Advanced Anti-Fouling Coatings to Improve the Efficiency of Coal Power Plants

AWARD NO. DE-FE0031533

Project Kickoff Meeting

Principal Investigator: Matthew Nakatsuka, PhD
Oceanit APOC: Ken Cheung, PhD, PE
Oceanit PM: Derek Ah Yo, MS
NETL PM: Gregory O'Neil

February 12, 2018

Background

- Founded 1985 in Hawai'i
- 100+ Employees
- Multi-Disciplinary Staff (25% PhDs)
- Recent Awards
  - *2016* ***Breathe Easy Innovator****, American Lung Association*
  - *2016* ***CEO of the Year****, Hawaii Business Magazine, Patrick K. Sullivan*
  - *2015* ***30 Years of Innovation*** *State (Gov/Mayor) Event*
  - *2014* ***Oceanit Spin-Out IBIS Networks wins East meets West***
  - *2013* ***Commitment to Green Employer of the Year,*** *Pacific Edge*
  - *2012* ***Outstanding Civil Engineering Achievement Award*** *– Best Study & Research Project, ASCE*

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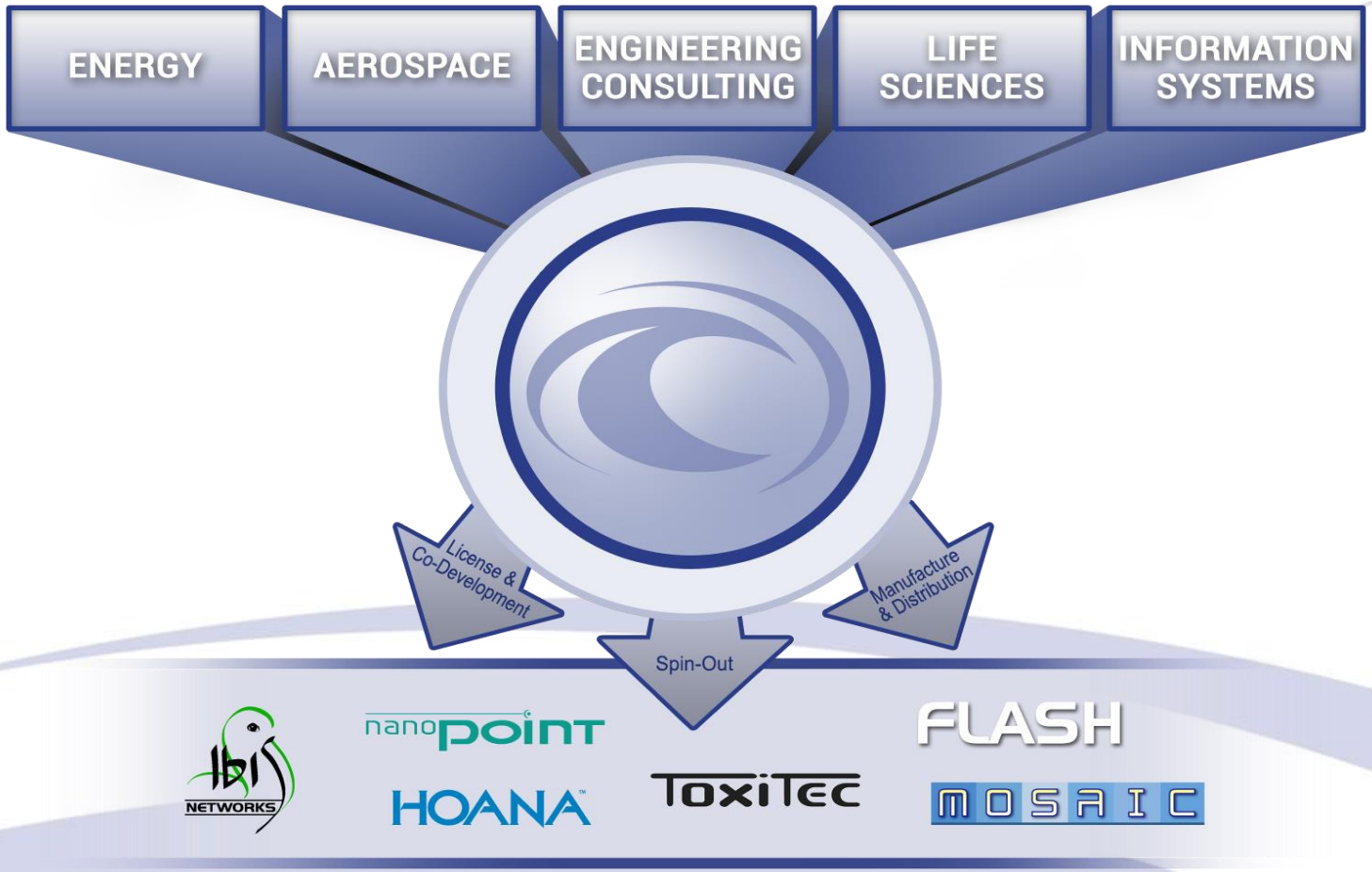
Business Model



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Innovation Process at Oceanit

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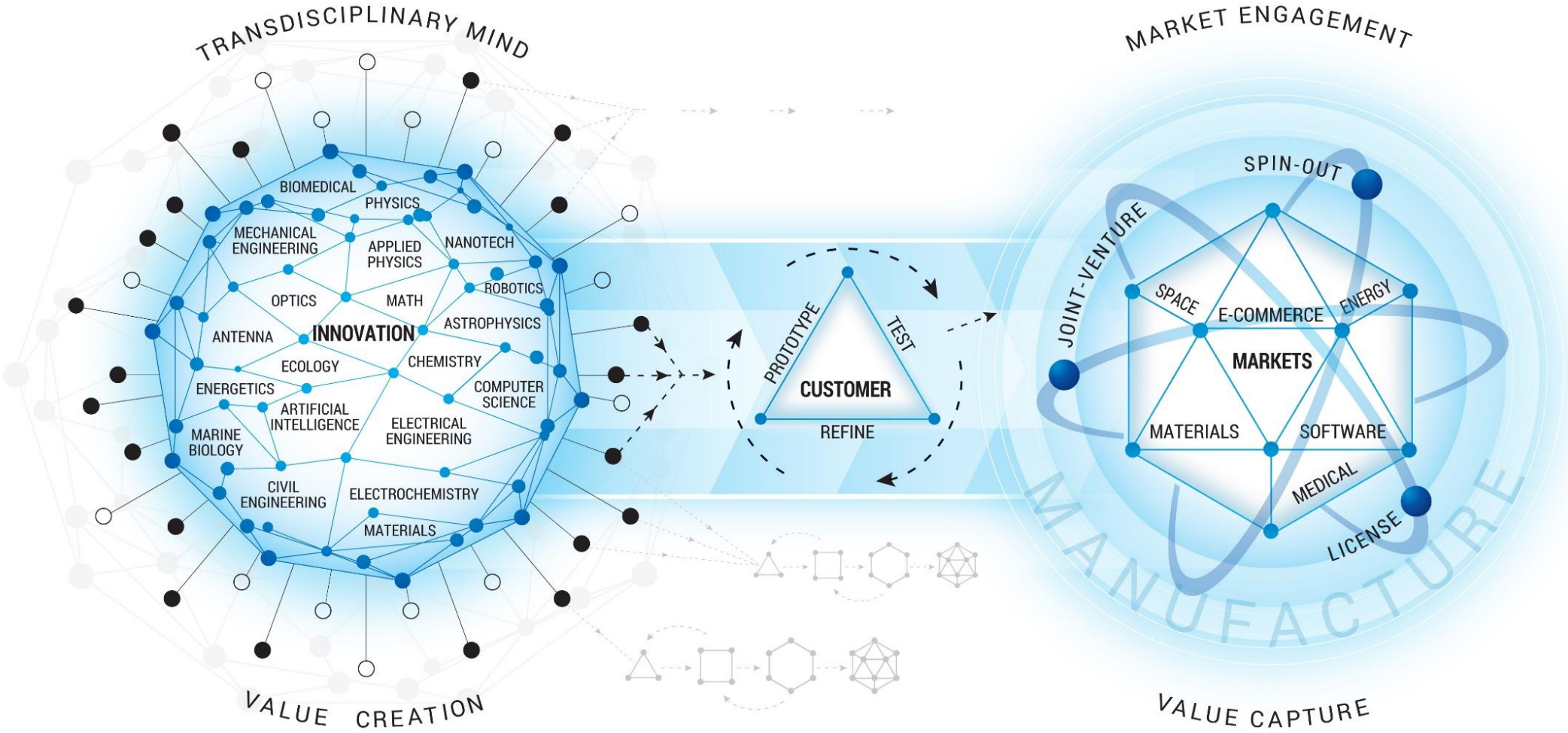
Mind to Market



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Partner: Shell Oil Company

Lab to Field

Rapid Prototype
Electrochemical Process Line

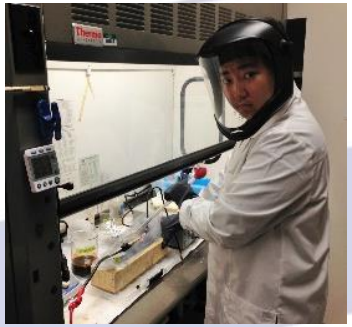
3 Mo

1.5 Mo

Tests in Unconventional Pilot Wells

Advanced Nanocoating for
Well Production Casing

3 Mo



Result:

- Oceanit coating far exceeds performance of industry state-of-the-art coatings for drill string pipe

Lab to Full-Scale Pilot in less than 1 year!

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Pilot Facility

Result:

- Full deployment of over 6,000’ of treated pipe in both unconventional land and off-shore Gulf of Mexico wells.
- Results from field deployment show that SCIN treatment significantly increases the confidence from sonic cement logging.
- Pilot plant was made operational within 4 months, and conformed to all Shell’s HSE requirements.

All manuscripts will be sent through an XML tagging process that will standardize the look of the paper and create links for figures, equations, and references. Figures and tables should be placed directly after the first paragraph they are mentioned in. The XML tagging will not alter the technical content of the paper.

OTC-27893-MS

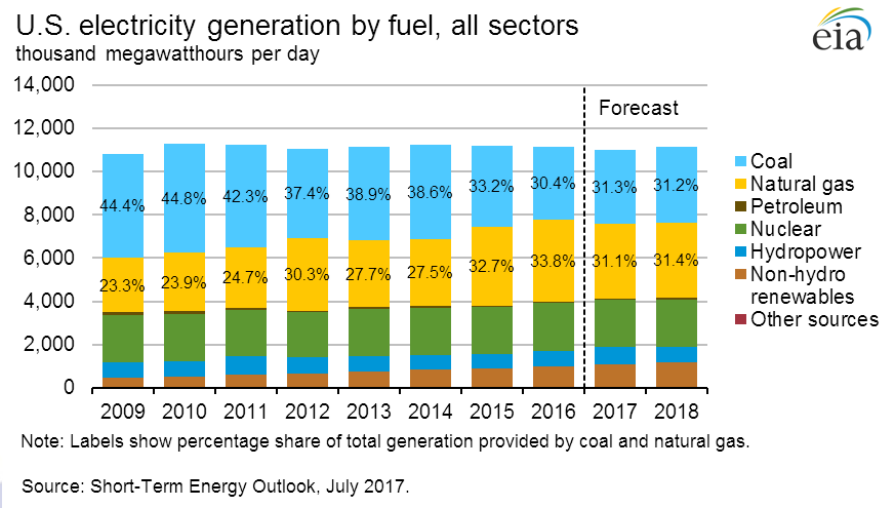
Development of Nanotechnology Pipe Treatment to Improve Acoustic Cement Evaluation

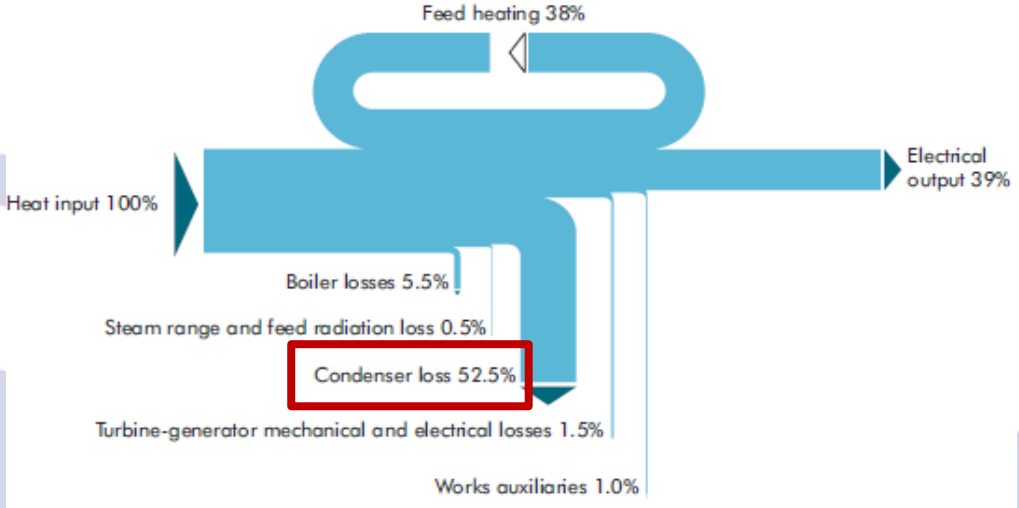
James Heathman, George Fuller, and Rebecca Taylor – Shell International Exploration & Production; and Ganesh Arumugam, Patrick Sullivan, Sumil Thapa, and Vinod Veedu - Oceanit

This paper was prepared for presentation at the Offshore Technology Conference held in Houston, Texas, USA, 1–4 May 2017.

Background

- Coal is projected to be an essential part of the U.S. energy portfolio going forward, however, existing fleet of power-plants are under significant economic pressure.
- One area in which economic efficiency gains can be realized is in reducing condenser loss; roughly 50%+ of generated heat is lost during condenser operation.





Improved Efficiency through Condenser Improvements

- Even a 2% loss due to fouling or deposits can lead to $1M + in additional fuel consumption per year.
- Most solutions currently available either have long payback periods with significant CAPEX, or cannot be used on existing equipment.
- Near-term, quickly deployable technology that makes sense for both operator and regulatory agencies is necessary to be economically competitive.

Improvement	Range of heat rate benefit	Payback period
Improving combustion controls and monitoring	0.25%–1.00%	<1 year
Increased condenser cleaning and repair of air leaks	0.30%–2.00%	<1 year
Turbine seal improvements	0.50%–2.30%	1–3 years
Increased feedwater heater monitoring, maintenance, and repair	0.20%–1.00%	1–3 years
Air heater seal repair or upgrade	0.10%–0.50%	2–3 years
Preheating combustion air with waste heat	0.10%–0.30%	2–3 years
Increased cleaning of turbine deposits	0.25%–3.50%	2–4 years
Low-pressure turbine blade upgrade	1.00%–2.00%	2–4 years
Replacement of main fan motors with variable frequency drives	0.20%–0.50%	3–5 years
Solar combustion air heating	0.25%–0.75%	>5 years
Solar feed water heating	3.00%–7.00%	>5 years

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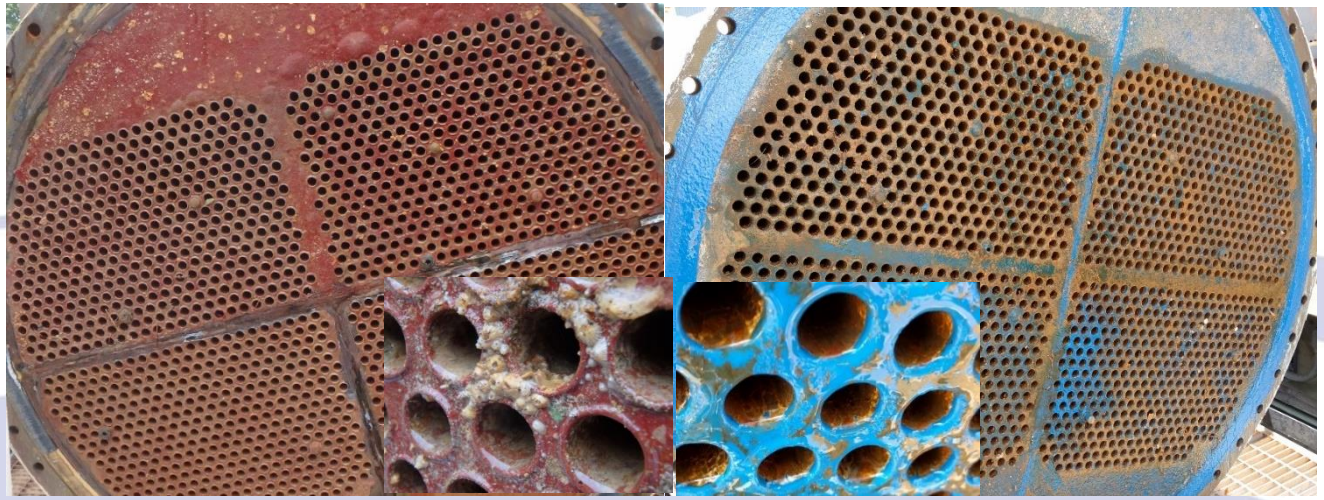
Oceanit Approach - HeatX™

- HeatX™ is an advanced nanocomposite coating designed to provide anti-fouling and corrosion protection for heat transfer equipment.
- Extremely thin application (> 4mil) allows for application directly to heat transfer surface without significant efficiency loss.
- Water-based formulation contains no VOCs and no biocides.
- Superior adhesion allows for 1-step application to in-place, previously in-service equipment.

After 6 months of operation



Uncoated **Coated**

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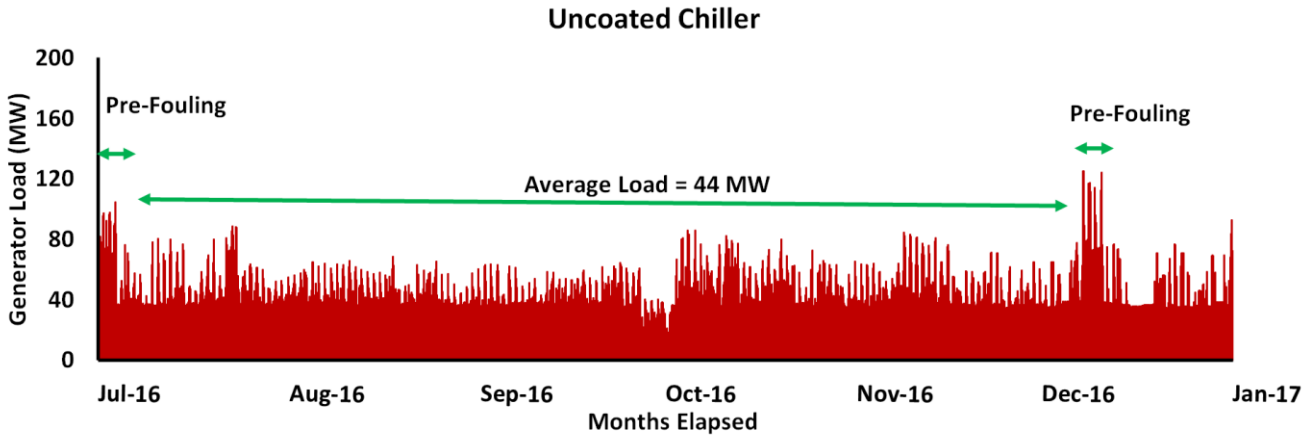
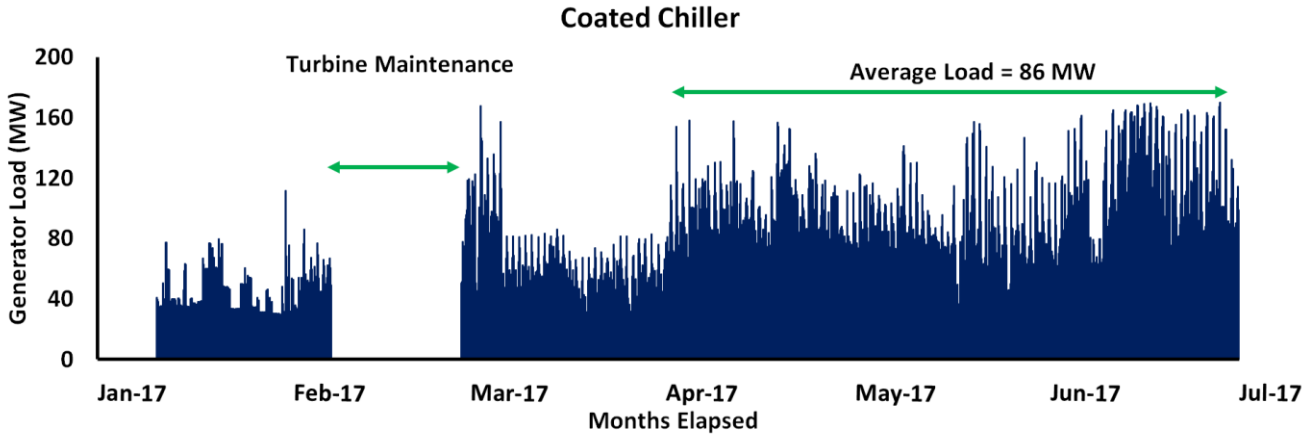
HeatX™: Field Application

Partner: Hawaiian Electric Company

Hawaiian Electric





HeatX™ coated chiller can handle twice the load of an uncoated chiller, and requires maintenance 1/3 as often.

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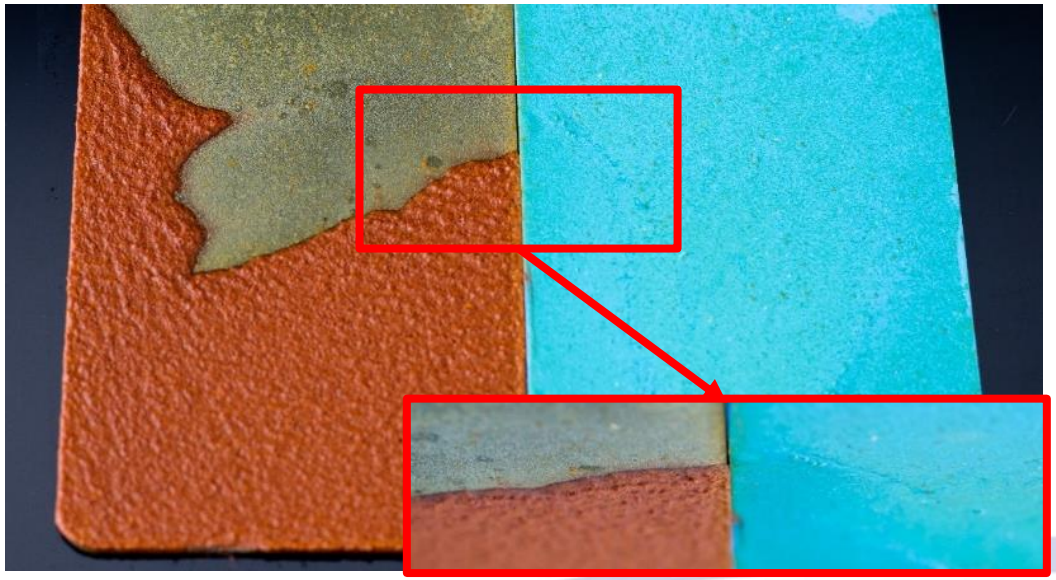
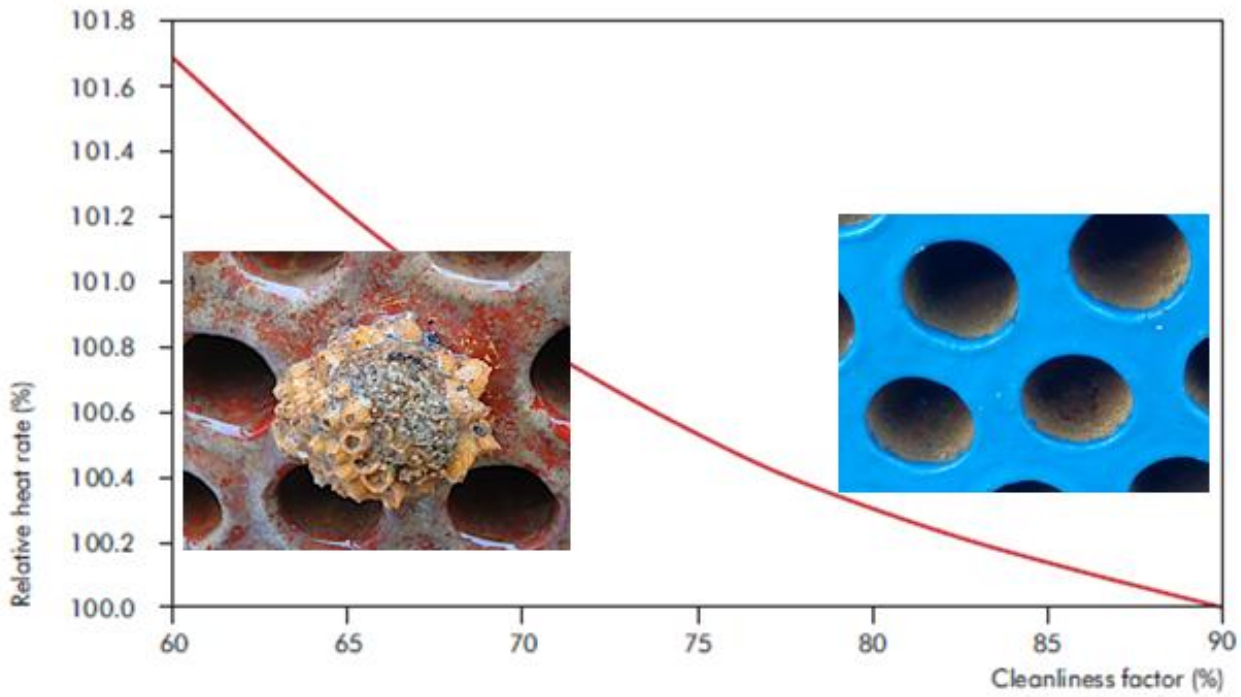
Reduction in Biofouling

Biofouling Resistance



Uncoated

Coated



Fouling alone can reduce overall system efficiency by 2% or more after as little as 45 days.

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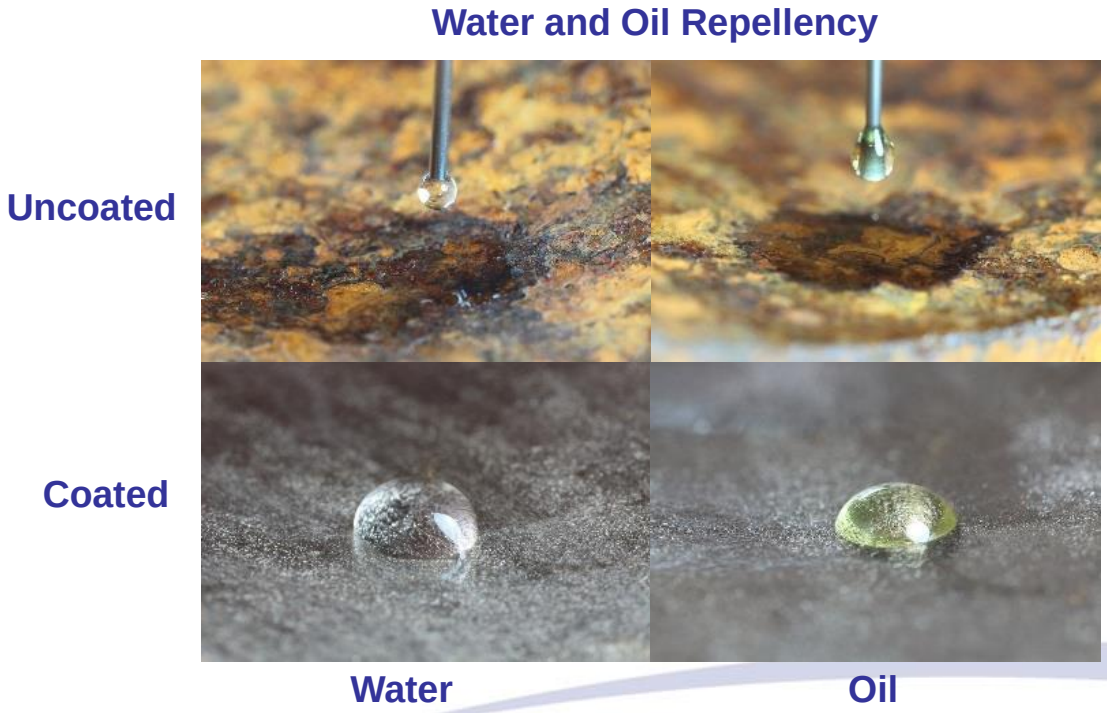
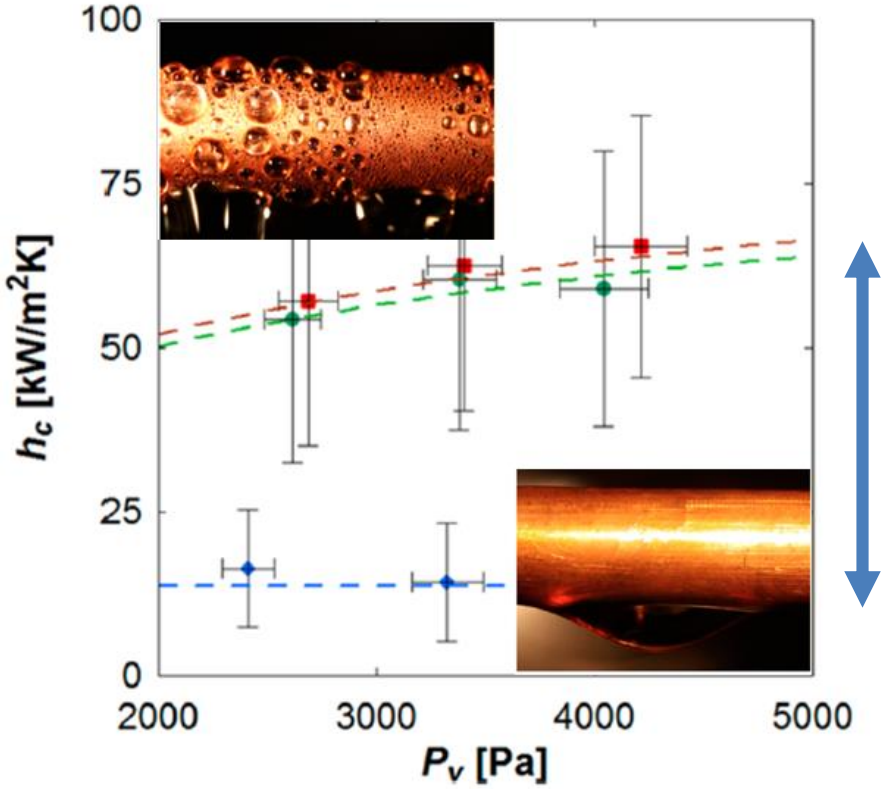
Promotion of Dropwise Condensation





Water repellency can result in up to 400% theoretical improvement in heat transfer coefficient.

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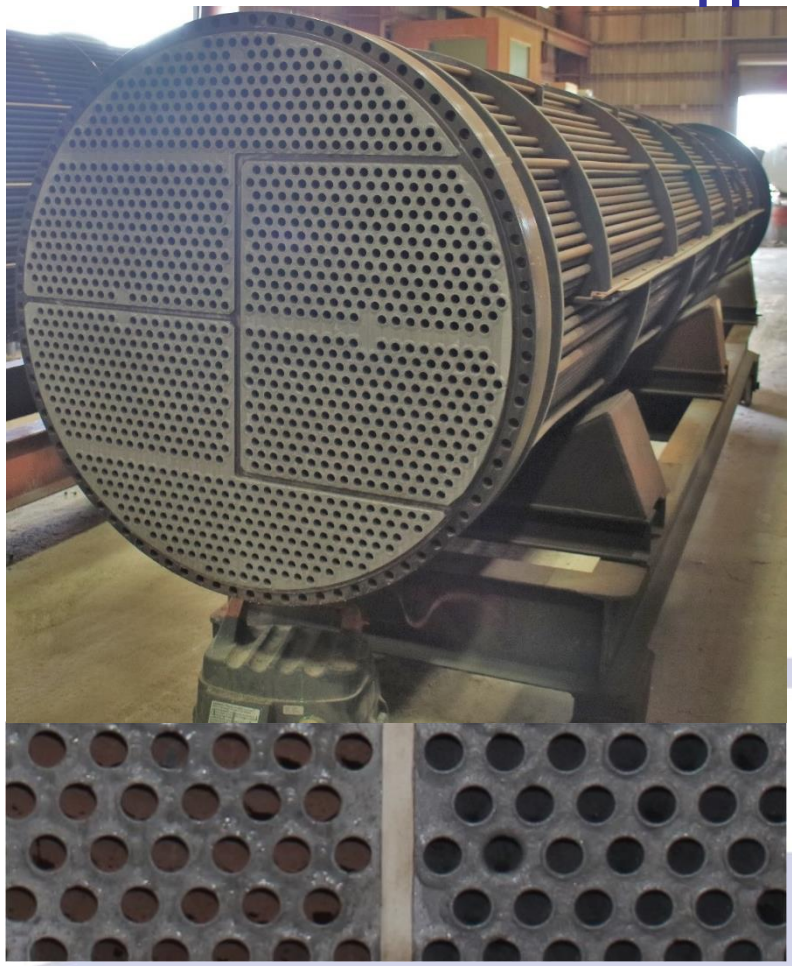
Application in-situ

Corrosion Protection and in-situ application



Uncoated Coated

- Application on in-place exchanger/condenser unit does not require significant capital expense.
- HeatX™ specific formulation allows for extremely long pot-life (> 72 hr), with fast cure time (< 45 minutes) when applied to metal surfaces.
- Enables reduced maintenance expenses and less downtime for system.

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Value Statement

HeatX™ offers the following benefits to improving coal-fired plant efficiency:

- Fouling resistance, promotion of dropwise condensation, and flow assurance allow for reduced fuel consumption and overall improved plant efficiency.
- Unique material properties allow for in-place application to already in-service units.
- Mechanically durable coating reduces maintenance requirements, and can improve power plant operational efficiency.

Project Objectives

The objective of the proposed research is to demonstrate the capability of Oceanit's HeatX™ coating to improve coal-fired power plant efficiency through reduction of fouling and enhanced condensation behavior.

- **Phase I: Evaluation and Testing of HeatX™ Performance**
- **Phase II: Demonstration and Deployment of HeatX™ on coal-fired condenser units.**

Project Schedule: Phase I (BP 1)
Evaluation of HeatX™ on Condenser Unit

Task #	Task	Start Date	End Date	BP 1						BP 2					
				Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
1.0	**Project Management and Planning/Documentation/Reporting**	1/1/2018	12/31/2020												
2.0	**Material Design, Formulation and Optimization**	1/1/2018	6/30/2018												
2.1	*Evaluation of coating durability*	1/1/2018	6/30/2018												
2.2	*Evaluation of coupon coating performance*	4/1/2018	6/30/2018												
A	**Milestone A: Coupon Study Validation**		6/30/2018												
3.0	**Low Pressure Condensation Testing**	4/1/2018	9/30/2018												
3.1	*Preparation and coating of test bundle*	4/1/2018	6/30/2018												
3.2	*Condenser testing and evaluation*	6/30/2018	9/30/2018												
B	**Milestone B: Simulated Field Conditions Validation**		9/30/2018												
4.0	**Test Site Identification and Baseline Monitoring**	7/1/2018	12/31/2018												
4.1	*Determination of efficiency test parameters*	7/1/2018	12/31/2018												
4.2	*Baseline monitoring*	7/1/2018	12/31/2018												
C	**Milestone C: Identify and Secure Pilot Test Site**		12/31/2018												
5.0	**Pilot Field Application and Validation**	1/1/2019	6/30/2019												
5.1	*Application of coating to condenser unit*	1/1/2019	3/30/2019												
5.2	*Data collection and economic analysis*	1/1/2019	6/30/2019												
D	**Decision Point/Milestone D: Sucessful application of HeatX to Condenser Unit**		3/30/2019												
6.0	**Quality Control Development and Application Refinement**	7/1/2019	12/31/2019												
6.1	*Development of field deployable quality control and coating health technique*	7/1/2019	12/31/2019												
6.2	*Application method refinement*	7/1/2019	12/31/2019												
E	**Milestone E: Process and Quality Control Documentation**		12/31/2019												
7.0	**Field Site Identification and Baseline Data Collection**	7/1/2019	12/31/2019												
7.1	*Determination of efficiency test parameters*	7/1/2019	9/30/2019												
7.2	*Baseline monitoring*	7/1/2019	12/31/2019												
8.0	**In-Field Extended Service and Evaluation Trials**	1/1/2020	6/30/2020												
8.1	*Application of coating to condenser unit*	1/1/2020	3/31/2020												
8.2	*Data collection and economic analysis*	1/1/2020	6/30/2020												
F	**Milestone F: HeatX Field Deployment**		6/30/2020												
9.0	**Commercialization Transition Planning and Scale-Up**	7/1/2020	12/31/2020												
G	**Milestone G: HeatX Final Performance Assessment**		12/31/2020												

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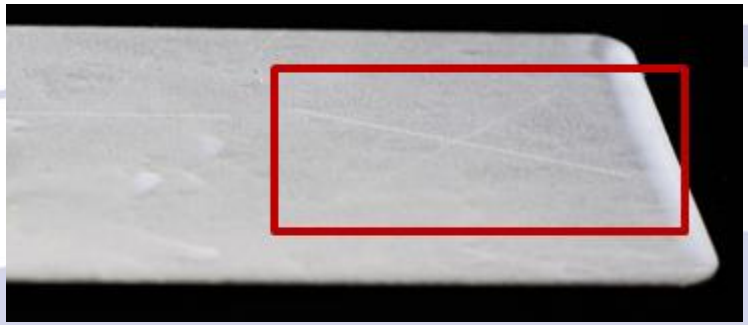
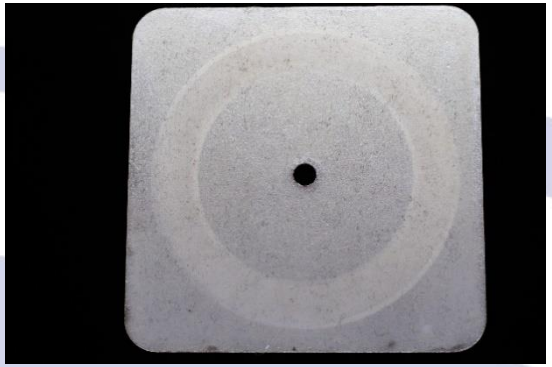
Task 1.0 – Project Management and Planning/Documentation/Reporting

- Oceanit will work together with the DOE project officer to develop and update project management plan.
- Submit and manage periodic and final technical reports.
- Oceanit shall conduct regular project reviews with DOE project officer.

Task 2.0 – Material Design, Formulation and Optimization

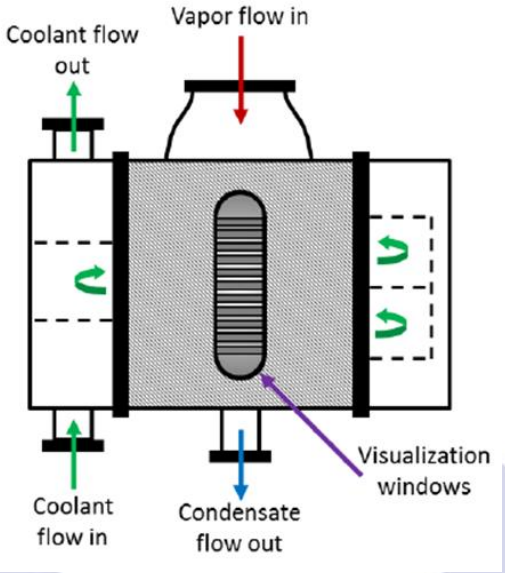
- Objective
  - Develop, customize, quantify and optimize HeatX™ material properties for fouling protection and in-place application.
- Subtasks
  - 2.1: Coating durability evaluation.
  - 2.2: Evaluation of coupon coating performance.





Task 3.0 – Low Pressure Condensation Testing

- Objective
  - Subscale laboratory testing of coating effect on condenser behavior.
- Subtasks
  - 3.1: Preparation and coating of test bundles
  - 3.2: Condenser testing and evaluation



Task 4.0 – Test Site Identification and Baseline Monitoring

- Objective
  - Determine condenser unit to be coated, based on economic concerns and availability.
  - Install monitoring equipment and collect pre-coating performance data.
- Subtasks
  - 4.1: Determination of efficiency test parameters
  - 4.2: Baseline monitoring

Task 5.0 – Pilot Field Application and Validation

- Objective
  - In-field application of HeatX™ to condenser unit, and final monitoring and validation of coating performance.
- Subtasks
  - 5.1: Application of coating to condenser unit
  - 5.2: Data collection and economic analysis

HeatX™ Economic Impact (from HECO)

	Uncoated	HeatX Coated	Projected Savings (5 year cycle)
Downtime for maintenance	20 days / year	2 days / year	5-year Savings $72,000
Cost of Replacement Power Generation	$15,000 per day	$0 (Can handle all load with alternate chiller)	5-year Savings $1.5M

Decision Point: Improve condenser efficiency based on field application such that partner feels significant economic impact (0.5% plant efficiency increase)

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Task 6.0 – Quality Control Development and Application Refinement

- Objective
  - Development and standardization of quality control procedures.
- Subtasks
  - 6.1: Development of field deployable quality control and coating health technique
  - 6.2: Application method refinement

Task 7.0 – Field Site Identification and Baseline Data Collection

- Objective
  - Identify and contract with existing coal-fired power plants to apply HeatX™ on the condenser unit or other existing equipment.
- Subtasks
  - 7.1: Determination of efficiency test parameters
  - 7.2: Baseline monitoring

Task 8.0 – In-Field Extended Service and Evaluation Trials

- Objective
  - Work with coal power plant operators identified in previous task to apply coating.
- Subtasks
  - 8.1: Application of coating to condenser unit
  - 8.2: Data collection and economic analysis

Task 9.0 – Commercialization Transition Planning and Scale-Up

- Objective
  - Identify potential commercial partners for expanded development and deployment.
- Oceanit currently has agreements with 2 supermajor oil companies, 1 national oil company, 1 independent refinery for application and development of coatings.

Project Updates

- Task 1: Kickoff meeting held.
- Task 2: Materials being fabricated, thermal heat transfer after in-situ method application being evaluated.
- Task 3: Contracting with 3rd Party Lab for LPCU testing.
- Task 4/5: Working with proposed test site for identification of condenser unit and monitoring setup.

Acknowledgements

- Department of Energy, NETL
  - Greg O'Neil
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  - Ed Curran
- Hawaiian Electric Company (HECO)
  - Robert Hirozawa