Office of Naval Research Global

Cung Vu, PhD
ONRG Associate Director - Singapore
August 2014

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ONRG Mission and Objectives

To ***search*** the ***globe*** for promising, ***emerging scientific research*** and ***advanced technologies*** to enable the Office of Naval Research to effectively address ***current needs*** of the Fleet and Force and to ***investigate and assess*** revolutionary, high-payoff technologies for ***future missions and capabilities***.

Discovering the Best Science	Maintain Global Technical Awareness	Science & Technology Partnerships and Collaborations
• Innovative basic research • Help shape future Naval investments / strategies • Leveraging great minds globally with positive engagement • Supporting Sailors & Marines	• Prevent technological surprise • Basic research is most transparent • Contributing open source data to Global Technology Awareness	• Advancement of mutual beneficial science • Supports Theater Security Cooperation goals • Relevance to USN/USMC programs is a key factor

Seeking S&T solutions globally as determined by CNR, DoN, DoD and USG

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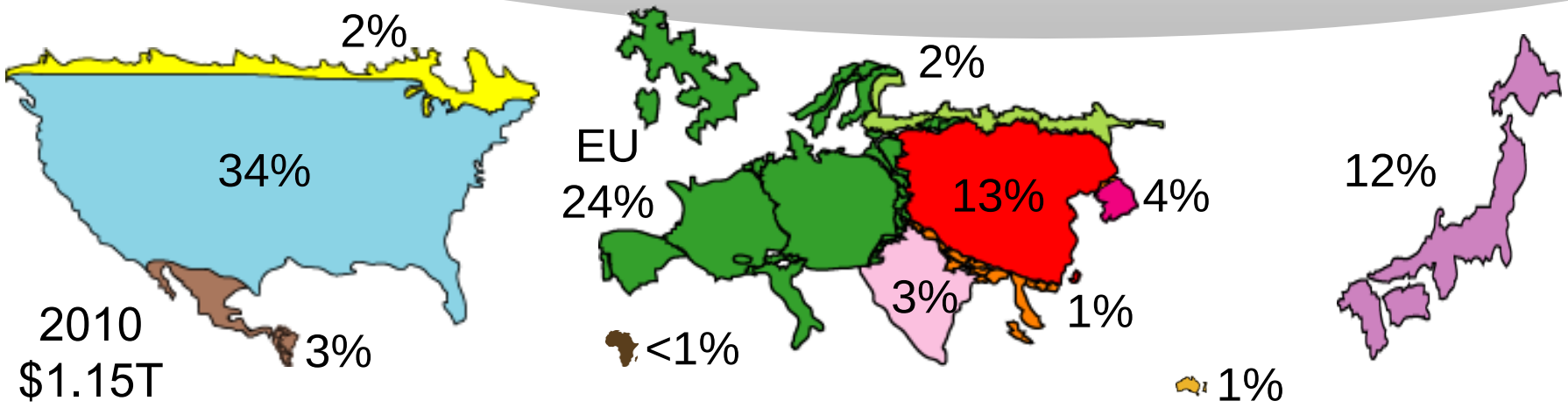
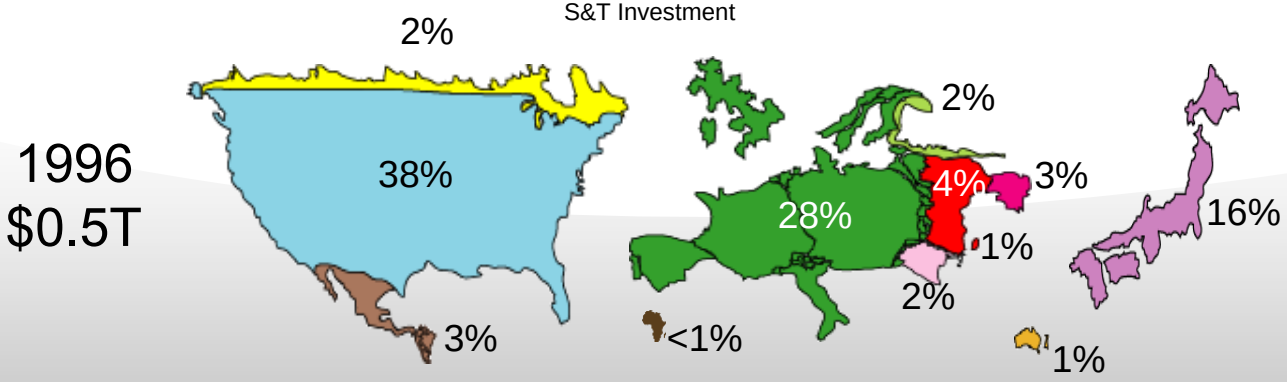
Total R&D Investment Growth



** OECD 2010 PPP; 2010 Global R&D Report (Battelle)

+100%
Growth in Global S&T Investment



* UIS S&T database; World Bank - PPP data

10% Dilution of Relative US S&T Investment in 15 years

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Updated: Nov 2011

ONRG History

- **1946** – **ONR London Office** created to survey, assess, and report on European S&T activities
- **1974** – **ONR Tokyo Office** opened to liaise and assess Asian S&T activities
- **1977** – ONR London and Tokyo Offices combined to form the **International Field Office** (IFO) to implement integrated DoN S&T strategy for fostering international collaboration
- **2000** – Tokyo Office expands its presence with a Singapore detachment
- **2002** – IFO opens **Santiago Office**
- **2003** – **Office of Naval Research Global** established through merger of Naval Fleet/Force Technology Innovation Office and IFO
- **2006** – ONRG opens **Singapore Office**
- **2009** – Director, Navy Staff designated ONRG an **Echelon II Command** reporting directly to CNR
- **2010** – ONRG opens **Prague Office**
- **2014** – ONRG opens **Sao Paulo Office**

LONDON

TOKYO

SANTIAGO

SINGAPORE

PRAGUE

SAO PAULO

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Associate Directors International Science Program

- ONR Global currently has 22 Associate Directors (ADs) distributed among 6 international locations.
- ADs are subject matter experts and/or regional experts whose primary mission is
  - To provide access to international experts in fields of interest to the Naval S&T community, and
  - Assessments of international S&T innovations
- ONR Global is working to ensure coverage across the Naval S&T strategy by
  - Mapping future staffing plans to increase coverage while recognizing some countries
  - Will require niche expertise staffing (e.g. China – Mandarin Speaker)

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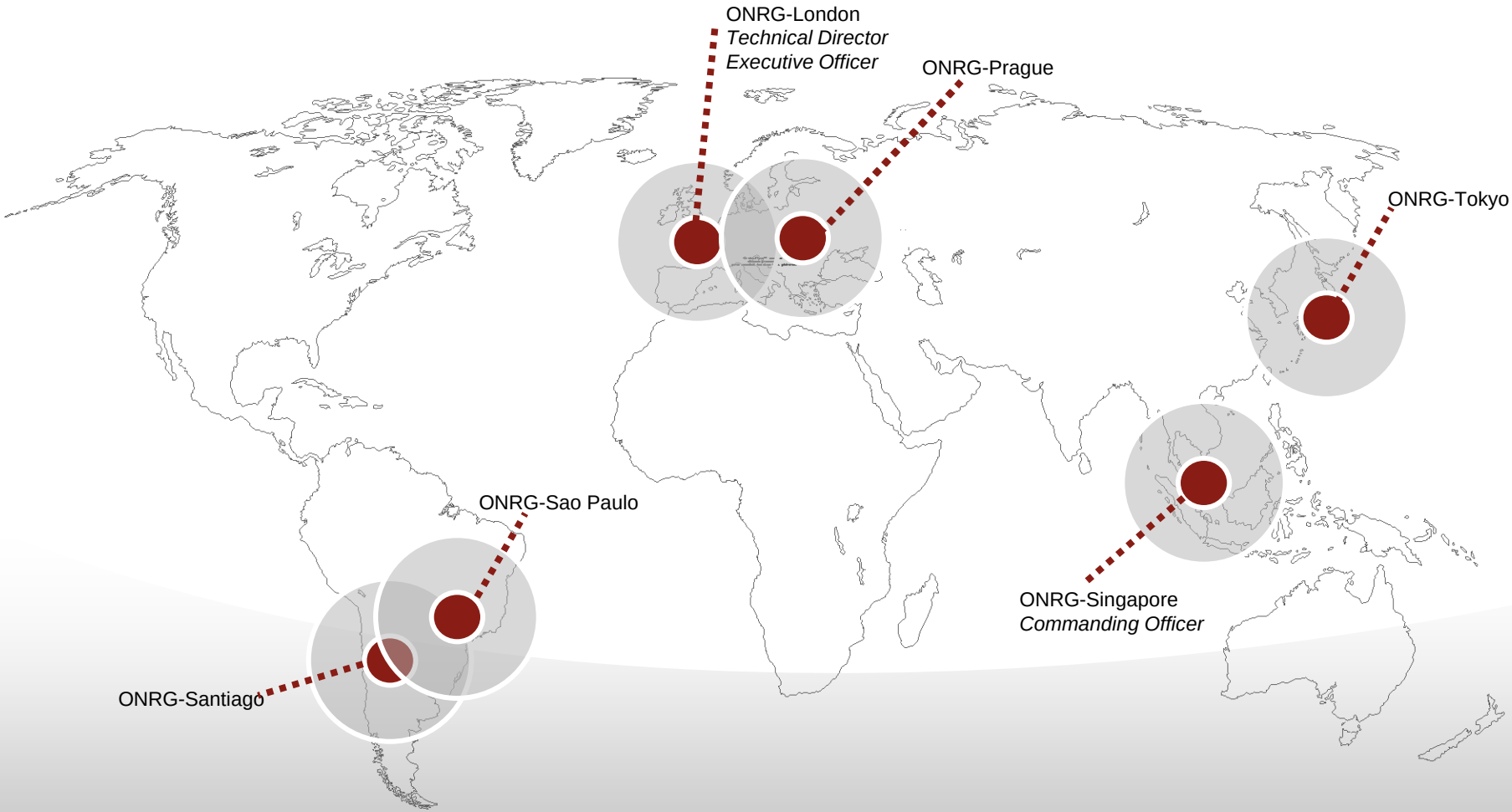
ONRG Associate Director Presence



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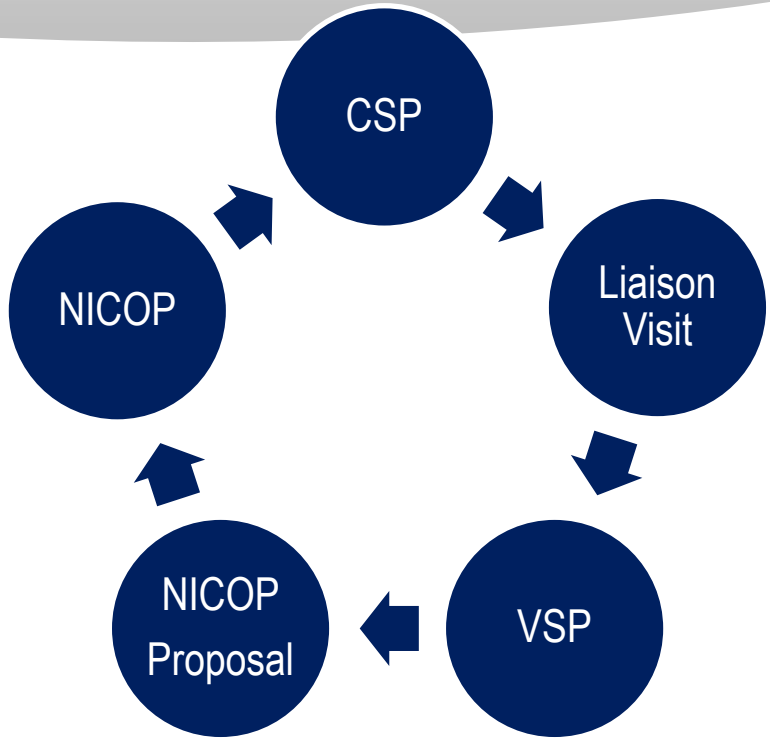
ONRG Science Program Tools

Collaborative Science Program (CSP)
- Support non-US engagements of Naval interest

Visiting Scientist Program (VSP)
- Support travel of non-US scientists to US to socialize new S&T ideas or findings with NRE

Naval International Cooperative Opportunities Programs (NICOP)
- Support insertion of innovative, international S&T into core ONR, NRE, & DoD S&T Programs

Liaison Visits (Not a Grant)
- ONRG technical staff visit international institutions to develop access and discover cutting edge S&T



ONRG provides seedling funding for innovative research

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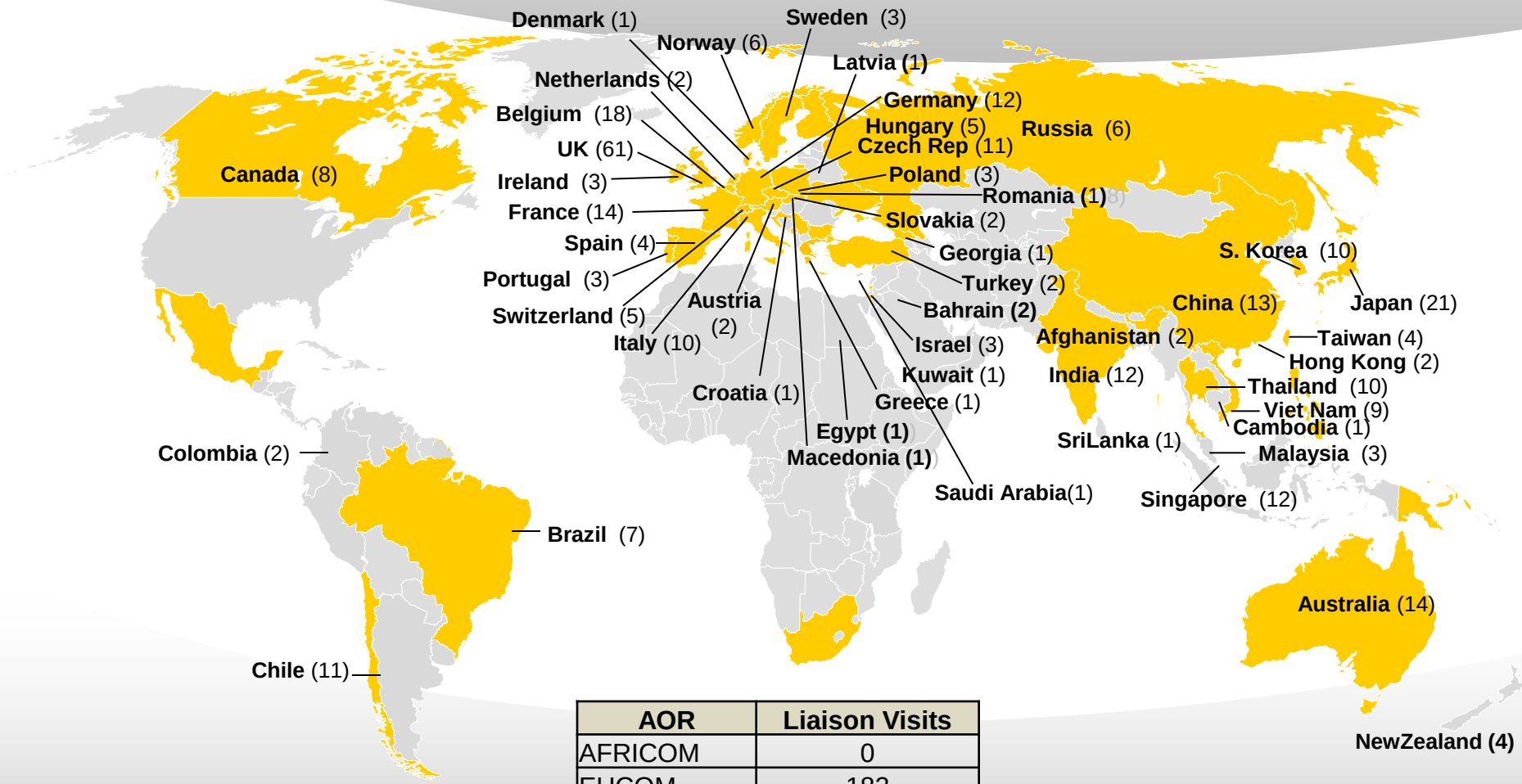
FY13 Liaison Visits



AOR	Liaison Visits
AFRICOM	0
EUCOM	182
NORTHCOM	8
PACOM	116
SOUTHCOM	20
CENTCOM	7
Total	333

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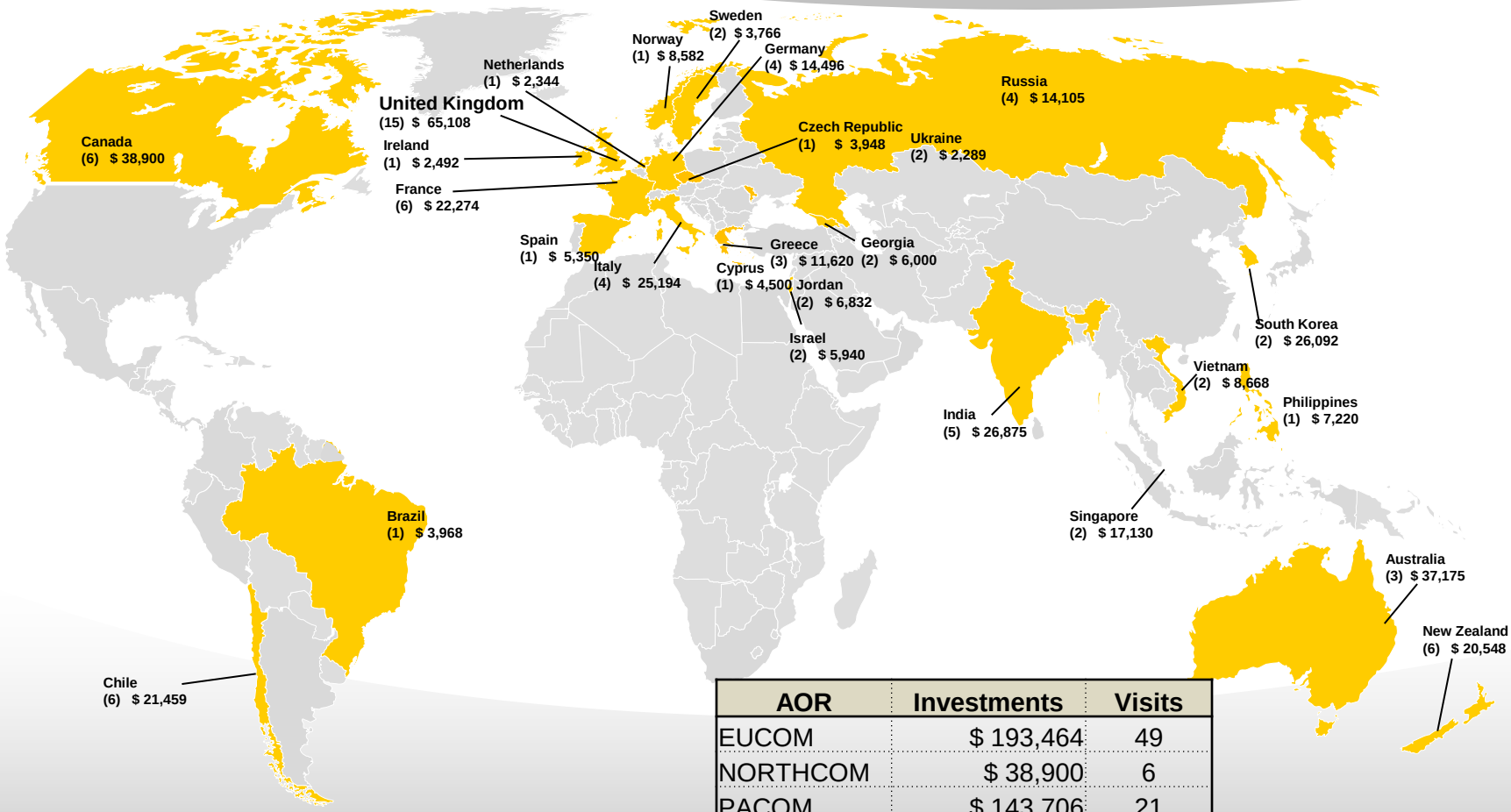
FY13 VISITING SCIENTIST PROGRAM



AOR	Investments	Visits
EUCOM	$ 193,464	49
NORTHCOM	$ 38,900	6
PACOM	$ 143,706	21
SOUTHCOM	$ 25,427	7
AFRICOM	$0	0
CENTCOM	$ 6,832	2
Totals	$ 408,329	85

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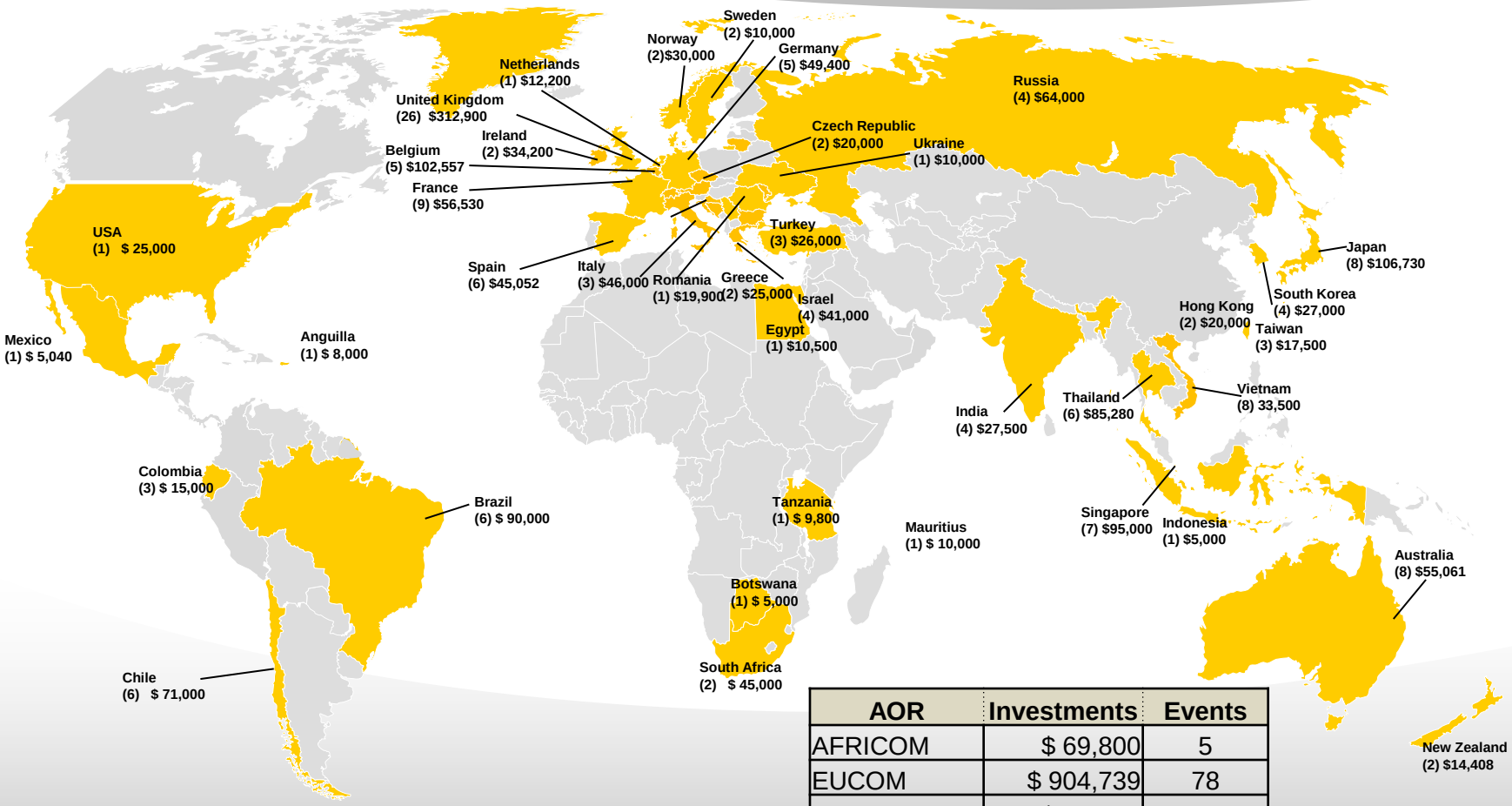
FY13 COLLABORATIVE SCIENCE PROGRAM



AOR	Investments	Events
AFRICOM	$ 69,800	5
EUCOM	$ 904,739	78
NORTHCOM	$ 30,040	2
PACOM	$ 486,979	53
SOUTHCOM	$ 184,000	16
CENTCOM	$10,500	1
Totals	$1,686,058	155

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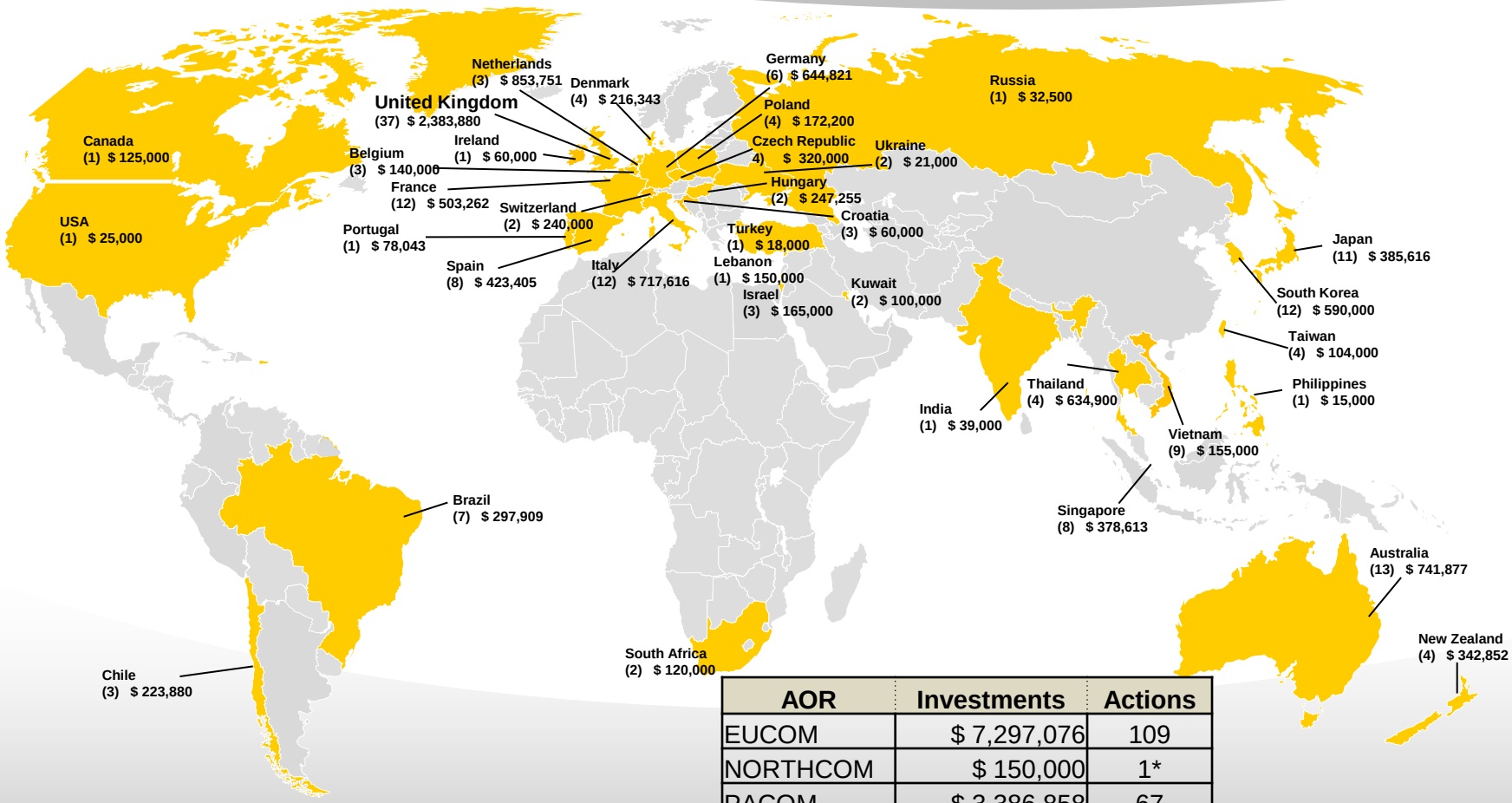
FY13 NAVAL INTERNATIONAL COOPERATIVE OPPPORTUNITIES IN S&T PROGRAM



AOR	Investments	Actions
EUCOM	$ 7,297,076	109
NORTHCOM	$ 150,000	1*
PACOM	$ 3,386,858	67
SOUTHCOM	$ 421,789	10
AFRICOM	$ 120,000	2
CENTCOM	$ 250,000	3
Totals	$ 11,625,723	192

* + 1 USA

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FY08-13 ONRG S&T Grants

ONRG S&T Grants – 1,348
Total Funding – $37.3 million

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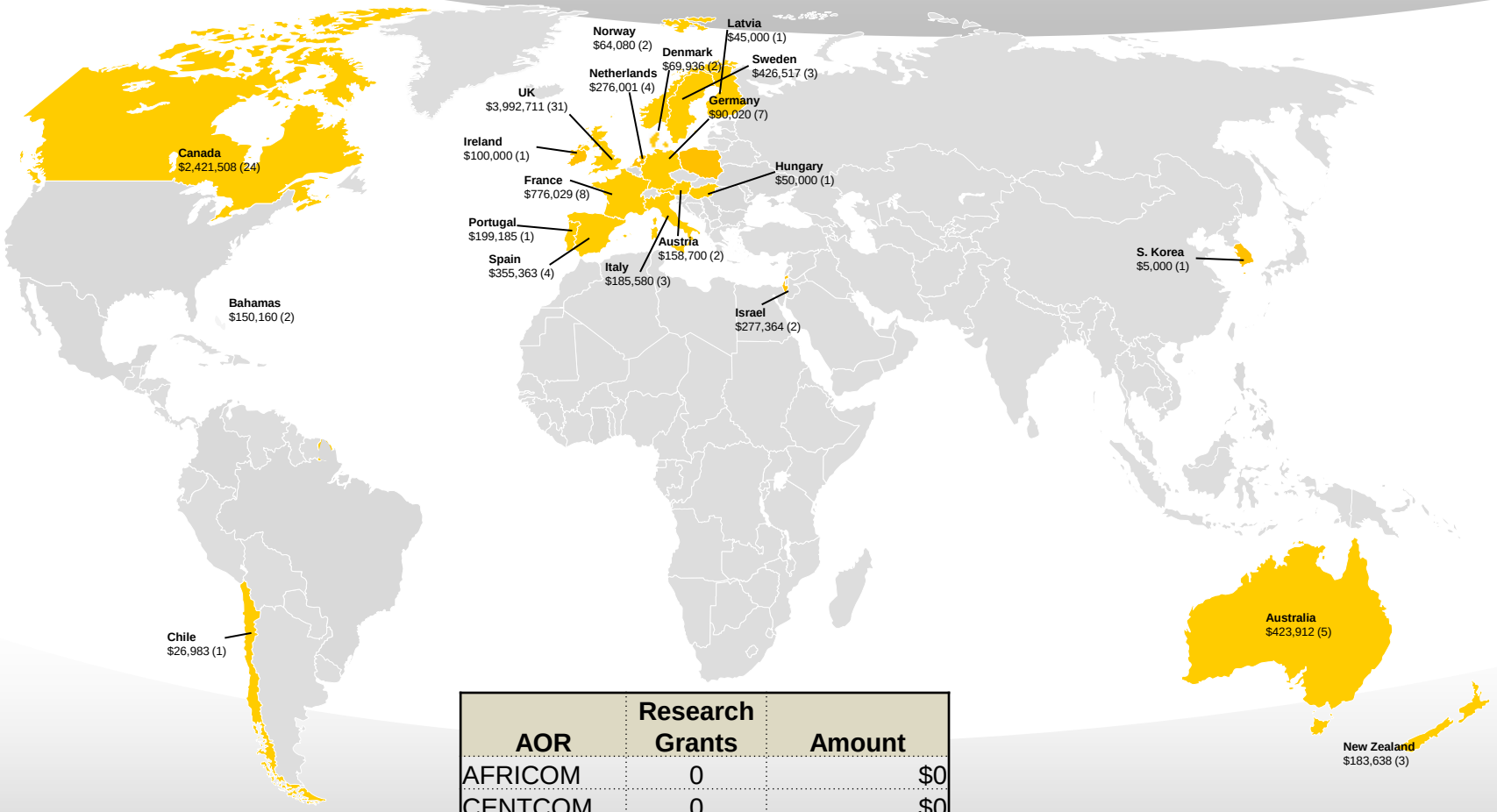
FY13 ONR Headquarters S&T Grants



AOR	Research Grants	Amount
AFRICOM	0	$0
CENTCOM	0	$0
EUCOM	72	$7,447,313
NORTHCOM	26	$2,571,668
PACOM	9	$612,550
SOUTHCOM	1	$26,983
Total	108	$10,658,514

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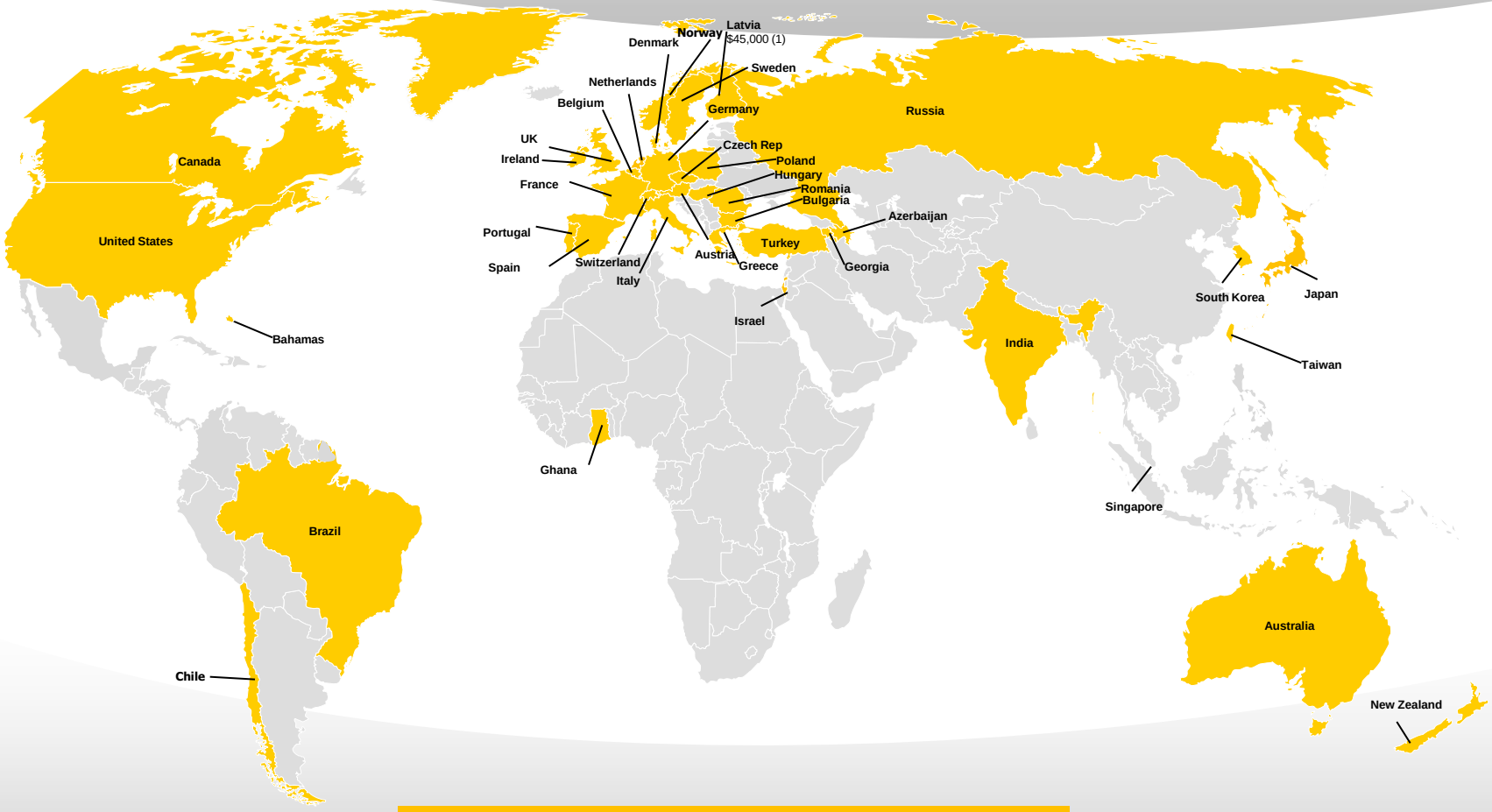
FY08-13 ONR HQ S&T Grants

International



Non-US ONR S&T Grants – 953
Total Funding – $75,639,222

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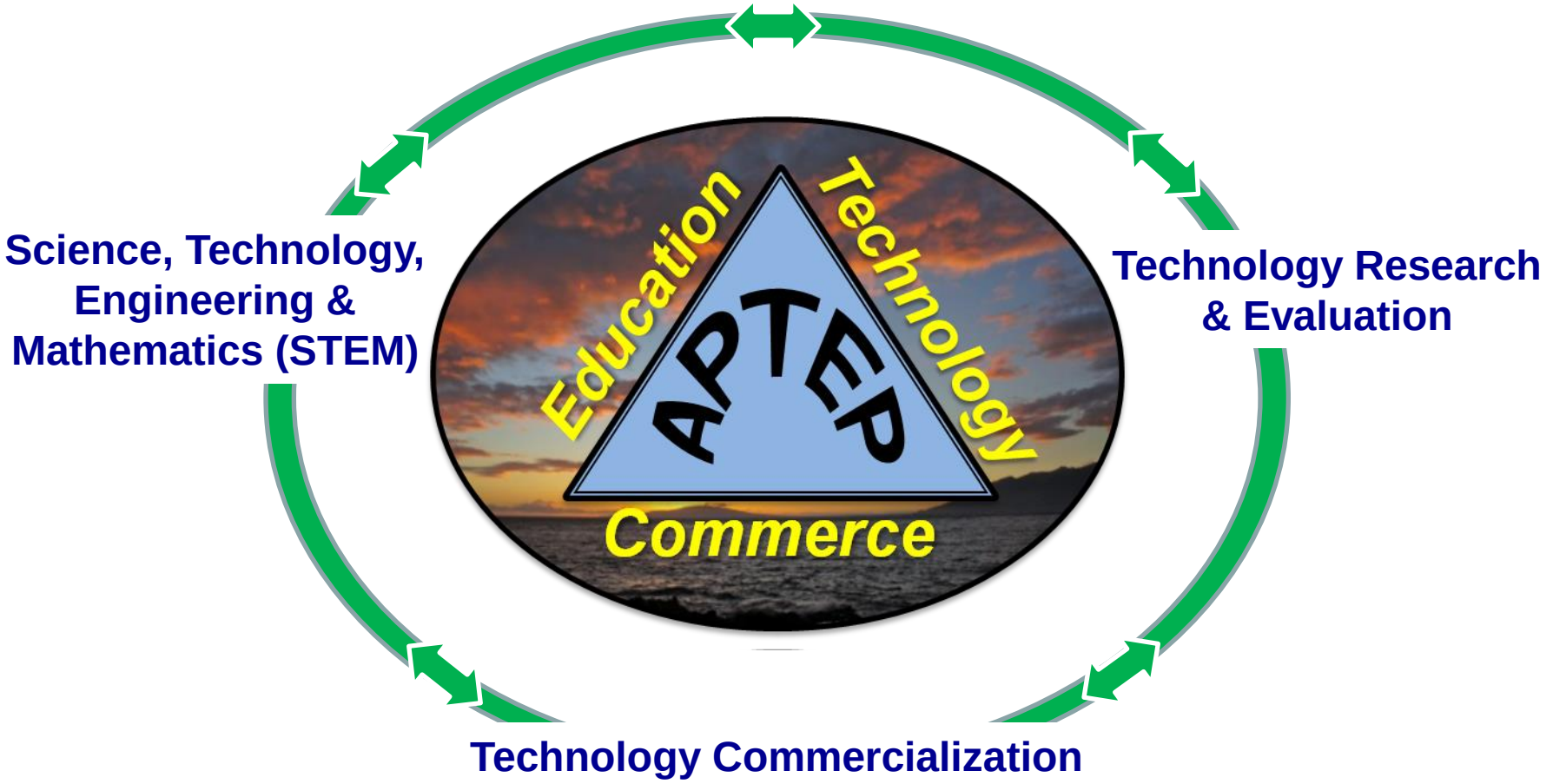
Asia Pacific Technology & Education Partnership [APTEP]



- **Promote sustainability through alternative energy research, technology development & education**
- **Provide a cleantech workforce by linking energy education & research institutes with cleantech companies**

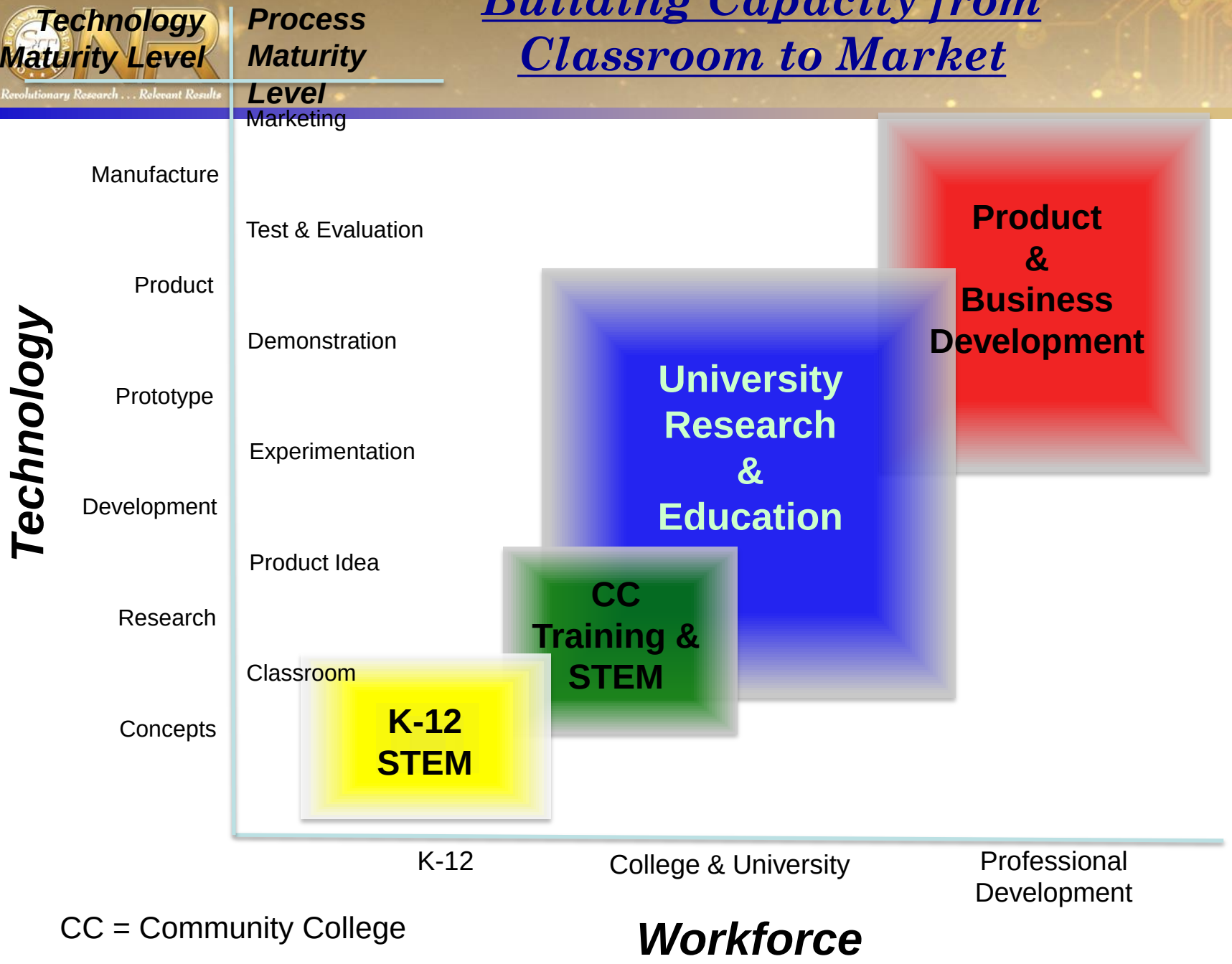
APTEP Vision & Purpose

Nationally and Internationally

“Promote sustainability through alternative energy research, technology development and education”

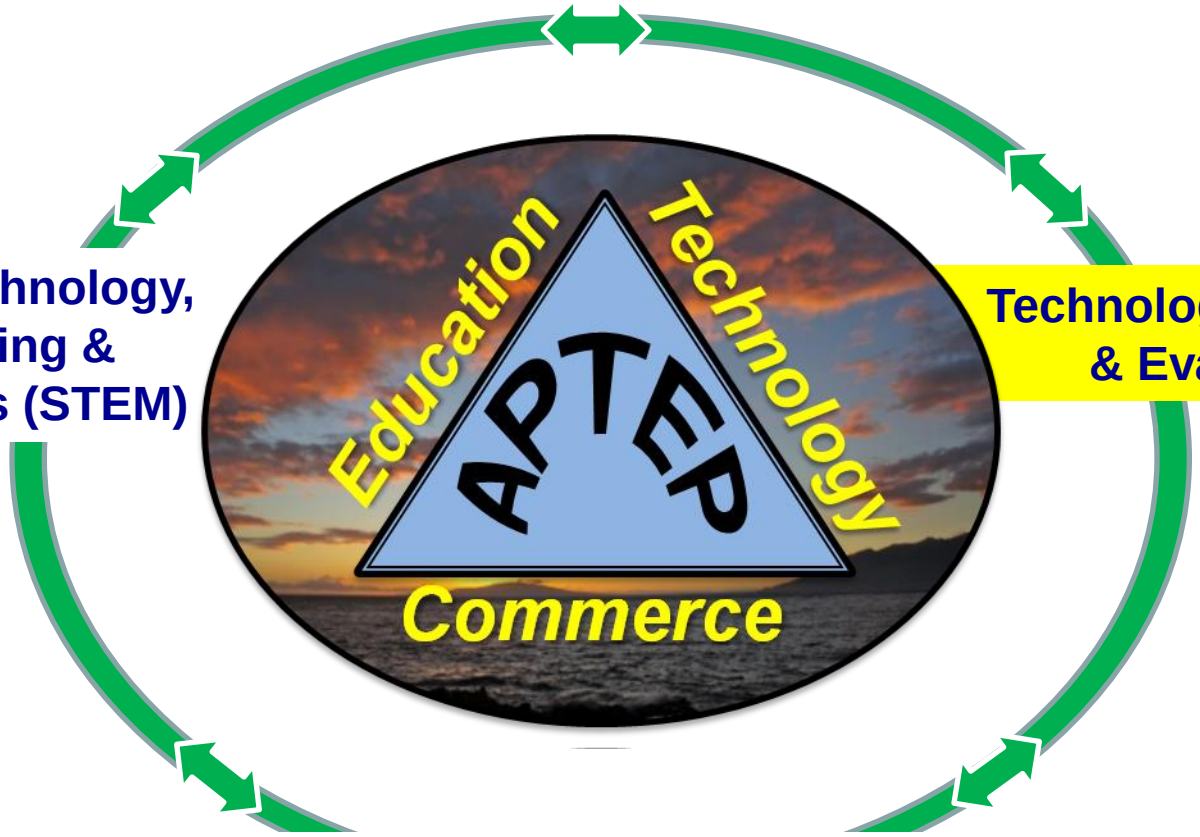
- **Research, develop and evaluate technologies applicable to Asia-Pacific regions.**
- **Grow commerce by promoting cleantech technology across Asia-Pacific.**
- **Provide a cleantech workforce by linking energy education, energy research and cleantech companies.**
- **Establish partnerships with Asia-Pacific nations through economic, research and educational opportunities.**

Building Capacity from Classroom to Market



CC = Community College

Asia-Pacific Technology & Education Partnership [APTEP]



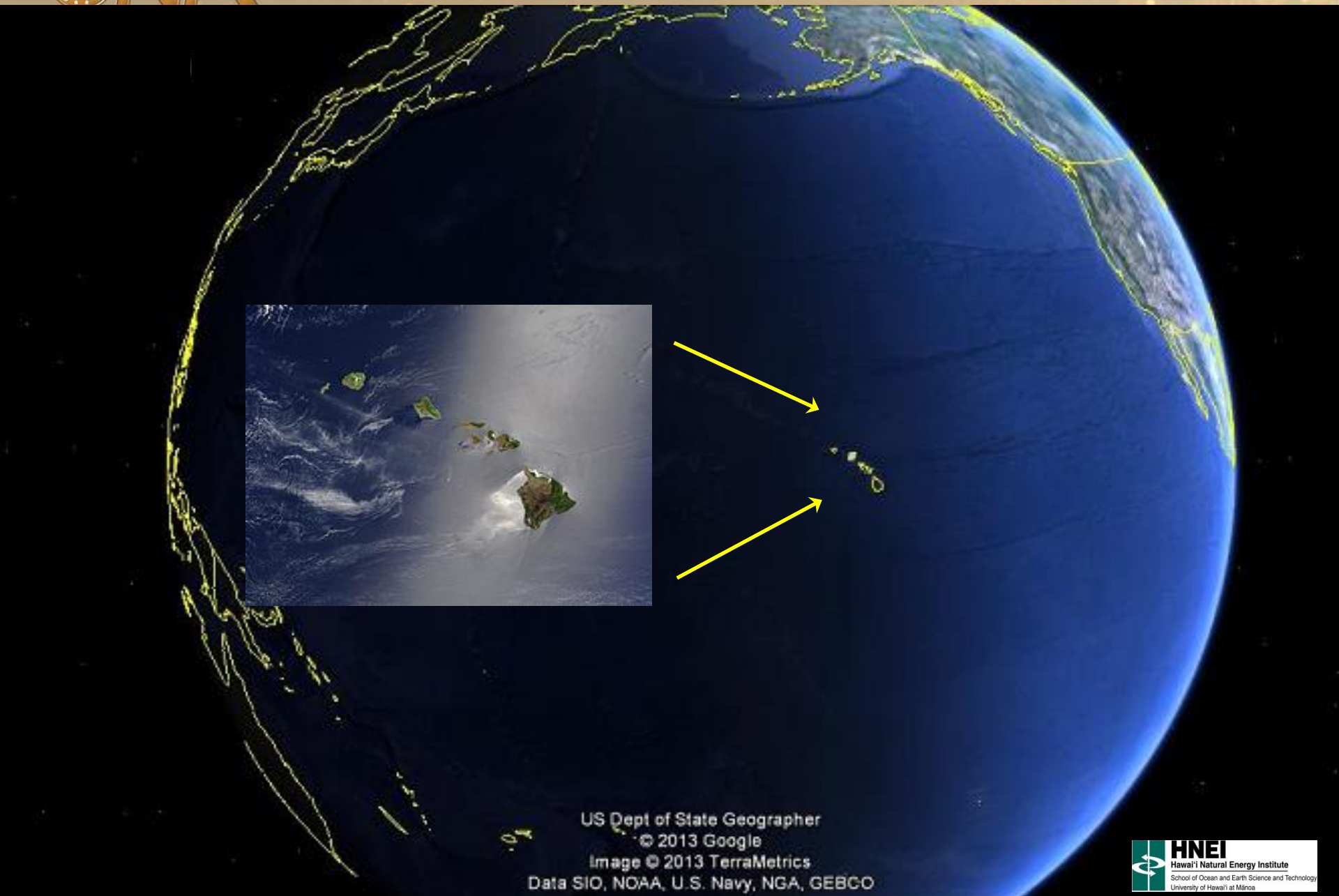
Science, Technology, Engineering & Mathematics (STEM)

Technology Research & Evaluation

Technology Commercialization

- **Promote sustainability through alternative energy research, technology development & education**
- **Provide a cleantech workforce by linking energy education & research institutes with cleantech companies**

Hawaii is Very Geographically Isolated ....



HNEI
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

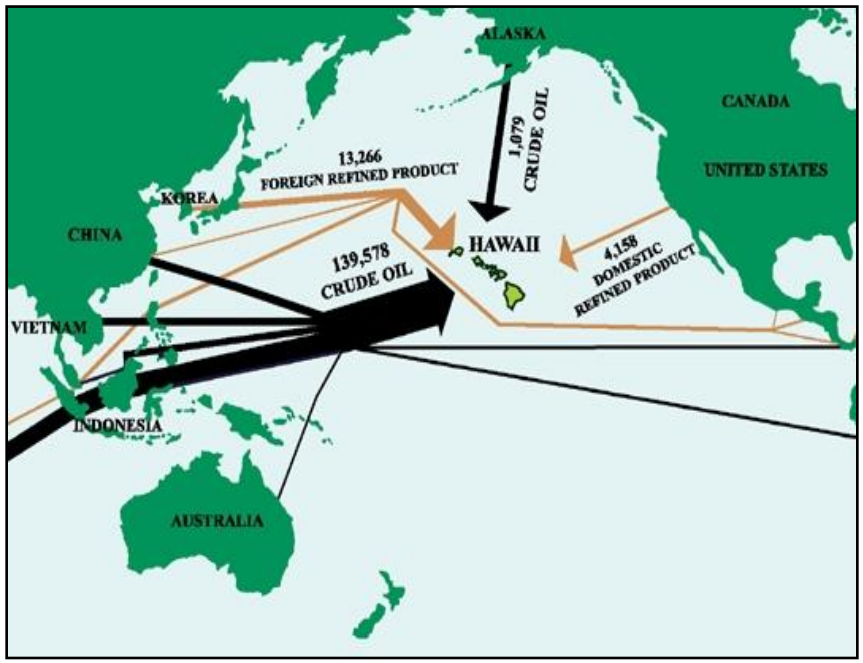
Energy Insecurity

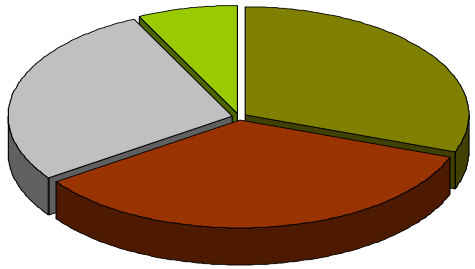
46.3 million barrels of petroleum were imported for Hawaii's total energy use in 2012

- **Primary energy: 90% fossil fuel, all imported, most of it is crude oil refined**
- **That's 36 barrels of petroleum for every man, woman and child living in Hawaii**
- **$5.09 billion left the state to pay for imported petroleum**

- **100% of the crude oil for the State is *imported***

Hawaii Department of Business, Economic Development & Tourism





JET FUEL	34%
ELECTRICITY	32%
GASOLINE/ MARINE FUEL	27%
OTHER	7%

Crude Oil Supplies to Hawaii

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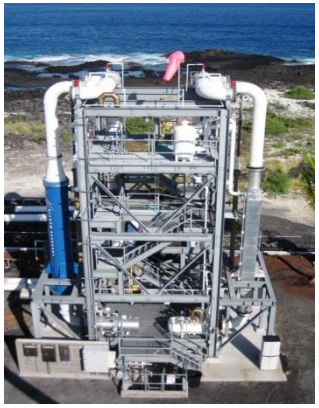
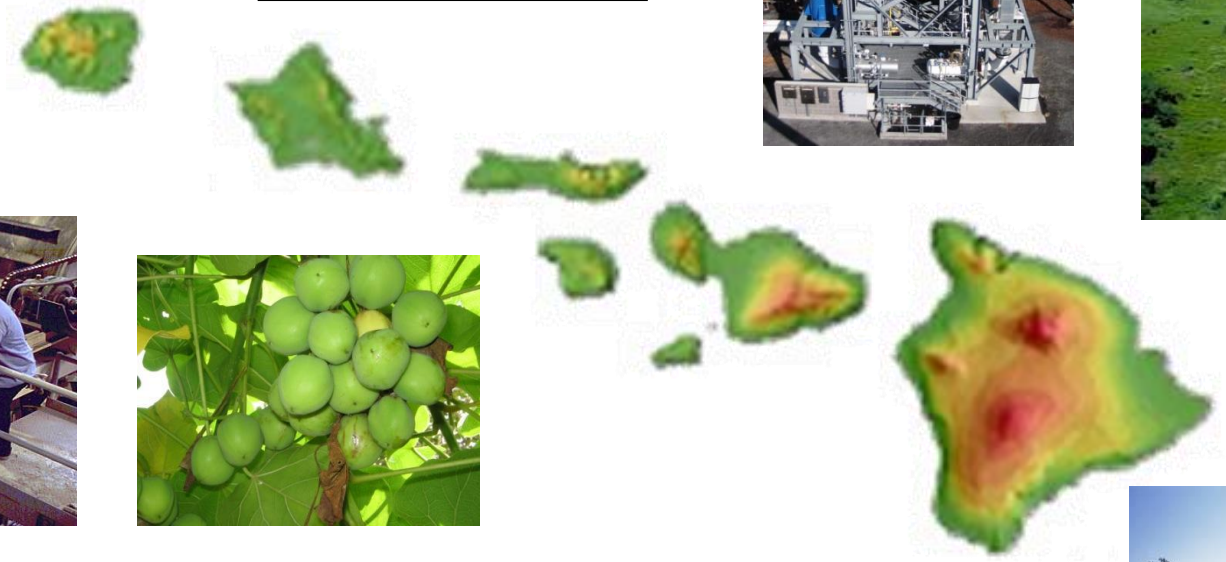
Clean Energy Opportunities in Hawaii are Abundant





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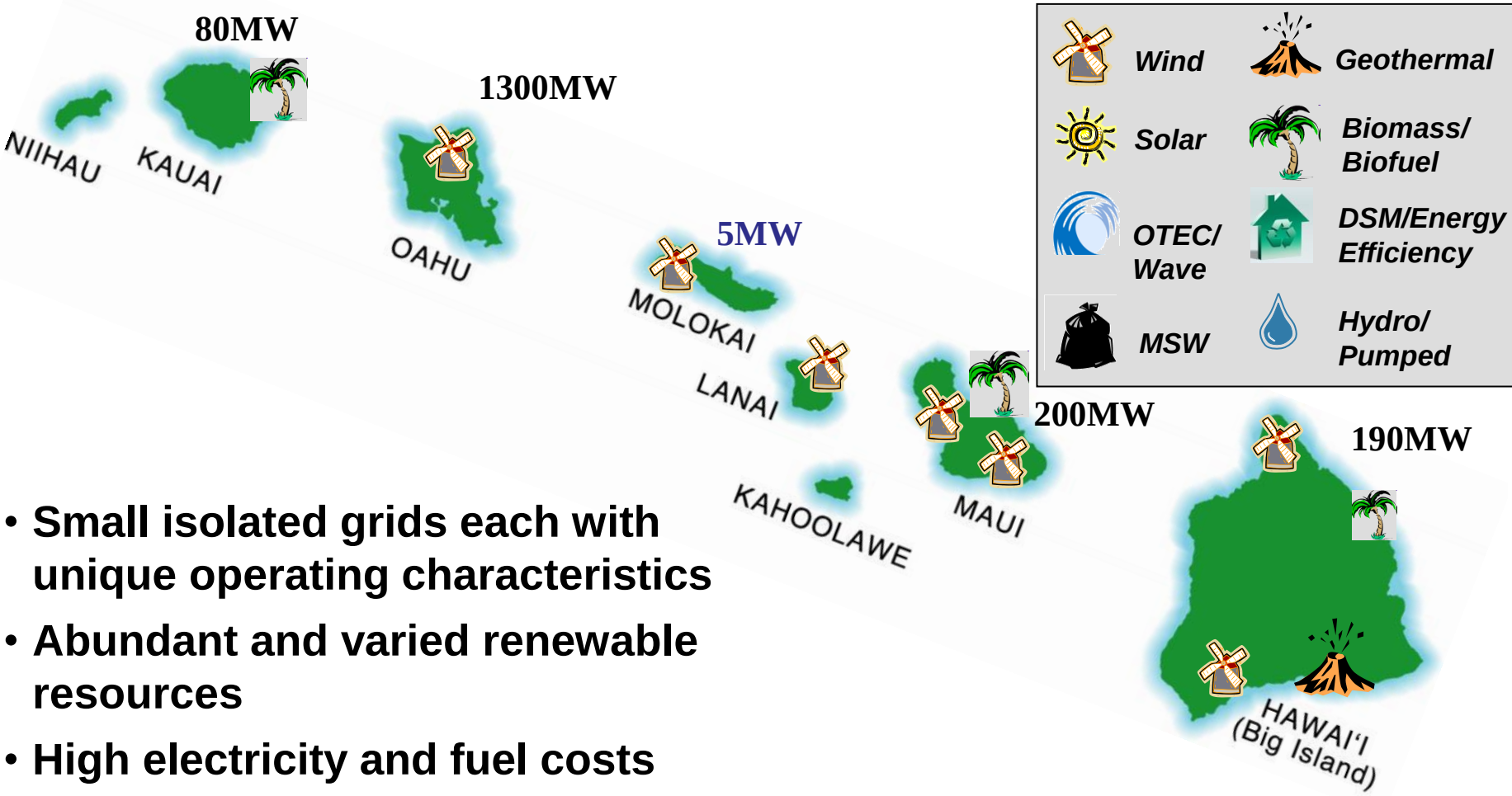
Hawaii is a Natural Test Bed for Renewable Integration



- **Small isolated grids each with unique operating characteristics**
- **Abundant and varied renewable resources**
- **High electricity and fuel costs**

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University of Hawai'i at Mānoa

Opportunity to deploy and validate new technologies

Hawaii Natural Energy Institute

Organized Research Unit in the School of Ocean and Earth Science and Technology, University of Hawaii at Manoa

Alternative Fuels: Biomass. Biofuels, Hydrogen

Electrochemical Power Systems

Fuels Cells, Batteries

Renewable Power Generation

Ocean Energy

Photovoltaics

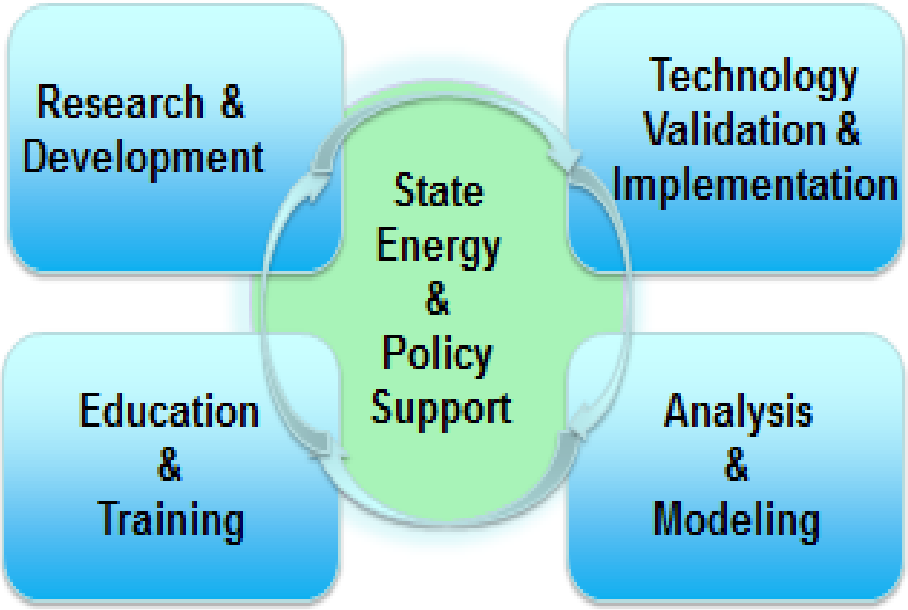
Energy Efficiency

Building technology

Sea Water Air Conditioning

Systems Integration

- Grid modeling and analysis
- Smart grid development
- Grid-scale storage



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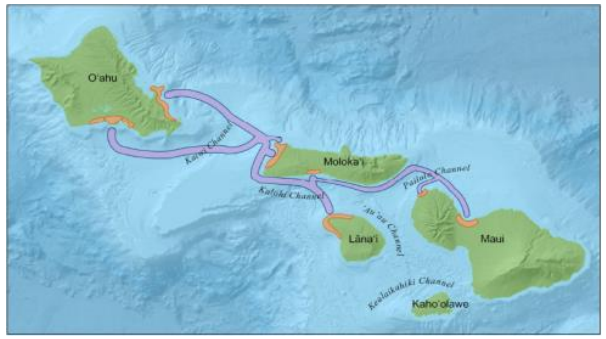
HAWAII ISLAND INTEGRATION STUDIES

Develop and use analytic tools for analysis of island grid systems with high penetration renewables

Identify solutions to inform technology selection and decision making groundbreaking use of analytical tools



Hawaii Grid Analysis

TECHNOLOGY VALIDATION

- Grid-scale storage
- Photovoltaics
- Small wind systems
- Dynamic Load Control
- Ocean Energy Systems
- Variable load ice/water production

Inform Policy

Work-force training

Regulatory Infrastructure

SMART AND MICRO-GRID DEMONSTRATIONS

- Maui Smart Grid Project
- Japan-US Smart Grid Demonstration Project
- DOE SEGIS Smart Inverter
- Coconut Island microgrid
- Molokai microgrid opportunity

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Battery Energy Storage (BESS) for Grid Management

Hawi 10 MW Wind farm at Upolu Point Hawaii Island

- 1MW, 250kW-hr Li-ion titanate at wind/utility interface
- Frequency regulation, wind smoothing, power quality

HECO feeder with high penetration (>1 MW Distributed PV)

- 1MW, 250 kW-hr Li-ion titanate at substation
- Voltage, VAR, Frequency regulation, power quality

Molokai Secure Renewable Microgrid

- 2MW, 375kW-hr Li-ion titanate, ~100kW community BESS,
- Operating reserves, frequency regulation, smoothing, peak shifting.

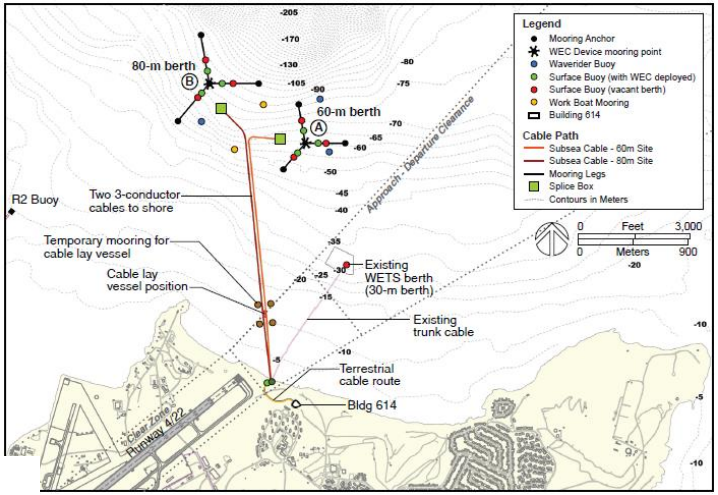
Kauai Waste Water Treatment Facility

- ~1MW, 2MW-hr integrated into MW PV system
- PV smoothing, energy storage/load shifting
- Grid independent operation

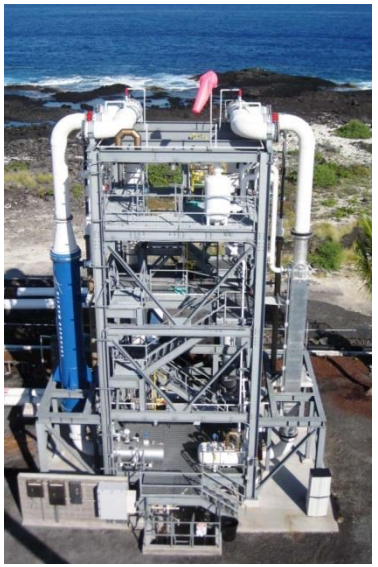
Grid-scale Energy Storage–
photos courtesy of Altairnano

Ocean Resources

- **Hawaii National Marine Renewable Energy Center - US DOE funding to:**
  - **Facilitate commercial development of wave energy conversion devices**
  - **Reduce technology risk for ocean thermal energy conversion (OTEC)**
- **Sea Water Air Conditioning (cost reduction)**
  - **Plume modeling to characterize impacts of discharge depth**
  - **Environmental monitoring to verify performance**
  - **Analysis of alternative designs**



Kaneohe Bay - WETS



Makai OE Test Facility at NELHA

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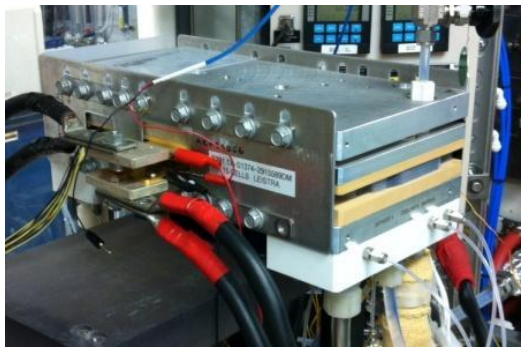
Hawaii Sustainable Energy Research Facility (HiSERF)

Characterize and optimize performance of proton exchange membrane fuel cell energy systems for use in harsh environments

- Performance and durability testing of single cells and stacks from 15 W to 5 kW with air or oxygen.
- Continuous long-term testing for performance and lifetime studies
- High resolution diagnostic tools for contaminant analysis
- High speed hardware-in-the-loop (HiL) test station to characterize fuel cell system response for UUV and UAV applications
- Custom designed impedance spectroscopy analyzer to analyze fuel cell stack and battery pack degradation mechanisms

FC Test Facility



Performance testing of GM Stack for UUV

HiL testing for Ion Tiger

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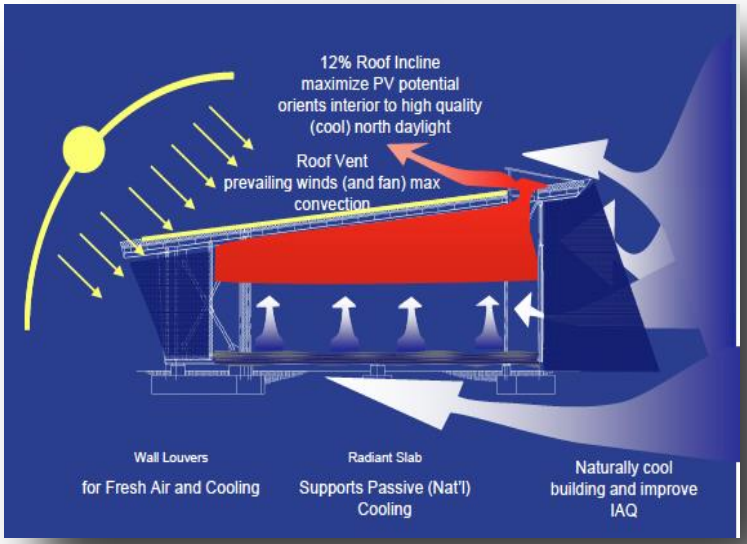
Project FROG:
Energy Neutral → Positive Structures

Ilima Middle School FROG, Oahu



- **Key step in reducing installation energy demand is adopting energy efficient structural design practices**
- **Energy neutral or low energy structures simplify the incorporation of alternative energy systems**
- **Advanced structural concepts**
  - **Provide low cost energy efficient facilities that are easy to install**
  - **Can be *Energy Positive* exporting power to a grid**

Kawaikini Charter School, Kauai

Expeditionary Waste Disposal
Micro Auto Gasification System (MAGS)

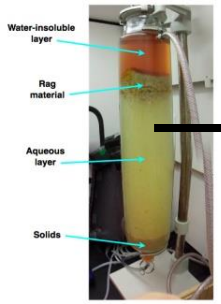
Background:

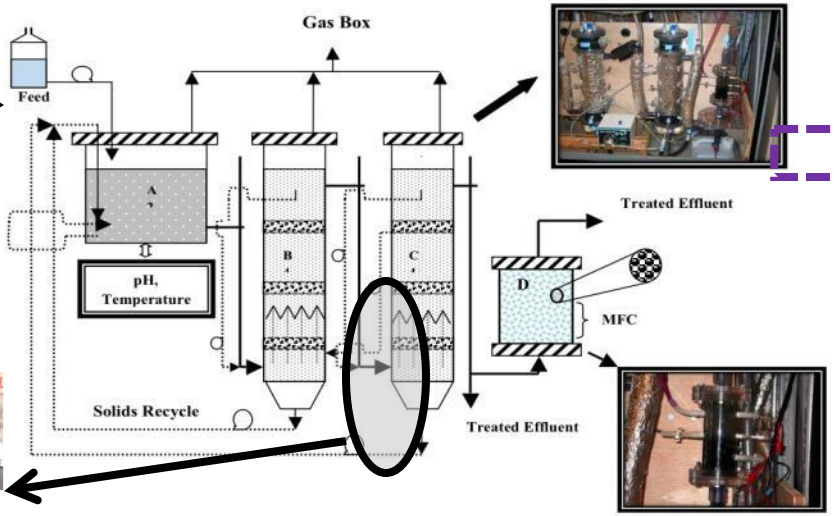
- Safely dispose of all waste generated in remote & expeditionary sites (FOBs)
- Treats organic waste, plastics, chemicals, wood products, bio-hazardous waste.
- Waste heat for water heating, environmental comfort, etc.
- Funded by Code 33 since 2006 (shipboard)
- FY10 project for expeditionary use

Current Situation:

- Site construction started - 4 Apr 2011
- Installation Complete - June 2011
- Assessment – Jun/July 2011
- Gasified 343 pounds (mean) of waste daily reducing volume 99% & weight 96%.
- *Phase II Pohakuloa Training Area: Lava Viper, Jan 2013*

Anaerobic Digestion for Dilute Waste Streams



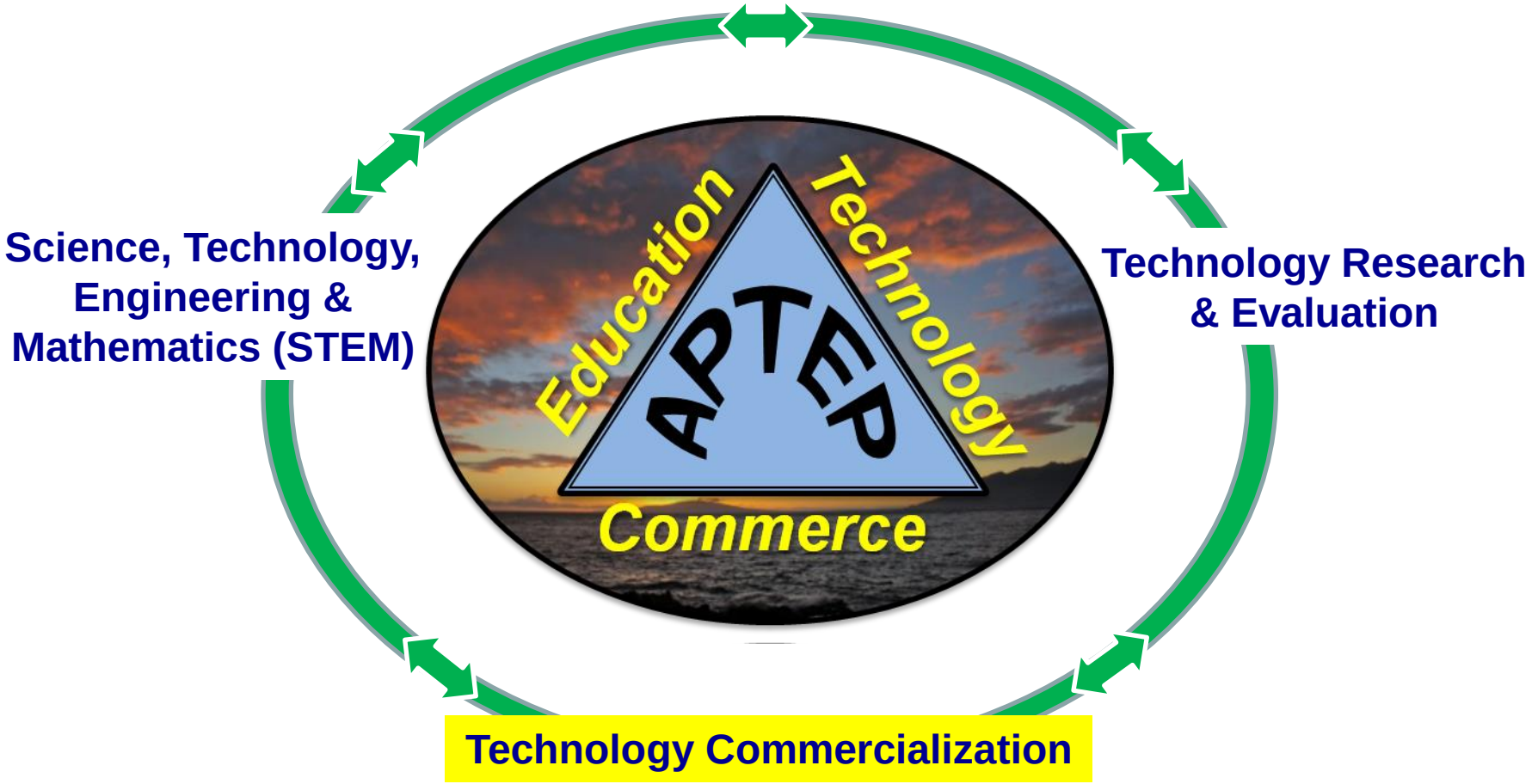


Ten (10) liter lab high-rate anaerobic digester for evaluation of packing materials and operating conditions (e.g. hydraulic retention time and packing density)

Five thousand (5000) liter demonstration at local waste water treatment facility to reduce BOD of primary effluent (operating)

One thousand (1000) liter demonstration at local grease-trap waste facility (under development)

Asia Pacific Technology & Education Partnership [APTEP]

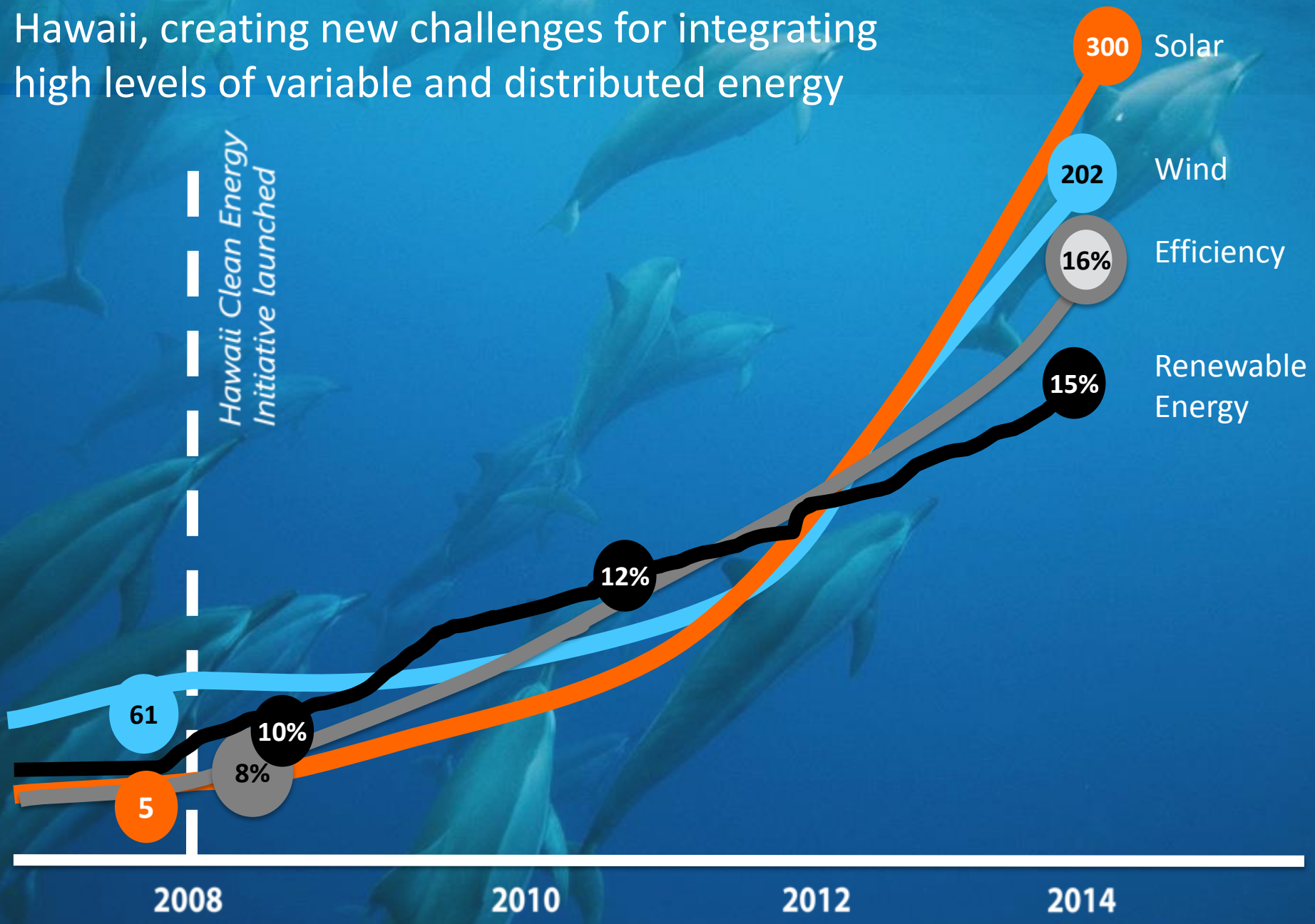


- **Promote sustainability through alternative energy research, technology development & education**
- **Provide a cleantech workforce by linking energy education & research institutes with cleantech companies**

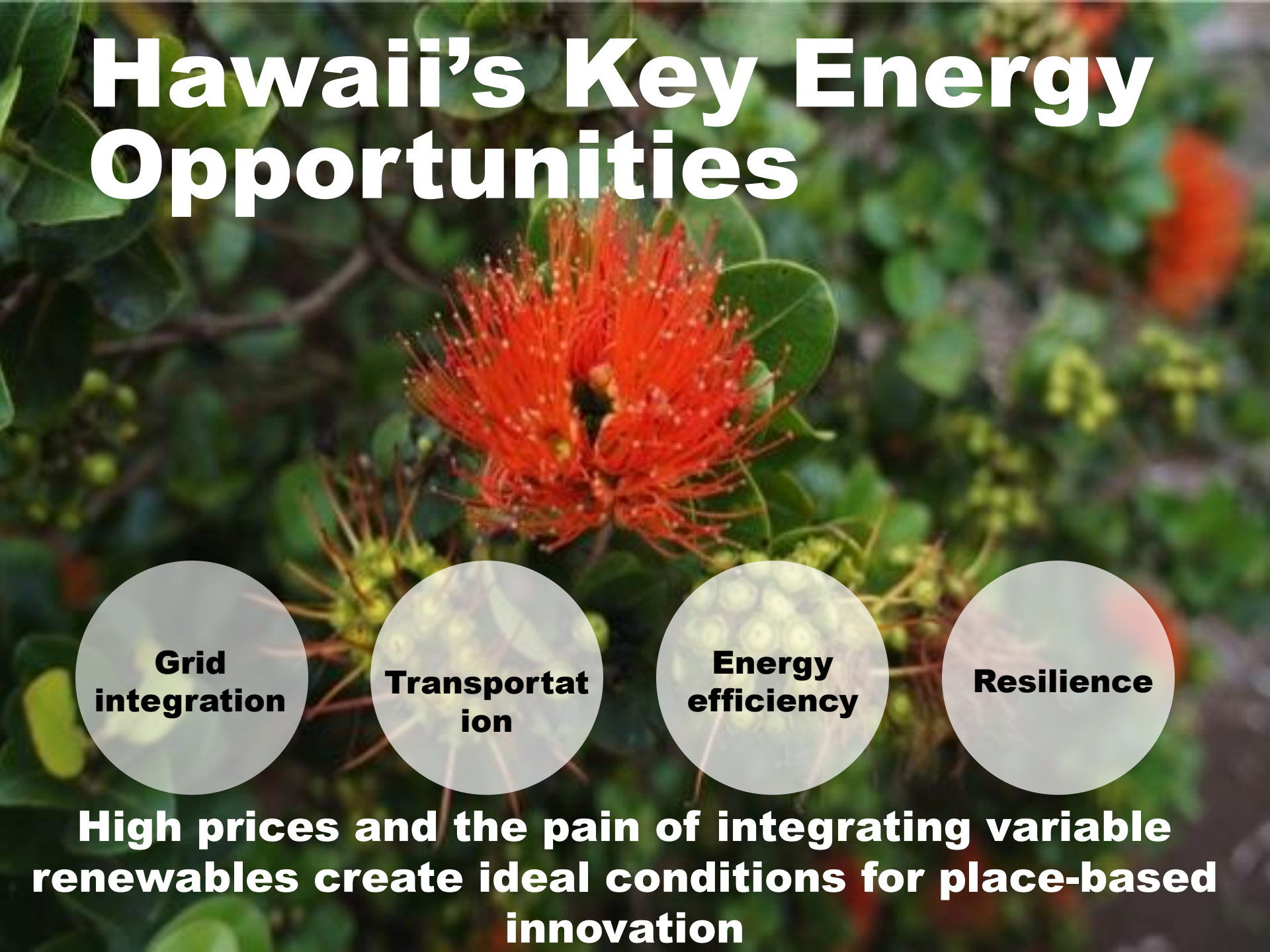
The Energy Excelerator

is a startup program dedicated to helping solve the world's energy challenges, starting in Hawaii.

Clean energy adoption is accelerating in Hawaii, creating new challenges for integrating high levels of variable and distributed energy



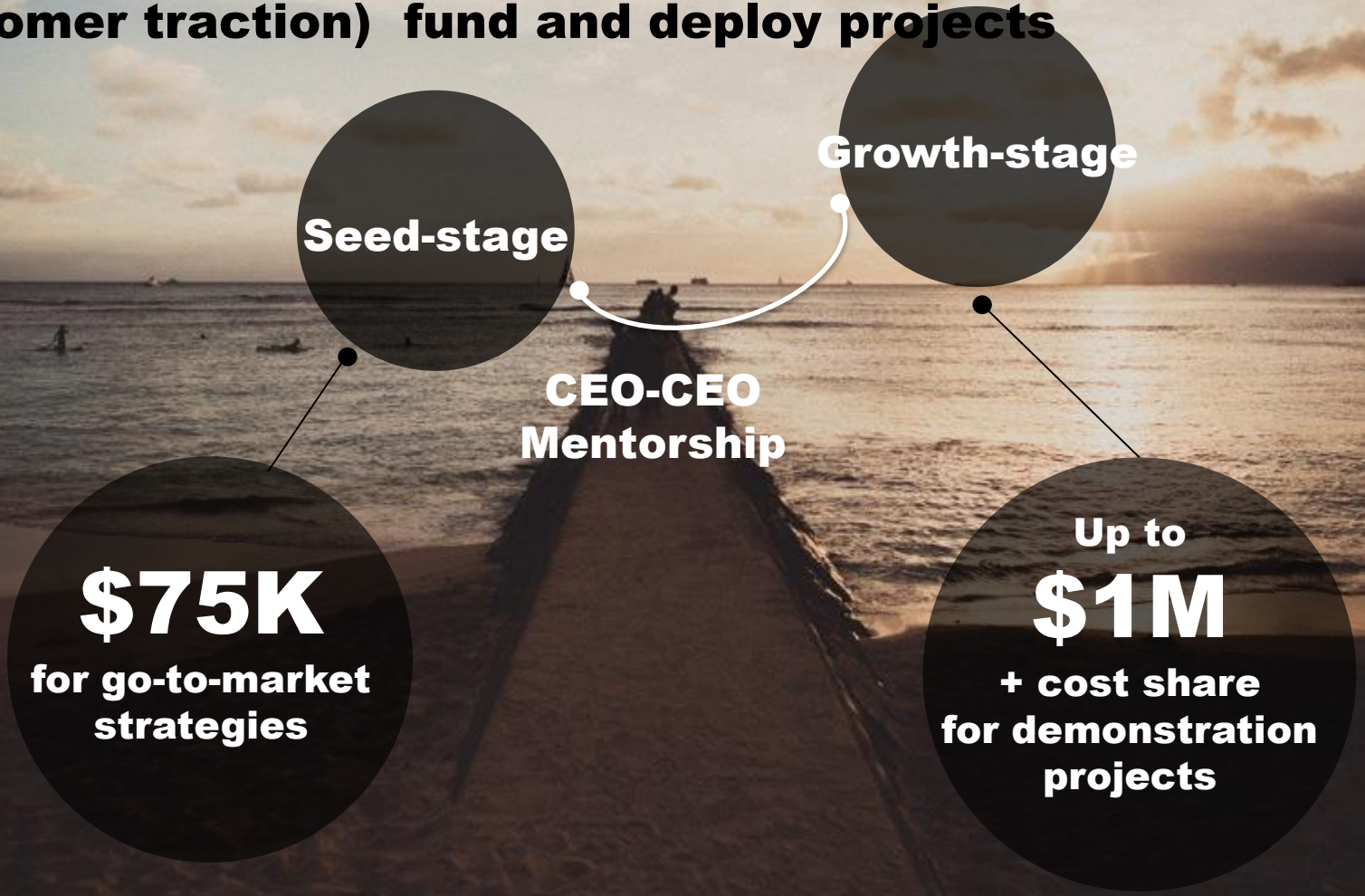
Hawaii's Key Energy Opportunities



High prices and the pain of integrating variable renewables create ideal conditions for place-based innovation

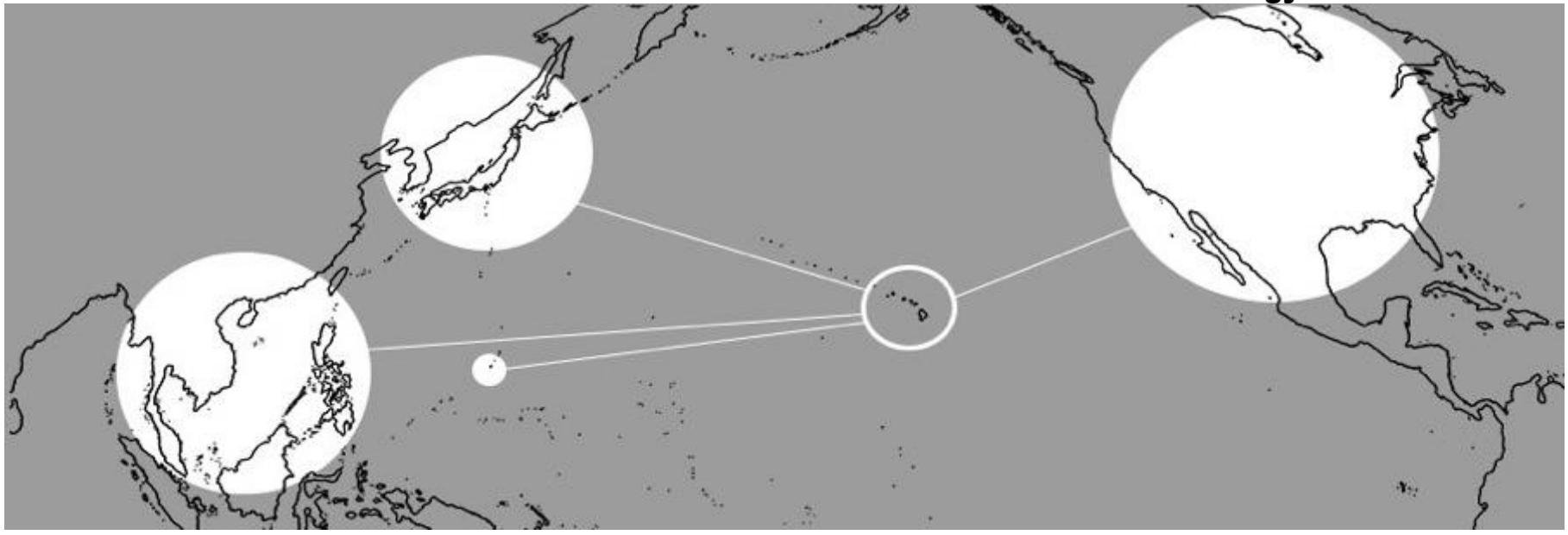
Funding

We help seed-stage companies (with a working prototype) find business models and growth-stage companies (with customer traction) fund and deploy projects

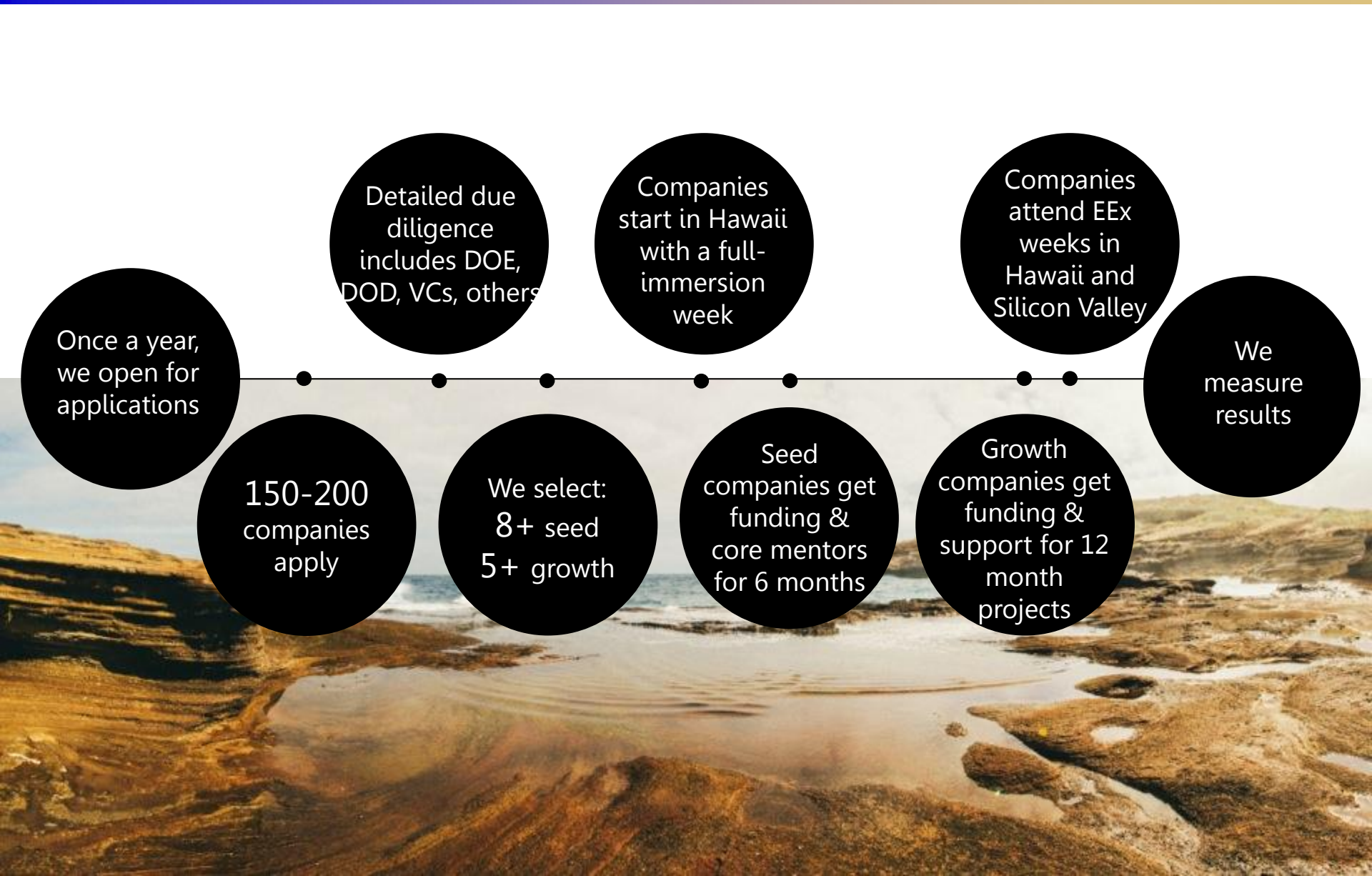


Partner network

Arsenal Venture Partners
Acquillian
Austin Technology Incubator Bizgym
Bloom Energy
Blue Planet Foundation
Caltech
Chaminade
Chevron Tech Ventures
Chrysalix
Claremont Creek Ventures
Clean Pacific Ventures
Cooley LLC
Convergent Law Group
First Wind
Garage Technology Ventures
Greenstart
Greentown Labs
Hawaii Energy
Hawaii Gas
Hawaii Pacific University
Hawaiian Electric Company
HiBEAM
Hitachi
Honeywell
HNEI
K&L Gates
Khosla Ventures
KIUC
Kleiner Perkins
Johnson Controls
Mbloom
NestGSV
NREL
Office of Naval Research
OpConnect
ProspectSV
Sandia National Labs
Shell
Startup Capital Ventures State of Hawaii
Surge Accelerator
True North Venture Partners
Ulupono Initiative
University of Hawaii
U.S. Department of Energy



Program Structure



Our Portfolio

Smart Grid & Energy Storage

AMBER_KINETICS
stem
Shifted Energy
HNU-ENERGY
AMBRI
Ballast energy
GEN-X
referentia

Energy Efficiency

people power
oroeco
Open Power Quality
BRIGHTLIGHT SYSTEMS
kWh analytics
PYRO-E
Waste Energy Recycling.
Concentris systems
NAVATEK
SPECTRUM 137

Transportation & Fuels

AUTOWATTS
better place
terviva
Kuehnle AgroSystems
HAWAI'IGAS
conscious commuter
BIG ISLAND BIODIESEL

Solar & Water

Acclimate
SOPOGY
RENEWABLE WATER TECHNOLOGIES

Success to Date

Our portfolio companies are raising money, making money, and creating jobs

17
Active Investments

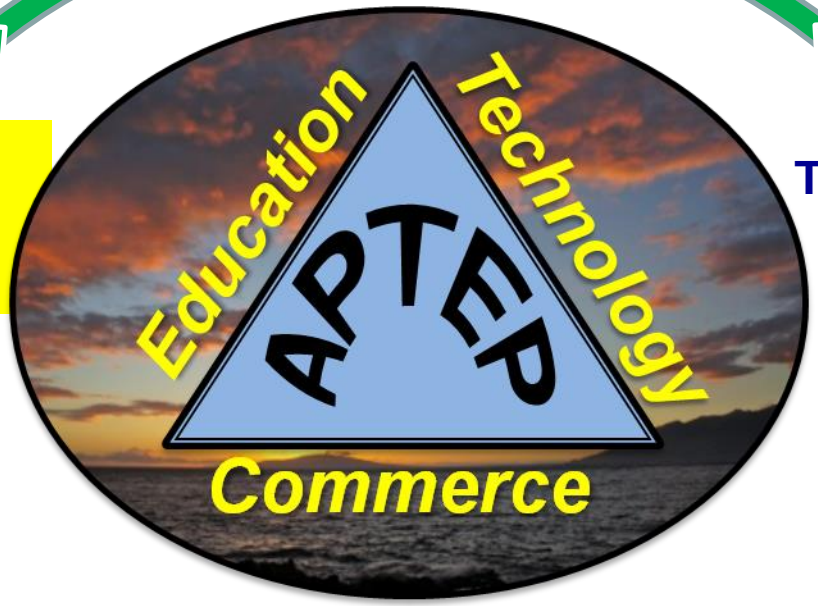
$55 M
Private capital raised as of 2013

$5.6 M
Revenue generated as of 2013

134
Jobs at our portfolio companies as of 2013

Asia Pacific Technology & Education Partnership [APTEP]

Science, Technology, Engineering & Mathematics (STEM)



Technology Research & Evaluation

Technology Commercialization

- **Promote sustainability through alternative energy research, technology development & education**
- **Provide a cleantech workforce by linking energy education & research institutes with cleantech companies**

The STEM Pipeline

Problem Statement:

- Developing a CleanTech workforce requires an increase in the number of technically skilled workers available, but:
- The number of Post Secondary students that are trained in Science, Engineering and Mathematics (STEM) entering our workforce is declining!

Solution:

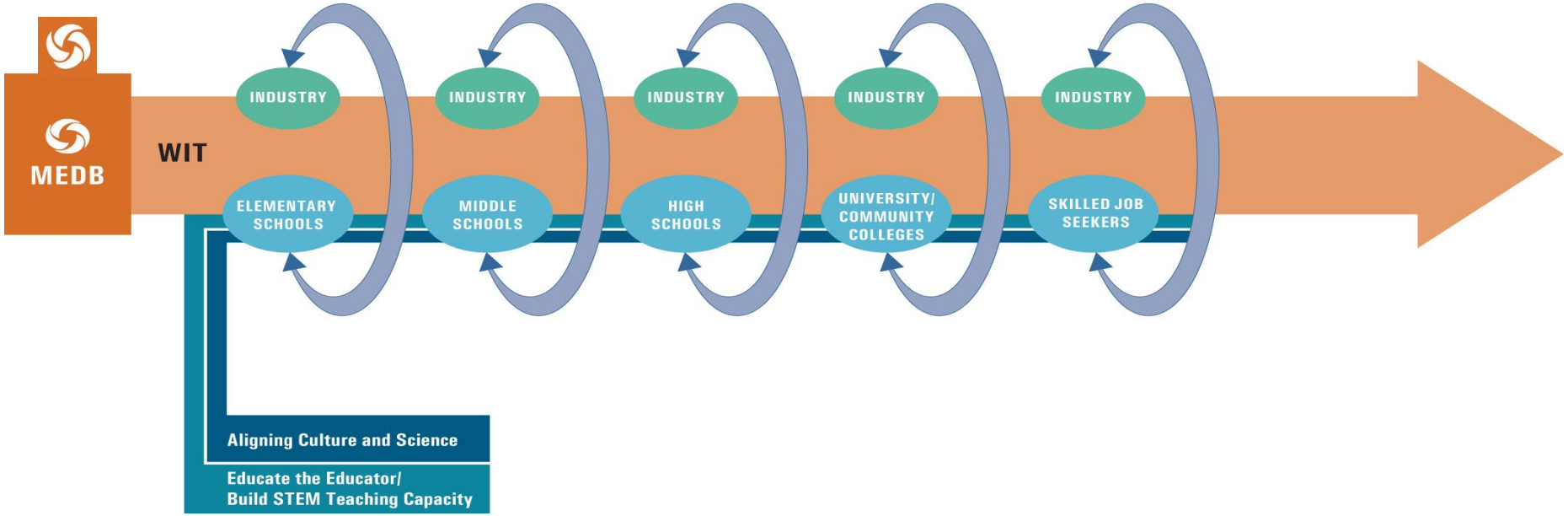
- In order to increase the number of technically trained workers, we must first determine the reasons for the lack of qualified workers
- We examine the flow of students entering the STEM training system (STEM Pipeline) that produces trained candidates for our workforce
- Then implement changes that will maximize flow and minimize leaks in the pipeline

The STEM Pipeline

The use of a pipeline to illustrate the flow of STEM students into the workforce is taken from a model developed by the Maui Economic Development Board (MEDB) in Hawaii:

BUILDING THE STEM EDUCATION TO WORKFORCE PIPELINE

A Model for Inclusion

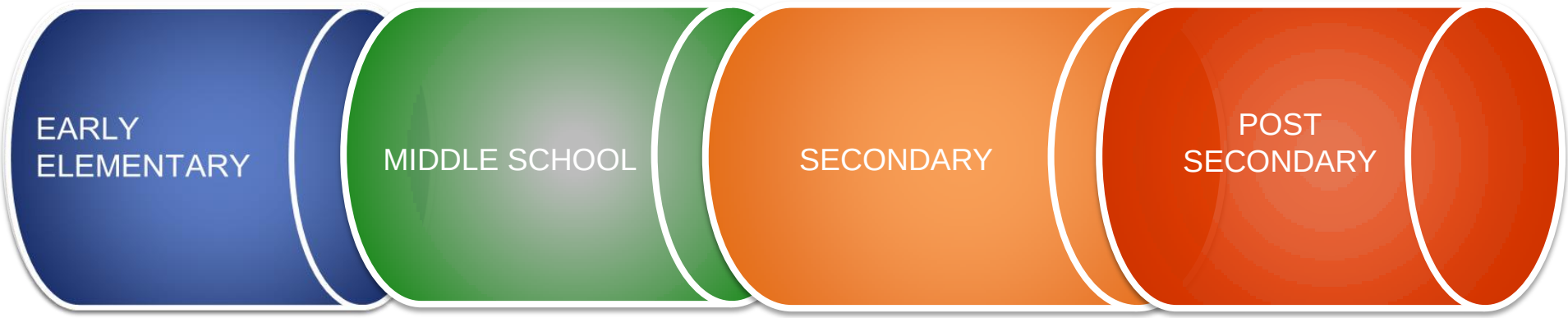


Growing the STEM Pipeline graphic

Copyright © Maui Economic Development Board, Inc. Women in Technology Project

The STEM Pipeline

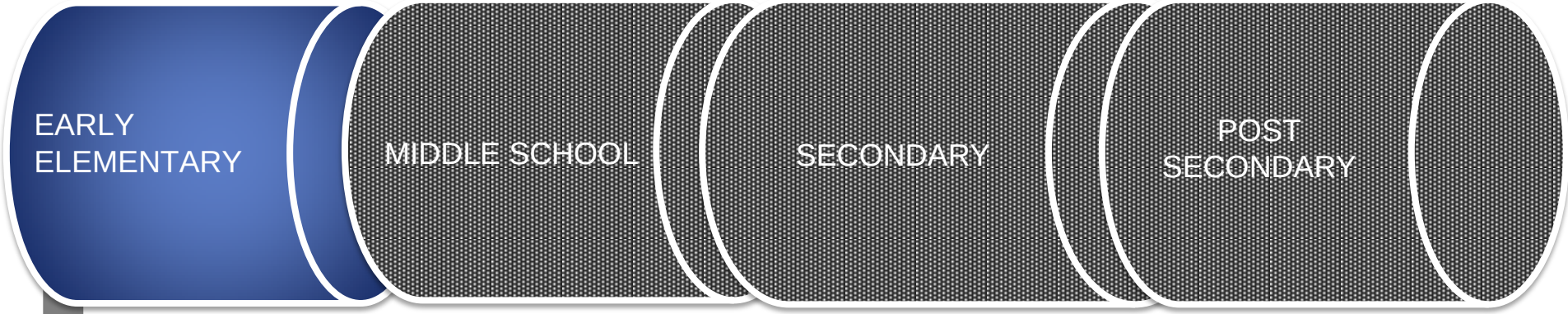
BUILDING THE STEM EDUCATION-TO-WORKFORCE PIPELINE



Maximize Flow – Minimize Leaks

The STEM Pipeline

BUILDING THE STEM EDUCATION-TO-WORKFORCE PIPELINE

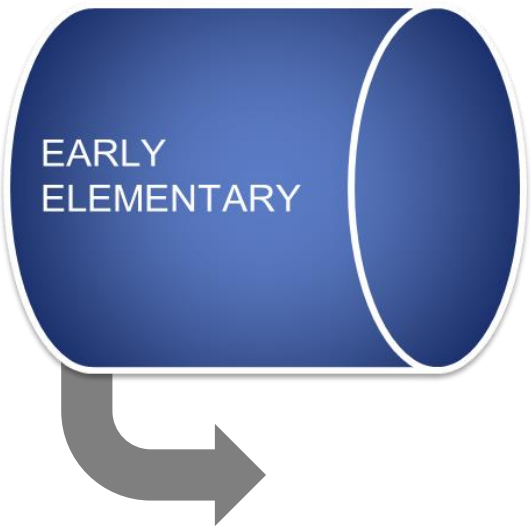


Starting with Early Education maximizes the number of students entering the STEM pipeline:

- **Nurture natural curiosity**
- **Keep science fun**
- **Provide hands-on activities that stimulate creative solutions resulting in innovation**
- **Train teachers in inquiry methods and scientific content**

The STEM Pipeline

ONR Investments in Early Education programs



TSAP - Technology Enhanced Sustainable Aina Project

- Engineering education in elementary schools
- Teacher training in engineering design resulting in teacher developed curriculum
- Engineering based curriculum provides relevance to science and mathematics resulting in improved test scores

IEI - Island Energy Inquiry

- Placed-based, standard aligned curriculum
- Professional development in inquiry science
- Hands-on tools for student projects

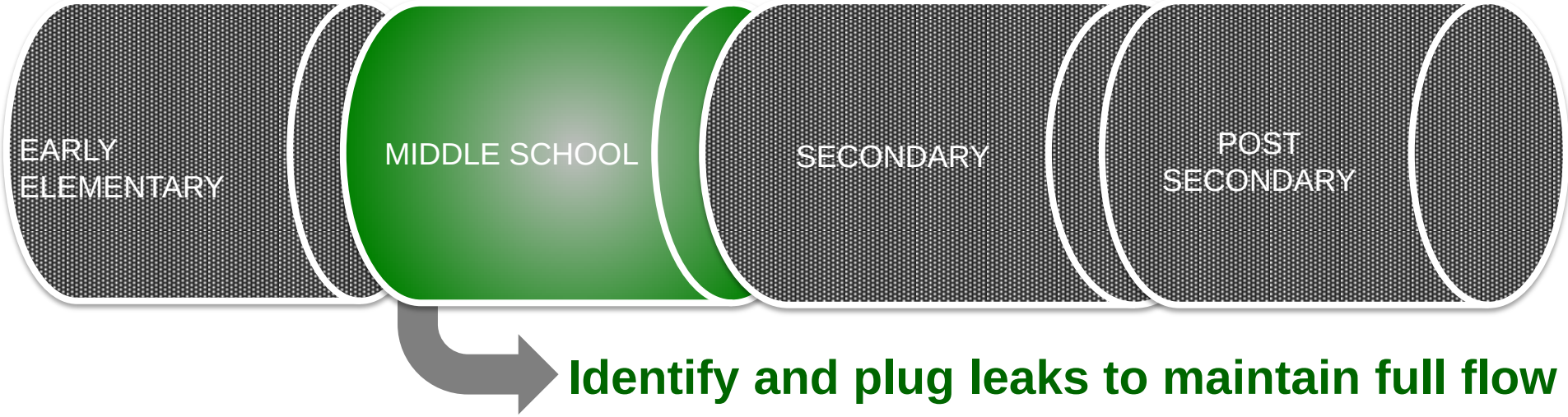
SeaPerch

- Underwater robotics provides relevance to sciences

Starting with early education maximizes the volume of students entering the STEM pipeline

The STEM Pipeline

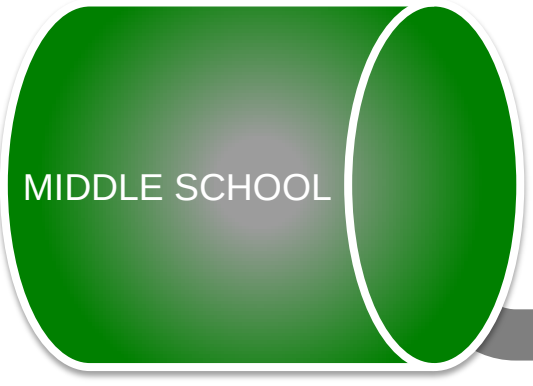
BUILDING THE STEM EDUCATION-TO-WORKFORCE PIPELINE

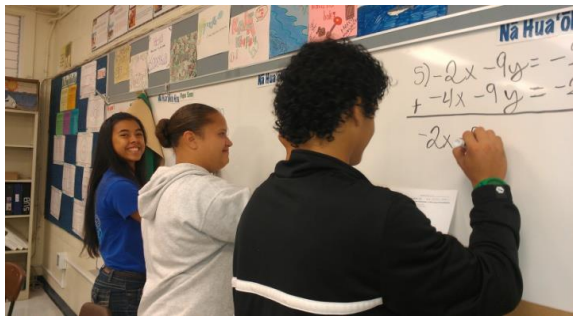


Identify and plug leaks to maintain full flow

- **Geek/Nerd stigma**
  - **Negative images in society/media reinforce stereotypes**
- **Increase gender and ethnic diversity**
- **Traditional math and science subjects perceived as boring and difficult**
- **Not relevant or exciting**
- **Lack confidence**

The STEM Pipeline





ONR Investments in Middle School programs

ESS - Engineering Success in STEM

- Engineering education continues into middle school
- Encourages students to enroll in more difficult science and mathematics classes

IEI - Island Energy Inquiry

- Curriculum training and hands-on energy science projects continues through middle school

SeaPerch

- Underwater robotics continues through middle school

STEMworks

- Service learning, project-based, student led
- Industry standard, technology equipped labs
- Industry mentors, real-world applications

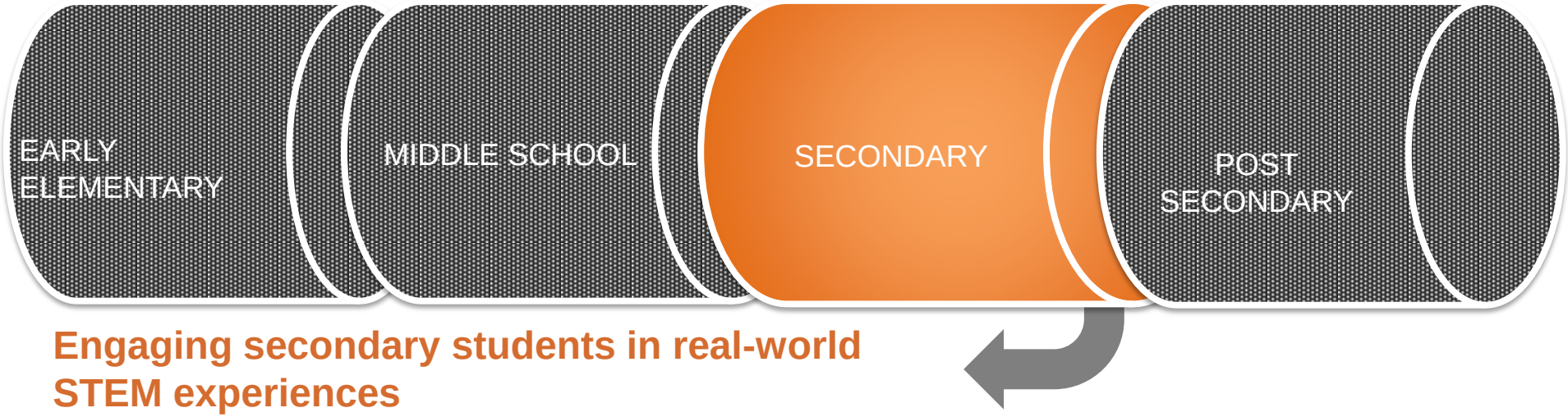
Royer Studio's Animation

- Sustainable Energy Project for Hawaii

ONR funded projects designed to plug leaks and maintain full flow

The STEM Pipeline

BUILDING THE STEM EDUCATION-TO-WORKFORCE PIPELINE



Engaging secondary students in real-world STEM experiences

- Early and ongoing STEM career pathways guidance
- Hands-on learning with real-world applications
- Broad appeal, targeted outreach to all students
- Job ready, technology skills to enter workforce, such as computer literacy
- Job site observations, industry mentors, internships, career awareness
- Building Industry commitment to active participation

The STEM Pipeline

SECONDARY

ONR Investments in Secondary Level programs

SEAP – Science Engineering and Apprenticeship Program

- Internship programs working alongside Navy researchers

ESS - Engineering Success in STEM

- Engineering education continues into secondary school
- STEM academy – Prepares students to be STEM career and university ready

IEI - Island Energy Inquiry

- Curriculum training and hands-on energy science
- Projects being developed for secondary school

SeaPerch

- Advanced under water robotics

STEMworks

- Service learning, project-based, student led
- Internships, technology equipped labs
- Industry mentors, real-world applications

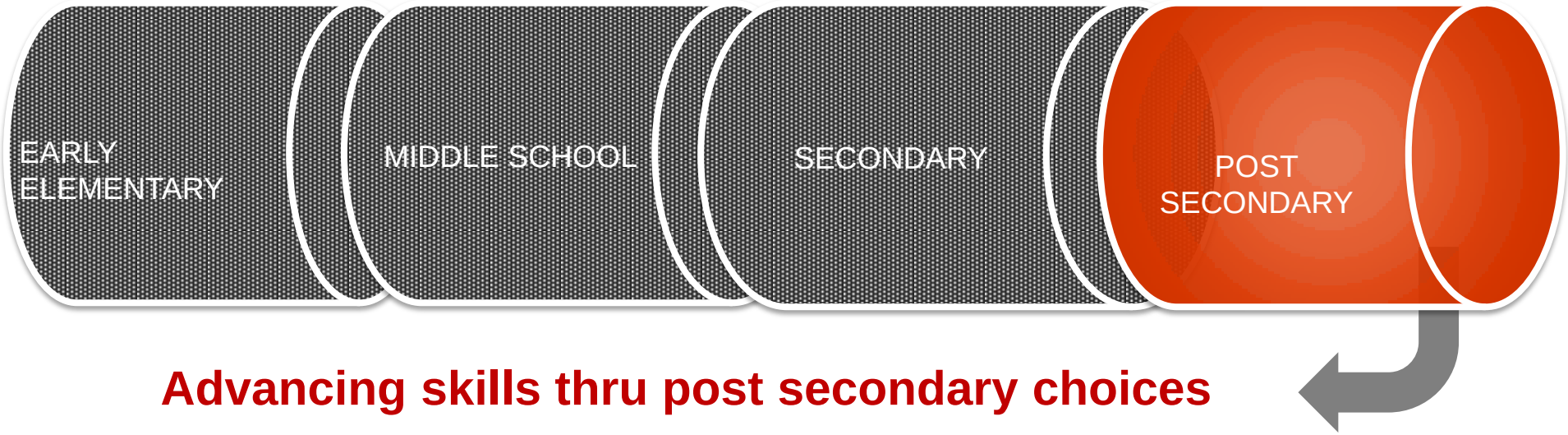
Royer Studio's Animation

- Sustainable Energy Project for Hawaii

Engaging secondary students in real-world STEM experiences

The STEM Pipeline

BUILDING THE STEM EDUCATION-TO-WORKFORCE PIPELINE

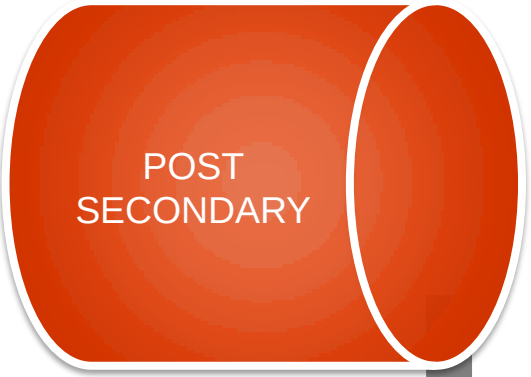


Advancing skills thru post secondary choices

- **Vocational and on the job training**
- **Internships and apprenticeships**
- **Job site observations, industry mentors, career awareness**
- **Developing world-class academic skills and advancing state of the art technology**
- **Ongoing STEM career pathways guidance**

The STEM Pipeline

ONR Investments in Post Secondary Level programs



NREIP – Naval Research Enterprise Internship Program

- Graduates and Undergraduates conducting research in Navy labs

Maritime RobotXChallenge

- International student autonomous surface vessel competition
- 15 multi-disciplinary student teams from US, Singapore, Australia, Japan and South Korea
- Inaugural event October 2014 in Singapore
- Pinnacle STEM student outreach event to be held biennially in various Pacific locations

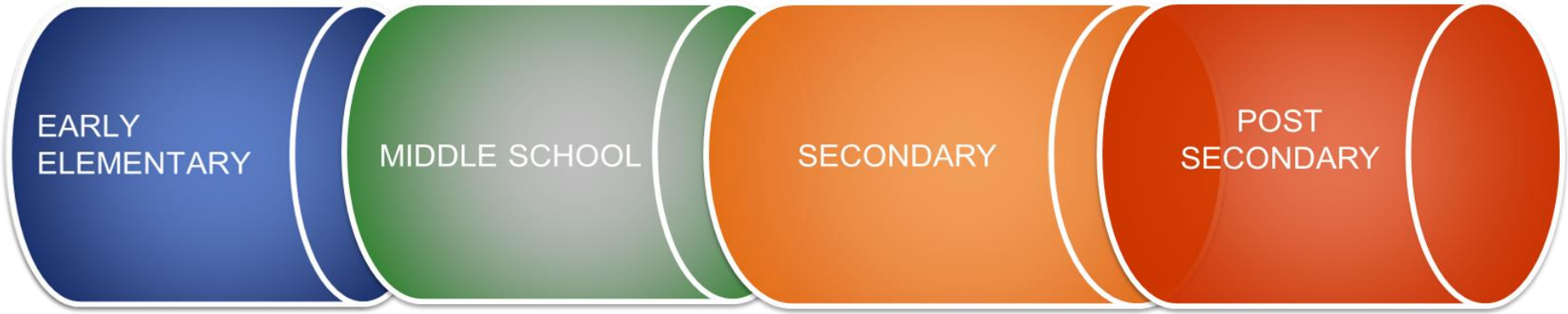
Office of Naval Research Grant

- Coordination of STEM Education and Professional Development Activities for Emerging Industries Across Asia-Pacific

Advancing skills through post secondary choices

The STEM Pipeline

BUILDING THE STEM EDUCATION-TO-WORKFORCE PIPELINE

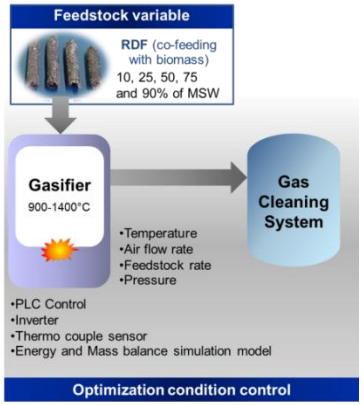


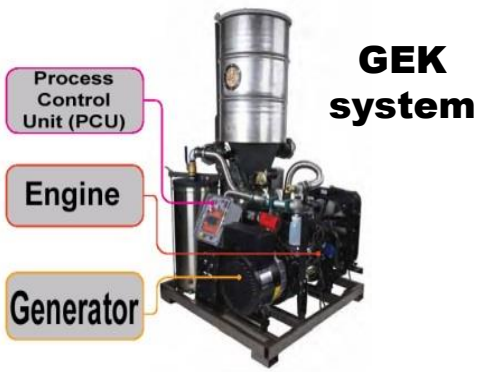
BENEFITS OF BUILDING THE STEM EDUCATION-TO-WORKFORCE PIPELINE

- Sustain technical workforce
- Drive industry success
- Enhance economic development
- Improve standard of living/quality of life

IRISES

- **I**ndigenous **R**esearch for **I**nnovation in **S**ustainable **E**nergy **S**olutions
- Indigenous researchers at community and regional levels have the best insight into "local" needs, opportunities & challenges across all factors -- technical, environmental, cultural and financial.
- Examples:





"Micro Solid Waste Gasification Systems for Thailand"
University of Phayao

The 10 steps of Local Energy Planning (LEP)

1 Introducing LEP Scheme.

2 Educating local energy planner (TOT).

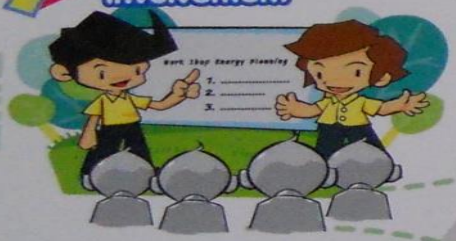
3 Collecting Energy data and information.

4 Data processing and analyzing.

5 Discuss finding with the community.

6 Field Trips. Study Tours.

7 Drafting of Local Energy Plan with community involvement



8 Feedback session. Listening to comments

9 Implementation stage. Let's do it together

10 Resuts & Impacts conclude lessons learned.

Acknowledgement

- Dr. Richard Carlin, ONR
- Dr. Richard Rocheleau, HNEI
- Ms Dawn Lippert, PICHTR
- Mr. Clifton Ching, ONR

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