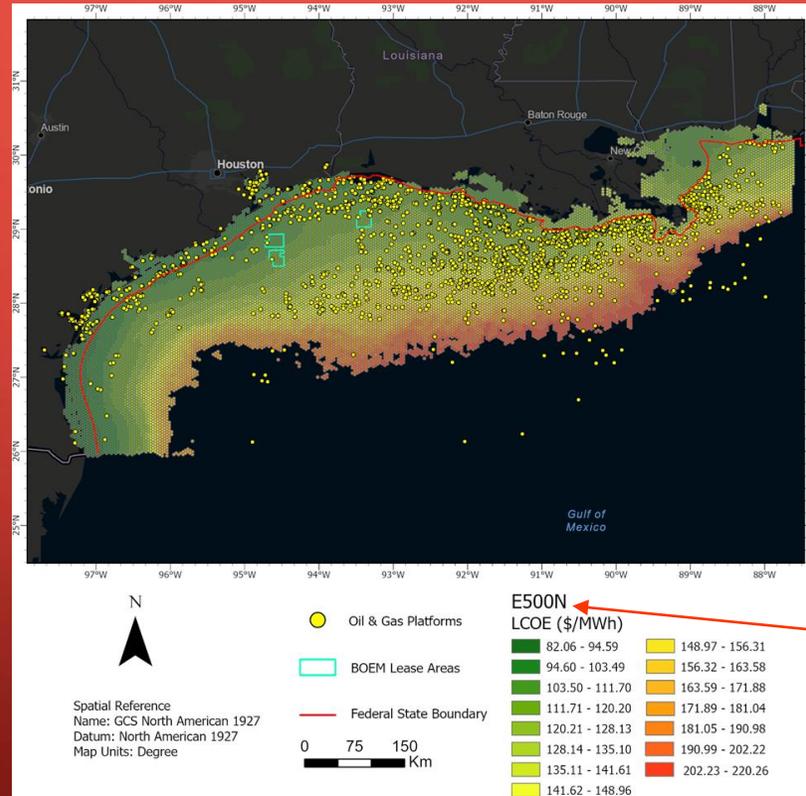
- Dr. Ram Seetharam, PI
- Yugbhai Patel, Junior, Honors Program Physics
- Younas Mohammed, Ph. D. Candidate, Geosciences
- Paulo Liu, Ph. D. Candidate, Pet Eng

## Advisory Board

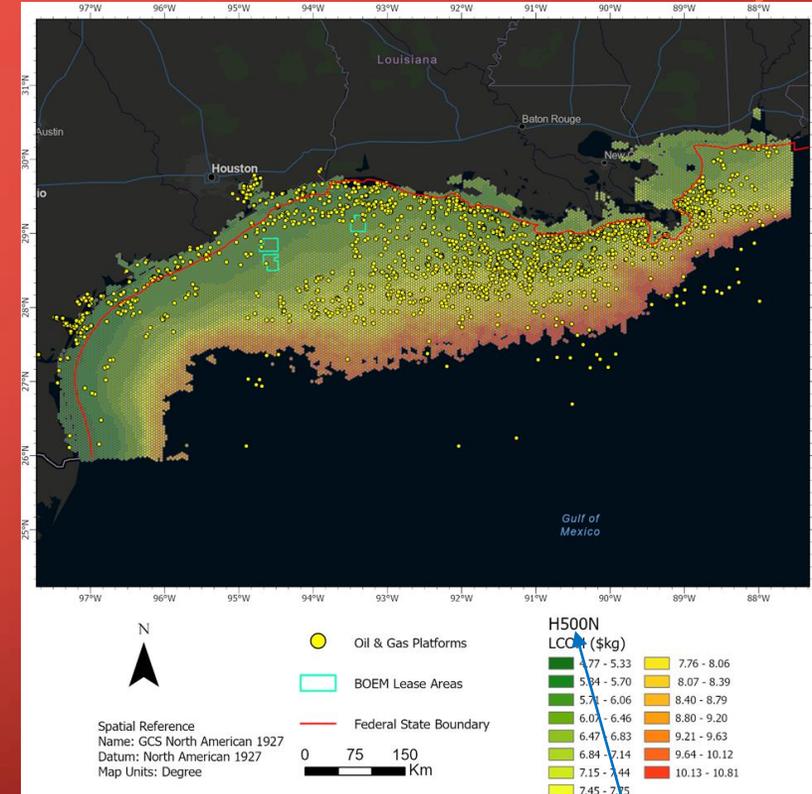
American Bureau of Shipping  
AquaTerra  
Ayatis / DSIDER  
Bentley  
Blacksmith Group / PPIC  
Bureau of Economic Geology  
Center for Houston's Future  
Elena Keen Consulting  
Endeavor Mgmt Group  
Enterprize Energy  
GE  
Grid Advisors  
Hatenboer  
Lummus Consultants  
McDermott  
Microsoft  
NEL / 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.



Heat Map for 435 MW New Build Power Export Project



Heat Map for 435 MW New Build Hydrogen Export Project

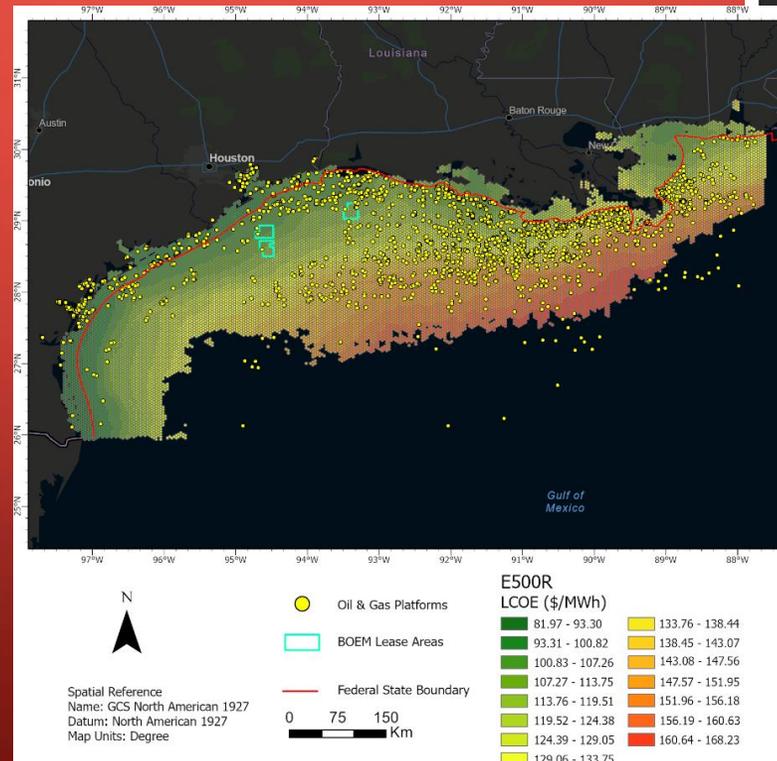
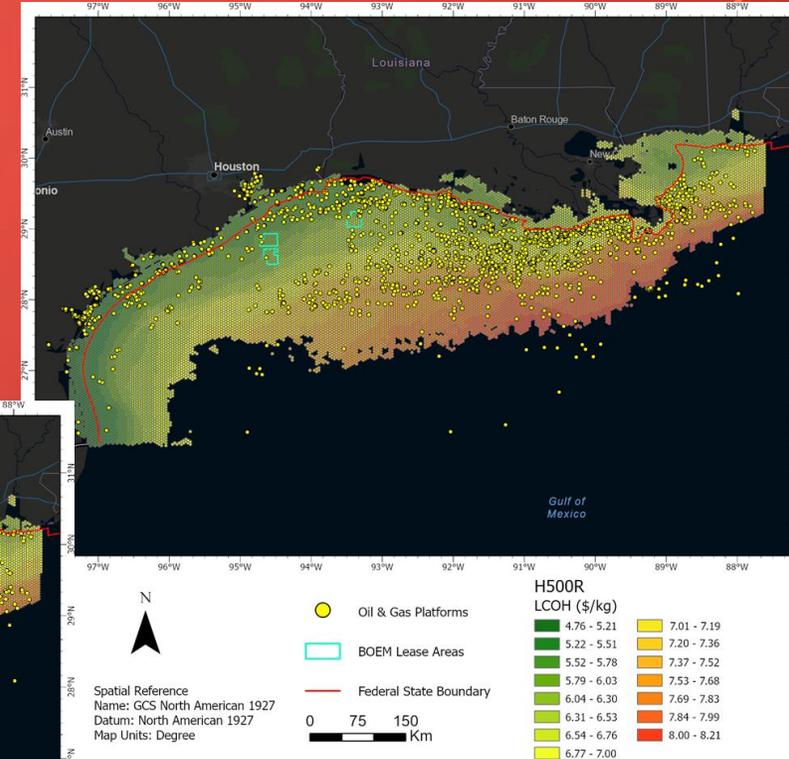
Case Nomenclature

Product	Capacity	Repurposing	New Build
Power	435 MW	E500R	E500N
	105 MW	E100R	E100N
Hydrogen	435 MW (180 MW Electrolyzer Capacity)	H500R	H500N
	105 MW (40 MW Electrolyzer Capacity)	H100R	H100N

# Phase 1 Results: Impact of Repurposing

- 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.

Capex Reduction from Repurposing		
Power	Shallow	Deep
435 MW	99%	93%
105 MW	98%	81%
Hydrogen		
Power	Shallow	Deep
435 MW	97%	85%
105 MW	88%	61%

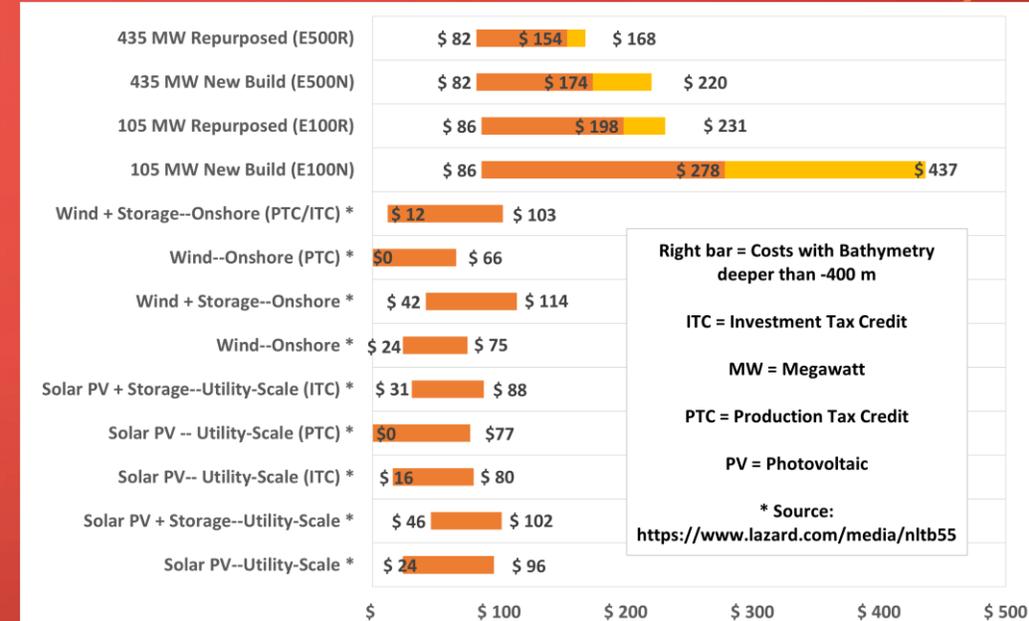
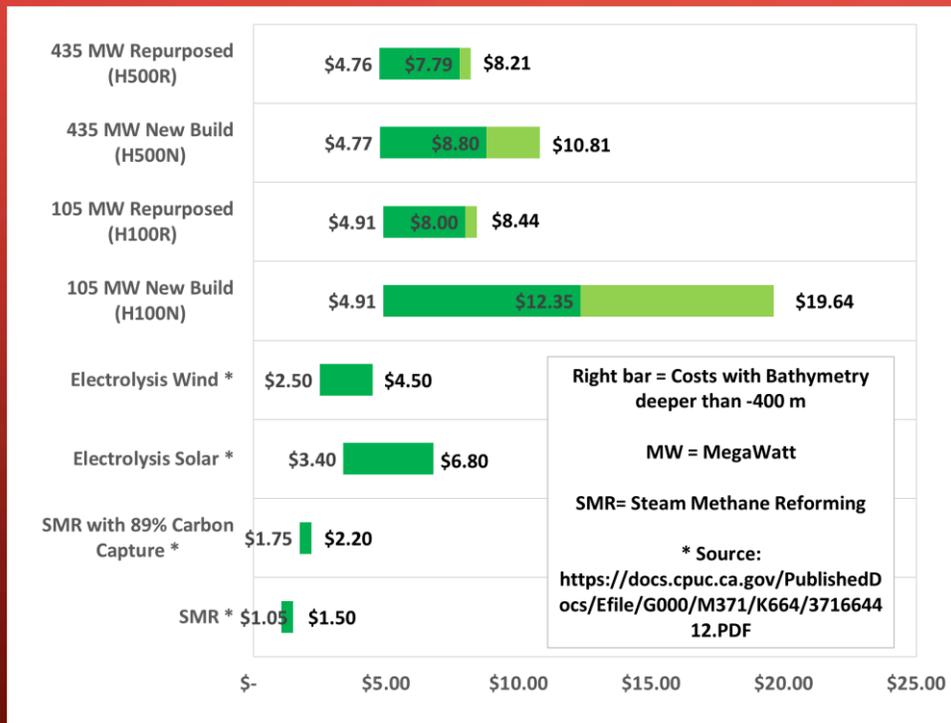


Heat Map for 435 MW Repurposed Hydrogen Export Project

Heat Map for 435 MW Repurposed Power Export Project

# Offshore Project Competitiveness

- 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.



LC Comparison for Power Projects

- 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.

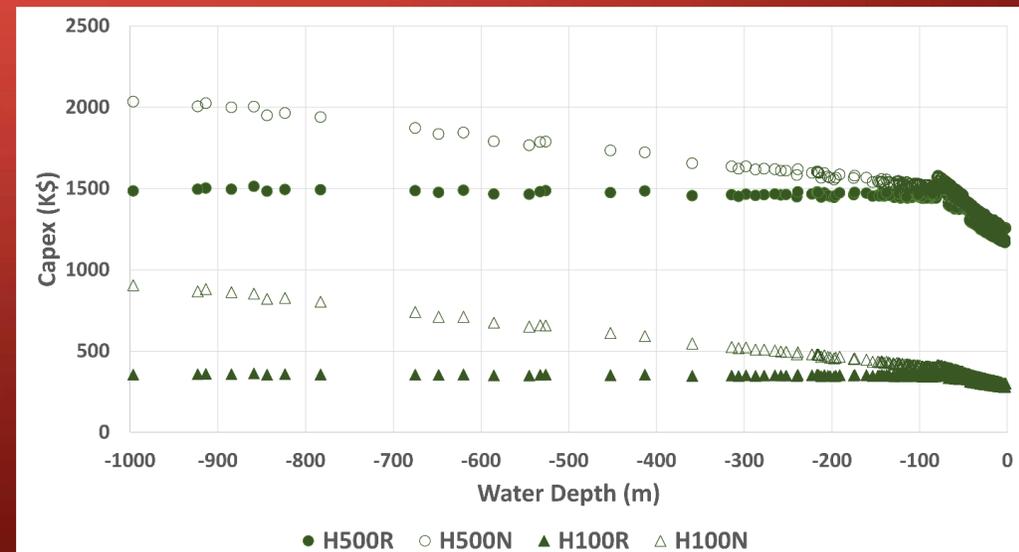
LC Comparison for Hydrogen Projects

# 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 increases 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 inceases 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.

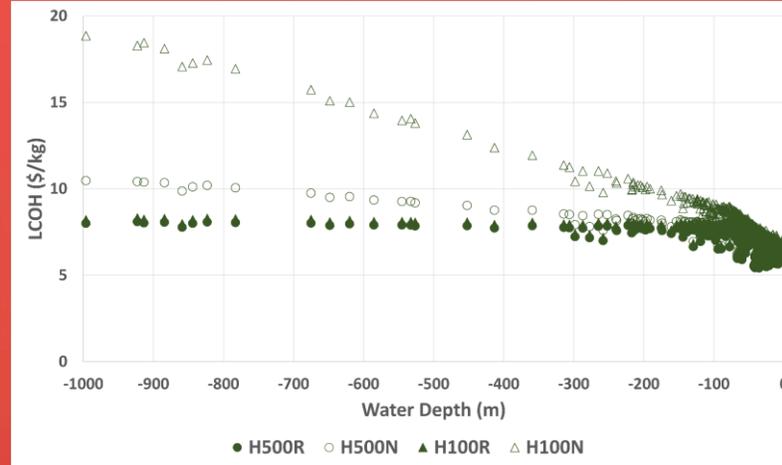
Power Projects: Capex Influencers	Project Size	Water Depth	Distance to Shore	Repurposing
WTG costs	√			
Structural Costs	√	√		√
Cables			√	
On-Shore Substation	√			
Off-Shore Substation	√		√	

Hydrogen Projects: Capex Influencers	Project Size	Water Depth	Distance to Shore	Repurposing
Electrolyzer	√			
Structural Costs		√		√
Pipeline			√	√
Compressor	√			
Desalination	√			



# 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



Hydrogen Capex vs Power Capex		
Repurposed	Shallow	Deep
	435 MW	108%
105 MW	87%	83%
New Build	Shallow	Deep
	435 MW	111%
105 MW	97%	111%

Major CAPEX Components	E100N	E100R	E500N	E500R
WTG costs	195.3	195.3	809.1	809.1
Structural costs (Foundations and Installations)	43.4	34.2	146.7	137.6
Cables	151.1	151.1	182.1	182.1
On-Shore Substation	2.0	2.0	4.2	4.2
Off-Shore Substation	3.8	3.8	15.8	15.8
Project Development Fixed costs	97.6	97.6	404.2	404.2
Total CAPEX	493.2	484.0	1562.2	1553.0

## Project Capex for a Typical Shallow Water Project (M\$)

Major CAPEX Components	H100N	H100R	H500N	H500R
Electrolyzer	48.0	48.0	216.0	216.0
Structural costs (Foundations and Installations)	10.5	1.3	10.5	1.3
Compressor	3.9	3.9	14.6	14.6
Desalination	1.2	1.2	3.4	3.4
Pipeline	74.8	26.2	74.8	26.2
Power Generation	339.0	339.0	1404.2	1404.2
Project Development costs	3.2	2.7	12.2	11.8
Total CAPEX	484.3	423.5	1,739.4	1,678.7

Major CAPEX Components	E100N	E100R	E500N	E500R
WTG costs	195.3	195.3	809.1	809.1
Structural costs (Foundations and Installations)	251.4	90.1	527.4	366.2
Cables	283.7	283.7	332.8	332.8
On-Shore Substation	19.1	19.1	79.0	79.0
Off-Shore Substation	22.9	22.9	94.8	94.8
Project Development Fixed costs	97.6	97.6	404.2	404.2
Total CAPEX	869.9	708.6	2,247.3	2,086.1

## Project Capex for a Typical Deepwater Project (M\$)

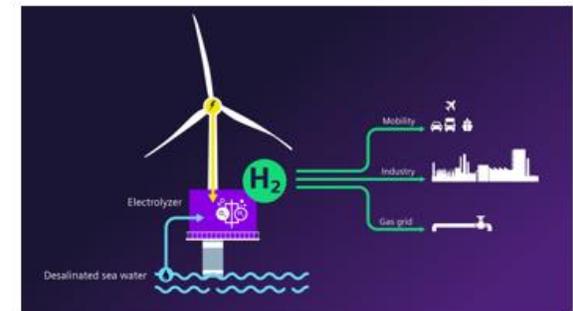
Major CAPEX Components	H100N	H100R	H500N	H500R
Electrolyzer	48.0	48.0	216.0	216.0
Structural costs (Foundations and Installations)	163.5	2.3	163.5	2.3
Compressor	3.4	3.4	12.7	12.7
Desalination	1.2	1.2	3.4	3.4
Pipeline	323.1	113.1	323.1	113.1
Power Generation	415.7	415.7	1731.5	1731.5
Project Development costs	10.8	2.7	19.8	11.7
Total CAPEX	981.8	592.0	2,486.3	2,096.5

# 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.



Courtesy: Endeavor Management



Courtesy: Siemens Gamesa

# 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

OBJECTID	Area Code	Block #	Auth. Status	Asset Details				Power Proj Rank	Hydrogen Proj Rank	Total Rank	LC for Hydrogen \$/kg				LC for Power \$/MWh			
				Bus Asc Name	Install Date	Latitude	Longitude				H500R	H100R	H500N	H100N	E500R	E100R	E500N	E100N
1404	WC	48	<Null>	Cox Operating, L.L.C.	2/20/2000	29.68298	-93.7474	1	4	5	5.72	5.89	5.73	5.92	101.26	115.58	101.41	116.19
1393	WC	46	TERMIN	Energy XXI GOM, LLC	10/14/2002	29.65965	-93.6673	4	3	7	5.71	5.88	5.72	5.92	102.02	118.71	102.22	119.51
1440	WC	48	UNIT	Cox Operating, L.L.C.	11/15/2003	29.68602	-93.7292	2	6	8	5.72	5.89	5.73	5.92	101.26	115.58	101.41	116.19
1384	WC	44	PROD	Sanare Energy Partners, LLC	5/24/2003	29.65248	-93.569	8	2	10	5.70	5.87	5.72	5.93	103.30	123.86	103.54	124.83
1392	WC	48	UNIT	Cox Operating, L.L.C.	6/9/2003	29.67495	-93.7604	3	8	11	5.73	5.90	5.74	5.94	101.70	116.45	101.87	117.10
1400	WC	21	PROD	Sanare Energy Partners, LLC	10/6/2005	29.70257	-93.54	5	14	19	5.78	5.95	5.79	5.99	102.86	118.41	103.02	119.06
370	HI	176	TERMIN	Walter Oil & Gas Corporation	2/14/2011	29.18171	-94.3699	10	9	19	5.74	5.91	5.76	5.99	104.93	127.71	105.28	129.10
1405	WC	95	TERMIN	Energy XXI GOM, LLC	1/3/2005	29.55721	-93.4719	16	5	21	5.71	5.88	5.72	5.93	105.35	131.55	105.61	132.55
288	GA	209	PROD	Arena Offshore, LP	10/13/1999	29.12999	-94.546	6	15	21	5.73	5.90	5.75	5.98	102.66	119.10	103.03	120.57
380	HI	176	TERMIN	Walter Oil & Gas Corporation	4/9/2012	29.1816	-94.3698	11	11	22	5.74	5.91	5.76	5.99	104.93	127.71	105.28	129.10
292	GA	209	PROD	Arena Offshore, LP	8/9/1996	29.13028	-94.5466	7	16	23	5.73	5.90	5.75	5.98	102.66	119.10	103.03	120.57
443	MI	657	TERMIN	Matagorda Island Gas Operations,	5/15/2008	28.04209	-96.605	23	1	24	5.58	5.72	5.60	5.81	104.79	136.91	105.24	138.67
1391	WC	96	UNIT	Talos Third Coast LLC	9/3/2004	29.5597	-93.4244	19	7	26	5.71	5.89	5.73	5.94	105.52	131.98	105.77	132.97
294	GA	288	RELQ	Blue Dolphin Pipe Line Company	4/25/2001	28.8936	-94.7042	9	26	35	5.82	5.99	5.84	6.08	105.12	126.77	105.55	128.48
654	SM	217	UNIT	Cox Operating, L.L.C.	8/30/2004	29.44075	-92.0612	24	18	42	5.84	6.01	5.85	6.03	107.75	134.95	107.84	135.32
1439	WC	62	TERMIN	Energy XXI GOM, LLC	7/27/2004	29.62733	-93.3032	34	10	44	5.75	5.92	5.76	5.98	107.26	137.06	107.53	138.10
676	SM	217	UNIT	Cox Operating, L.L.C.	9/5/2004	29.44066	-92.062	26	19	45	5.84	6.01	5.85	6.03	107.75	134.95	107.84	135.32
88	EI	10	PROD	Contango Operators, Inc.	1/8/2008	29.38232	-91.7799	12	33	45	6.06	6.23	6.06	6.25	107.11	128.40	107.21	128.78
785	SM	217	UNIT	Cox Operating, L.L.C.	6/9/2011	29.44133	-92.0621	27	20	47	5.84	6.01	5.85	6.03	107.75	134.95	107.84	135.32
1473	WC	62	TERMIN	Energy XXI GOM, LLC	12/21/2007	29.62748	-93.3029	35	12	47	5.75	5.92	5.76	5.98	107.26	137.06	107.53	138.10
169	EI	10	PROD	Contango Operators, Inc.	2/7/2007	29.3836	-91.7687	13	34	47	6.06	6.23	6.06	6.25	107.11	128.40	107.21	128.78
789	SM	217	UNIT	Cox Operating, L.L.C.	10/18/2009	29.44043	-92.0611	28	21	49	5.84	6.01	5.85	6.03	107.75	134.95	107.84	135.32
268	EI	32	PROD	Cox Operating, L.L.C.	1/1/1993	29.31151	-91.5354	20	29	49	5.91	6.09	5.92	6.11	107.49	130.19	107.57	130.52
252	EI	10	PROD	Contango Operators, Inc.	1/8/2008	29.38232	-91.7799	14	35	49	6.06	6.23	6.06	6.25	107.11	128.40	107.21	128.78
791	SM	217	UNIT	Cox Operating, L.L.C.	5/1/2009	29.4416	-92.0619	29	22	51	5.84	6.01	5.85	6.03	107.75	134.95	107.84	135.32
97	EI	11	Approved	Contango Operators, Inc.	3/17/2008	29.37895	-91.7529	15	36	51	6.06	6.23	6.06	6.25	107.16	128.68	107.27	129.09
782	SM	212	UNIT	Cox Operating, L.L.C.	6/21/2008	29.47323	-92.0487	25	27	52	5.87	6.05	5.88	6.07	107.83	133.59	107.92	133.95
1431	WC	73	RELINQ	Talos Third Coast LLC	10/12/2003	29.60715	-93.2159	39	13	52	5.75	5.92	5.76	5.98	108.10	140.13	108.36	141.14
800	SM	217	UNIT	Cox Operating, L.L.C.	7/4/2008	29.44136	-92.0625	30	23	53	5.84	6.01	5.85	6.03	107.75	134.95	107.84	135.32
804	SM	217	UNIT	Cox Operating, L.L.C.	6/22/2008	29.44137	-92.062	31	24	55	5.84	6.01	5.85	6.03	107.75	134.95	107.84	135.32
103	EI	11	Approved	Contango Operators, Inc.	3/17/2008	29.37895	-91.7529	17	38	55	6.06	6.23	6.06	6.25	107.16	128.68	107.27	129.09
195	EI	11	Approved	Contango Operators, Inc.	9/4/2010	29.37864	-91.753	18	39	57	6.06	6.25	6.06	6.25	107.16	128.68	107.27	129.09
1457	WC	65	RELINQ	Apache Corporation	4/22/2003	29.62776	-93.1721	40	17	57	5.83	5.97	5.84	6.03	110.44	144.18	110.71	145.25
441	MI	622	TERMIN	Apache Corporation	1/1/1995	28.10214	-96.3699	33	25	58	5.76	5.90	5.78	6.01	106.29	137.25	106.83	139.41
92	EI	10	PROD	Contango Operators, Inc.	6/12/2006	29.3759	-91.7842	21	37	58	6.29	6.25	6.08	6.28	107.94	130.62	108.05	131.04
690	SM	223	UNIT	Cox Operating, L.L.C.	3/10/2004	29.40901	-91.9923	32	28	60	5.88	6.06	5.89	6.08	108.12	134.12	108.22	134.51
194	EI	10	PROD	Contango Operators, Inc.	4/27/2007	29.37041	-91.7817	22	40	62	6.08	6.29	6.08	6.28	107.94	130.62	108.05	131.04
783	SM	223	UNIT	Cox Operating, L.L.C.	8/2/2003	29.4087	-91.9923	36	30	66	5.88	6.06	5.89	6.08	108.12	134.12	108.22	134.51
80	EI	39	PROD	Cox Operating, L.L.C.	5/1/2000	29.26035	-91.4604	37	31	68	5.93	6.11	5.94	6.13	109.08	135.30	109.19	135.76
250	EI	39	PROD	Cox Operating, L.L.C.	12/20/2004	29.26031	-91.4604	38	32	70	5.93	6.11	5.94	6.13	109.08	135.30	109.19	135.76

