Bluerise - Ocean Thermal Energy Technology and Project Development

Remi Blokker, CEO

2nd Regional District Cooling Technology Conference
in Latin America and the Caribbean
October 26, 2015

Bluerise
harnessing the ocean's power

Short Bluerise Intro

What we do

Project development

OTEC, SWAC, Ecopark (Curaçao, San Andres, Colombia, and others…)

Technology

More efficient ➔ lower $/kWh

Software

- Resource Assessment
- System Control SW

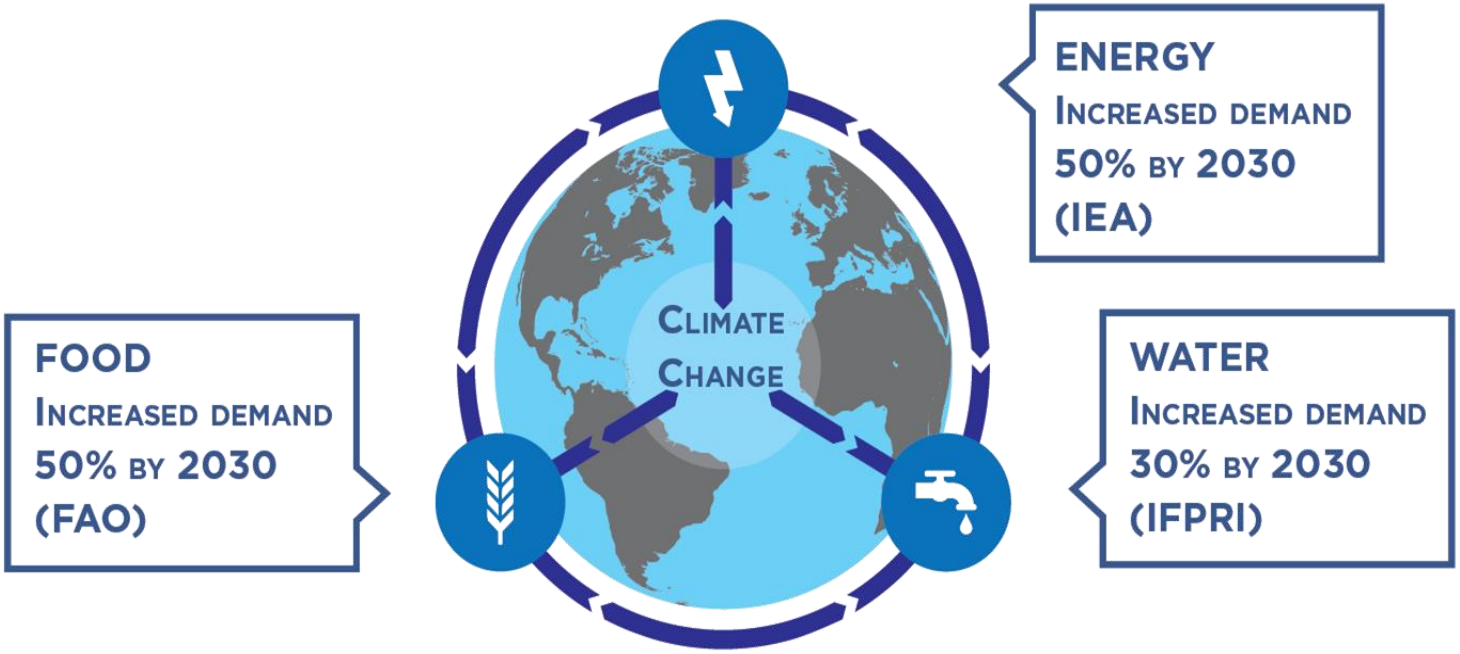
Team of dedicated international experts with complementary skills

Agenda

- Context – why OTEC & SWAC are essential
- Project Highlight – Ocean Ecopark Curaçao
- Structuring and financing OTEC projects
- Technology update
- Working with us

Context - Global

Increasing demand, in particular in **tropical regions**



Context - Caribbean

"This region has some of the highest energy costs in the world.

Caribbean countries are particularly vulnerable to the effects of climate change and we have to act now.",

US President Obama, CARICOM summit, April 2015

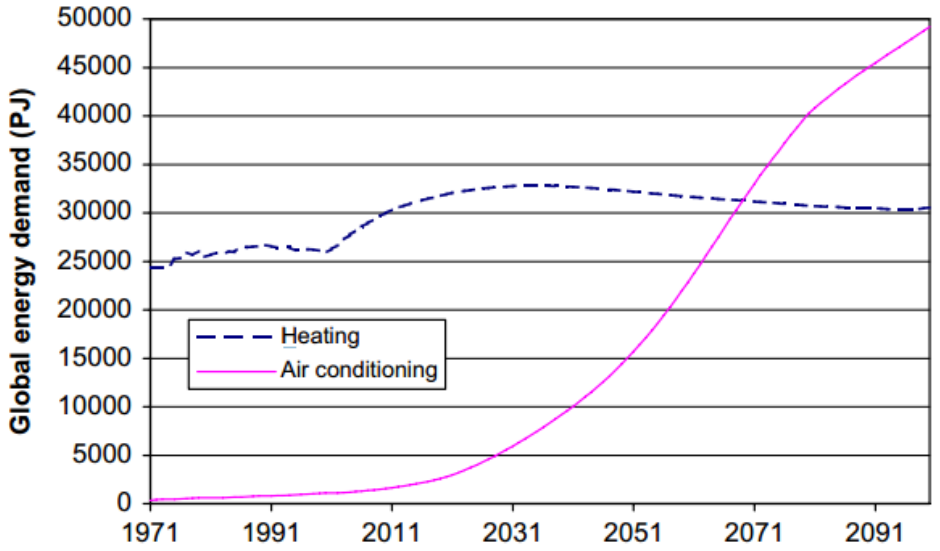
Context - Cooling

Energy for Heating – stabilizing

- Energy savings – insulation
- Climate Change

Energy for Cooling – growing

- Increasing prosperity
- Climate Change



M. Isaac and D. P. van Vuuren, 2009

Energy Options for Caribbean

Fossil fuels

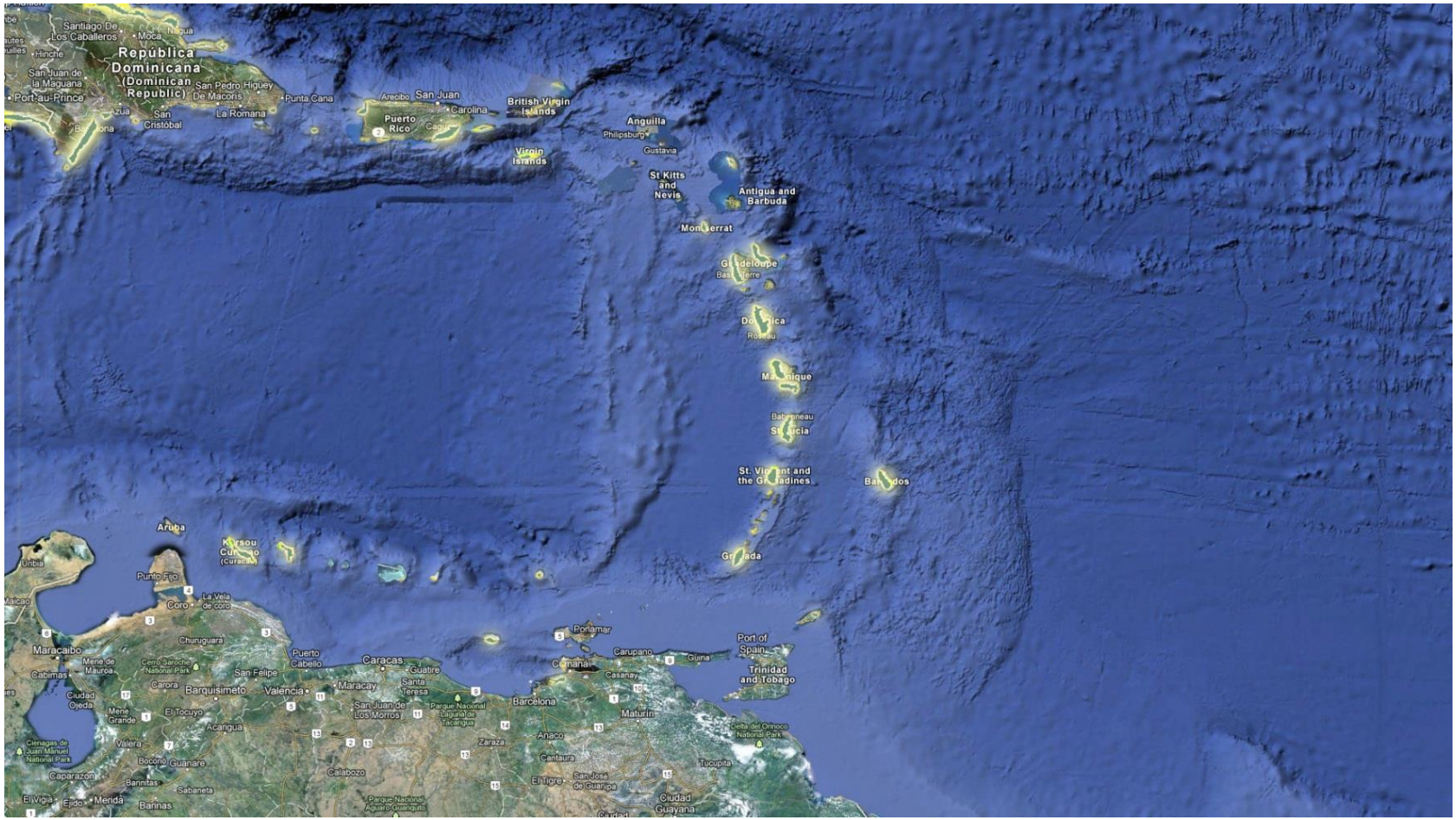
- Most Caribbean countries do not have fossil resources and need to import
- Serious energy security risks
- LNG & CNG do not change this
- Fossil fuels emit large amounts of greenhouse gas
- Low-carbon fossil a false hope?

Nuclear – not sustainable, and requires scale that is probably prohibitive for Caribbean

Renewables – only real option for sustainable, energy-secure, future

- Hydro – mature, very dependent on local conditions
- Wind – mature, intermittent
- Solar – mature, intermittent
- SWAC, mature, baseload
- OTEC, near-commercial, baseload
- Geothermal – semi-mature, baseload, very dependent on local conditions, considerable risk with drilling
- Biomass – mature, but arguably non-sustainable, large land usage, competing with food

Ocean Thermal Energy resource in the Caribbean



Almost all Caribbean countries have good access for SWAC & OTEC!

***NB, eastern side shown, western side also has good access**

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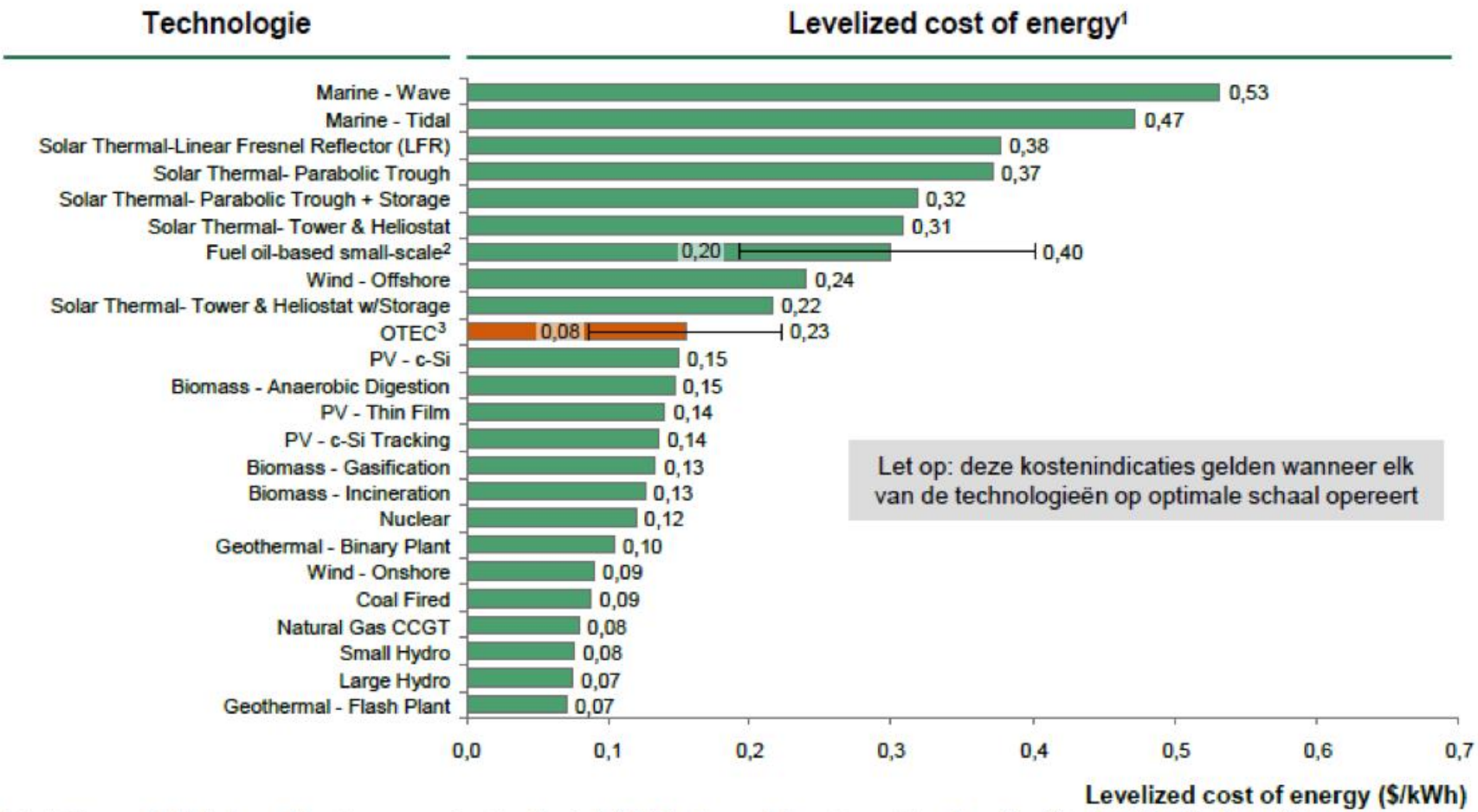
Cost comparison various technologies

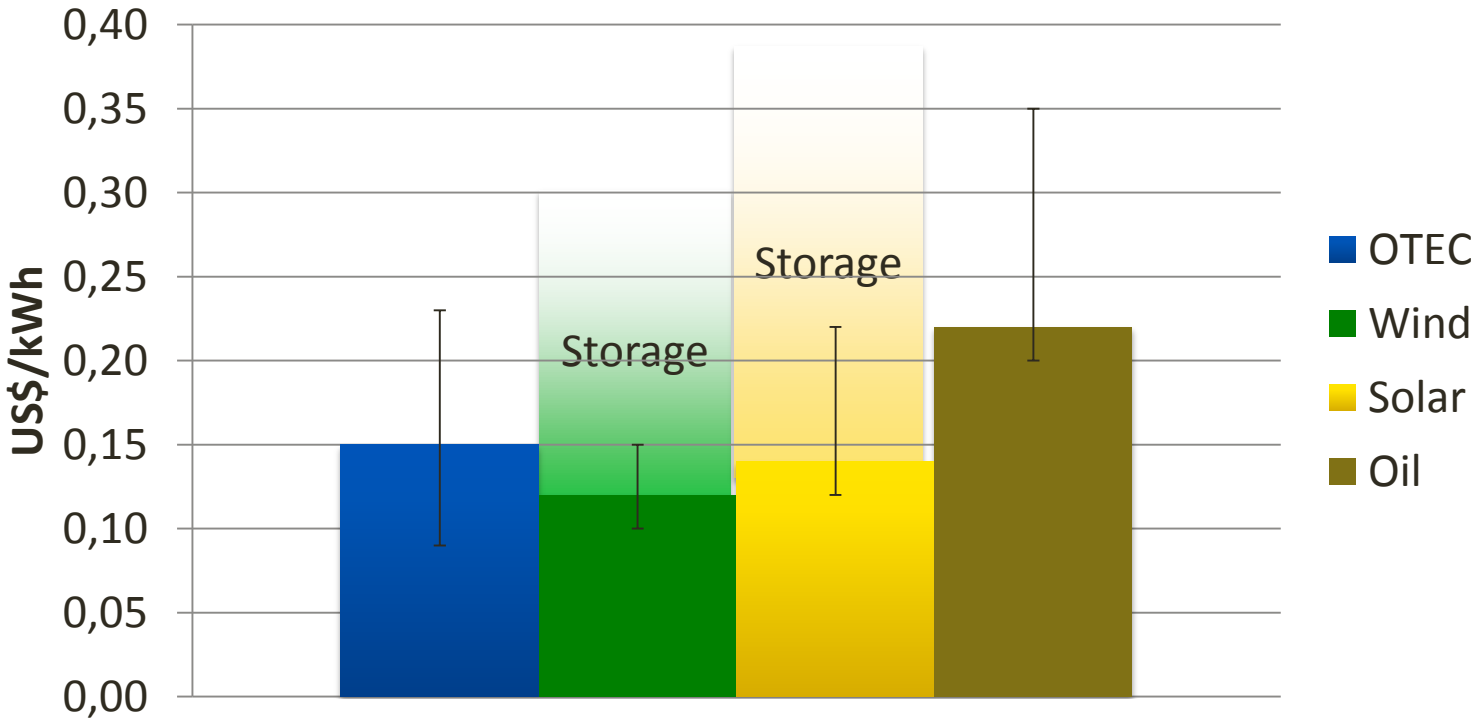
Levelized cost of energy - kWh price over life of installation



Let op: deze kostenindicaties gelden wanneer elk van de technologieën op optimale schaal opereert

1. Inschatting van de totale kosten van het systeem om energie op te wekken, inclusief alle kosten over de levensduur van het systeem. (Bron: Bloomberg; "Base Case" scenario)
2. Range loopt van 0,20-0,40. Omvat zowel heavy fuel oil (HFO) als diesel
3. Range loopt van 0,08-0,23. Bron: IIASA Global Energy Assessment, 2012

System LCOE



Wind & solar, being intermittent sources, require additional storage / back-up generation, adding cost

Barriers for SWAC?

Technical

- Although SWAC is not found in Caribbean yet, District Heating and Cooling systems have become commonplace elsewhere
- Deployment of offshore infrastructure has fully matured

Financial

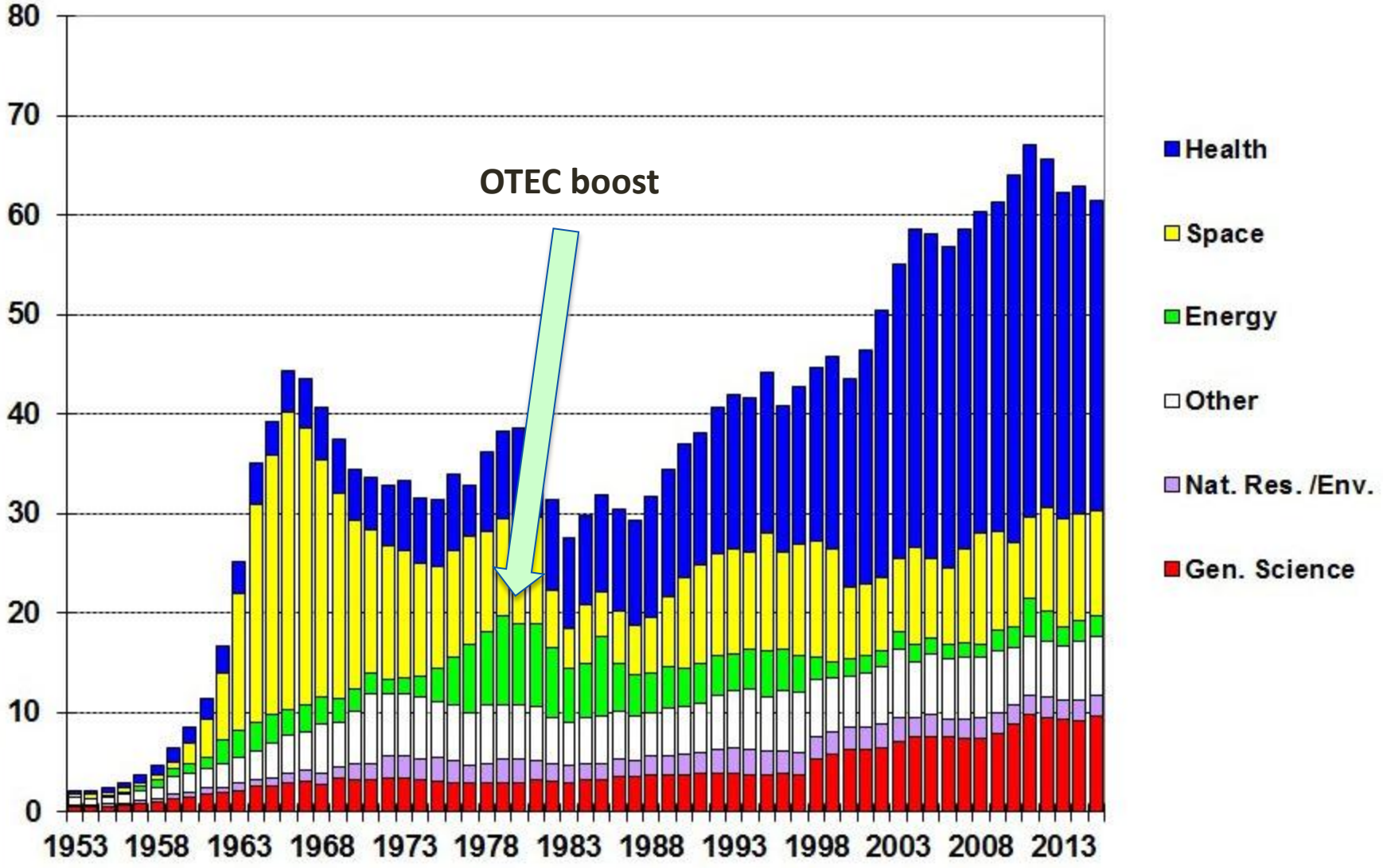
- SWAC is competitive with status quo
- Shift from low CAPEX generation sources like diesel to high CAPEX requires different financing model

Political

- Relatively complex and novel projects – challenge for small public sector
- Requires some new policies and guarantees
- Grant funding of projects can boost progress

Trends in Nondefense R&D by Function

outlays for the conduct of R&D, billions of constant FY 2014 dollars



Source: AAAS, based on OMB Historical Tables in *Budget of the United States Government FY 2015*. FY 2015 is the President's request. Some Energy programs shifted to General Science beginning in FY 1998.

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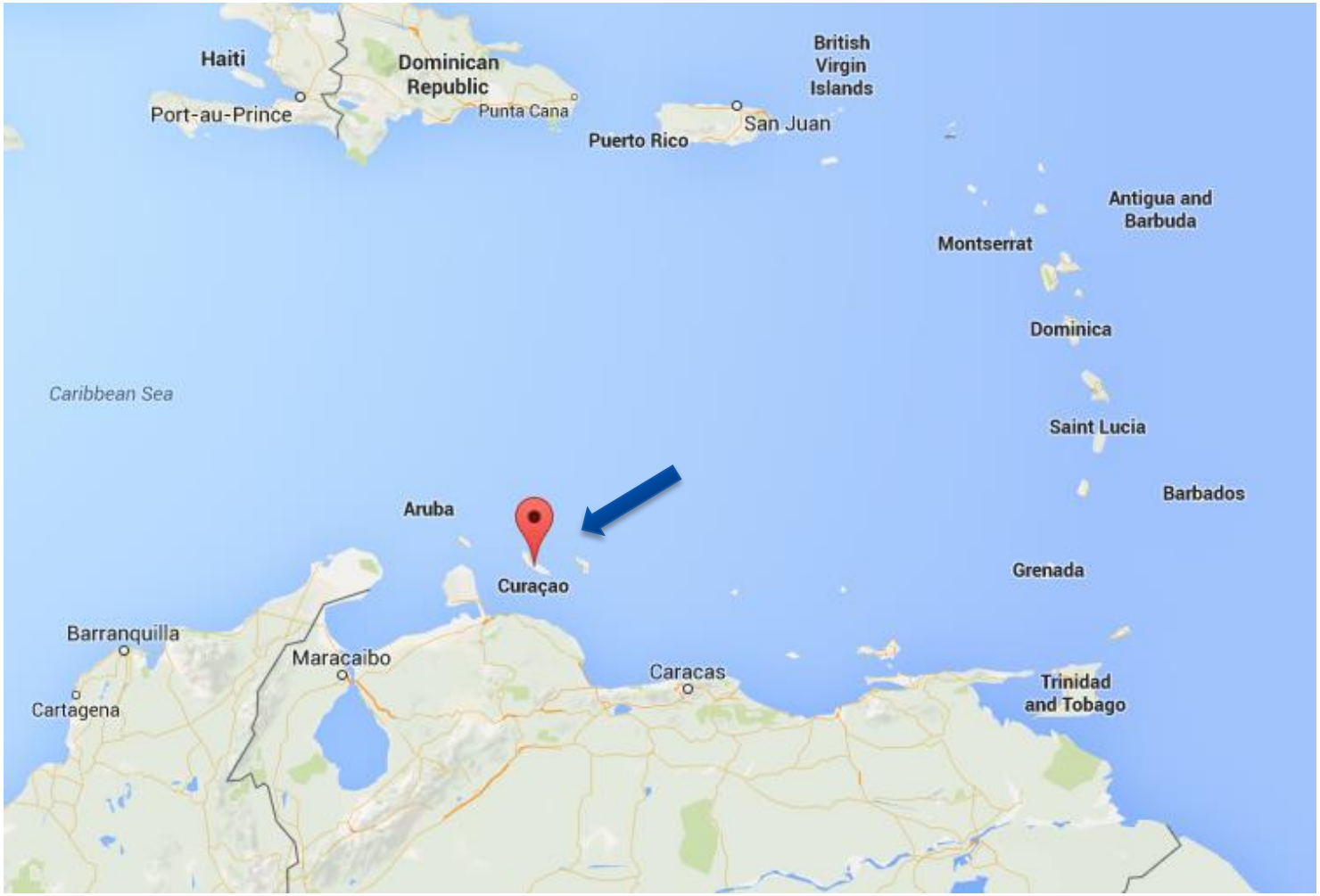
Project Highlight - Ocean Ecopark Curaçao



Ocean Ecopark Curaçao

Addressing the **global challenges locally**

- Local Sustainable Development of Energy, Food and Water
- 50+ M$ investment in a high profile project creating over 400 jobs
- Central element is the cold deep seawater brought up by a pipe
- Project has three main components:
  - SDC cooling of buildings in airport area
  - Ecopark
  - OTEC

A new generation of technologies is enabling us to design smarter, safer, more sustainable and more accessible solutions

Ocean Ecopark Curaçao

Sustainability as a **Strategic Advantage**

- Seawater District Cooling of buildings in airport area
  - Energy savings of 80-90%
  - Stable, cost-effective cooling
  - Industry proven technology

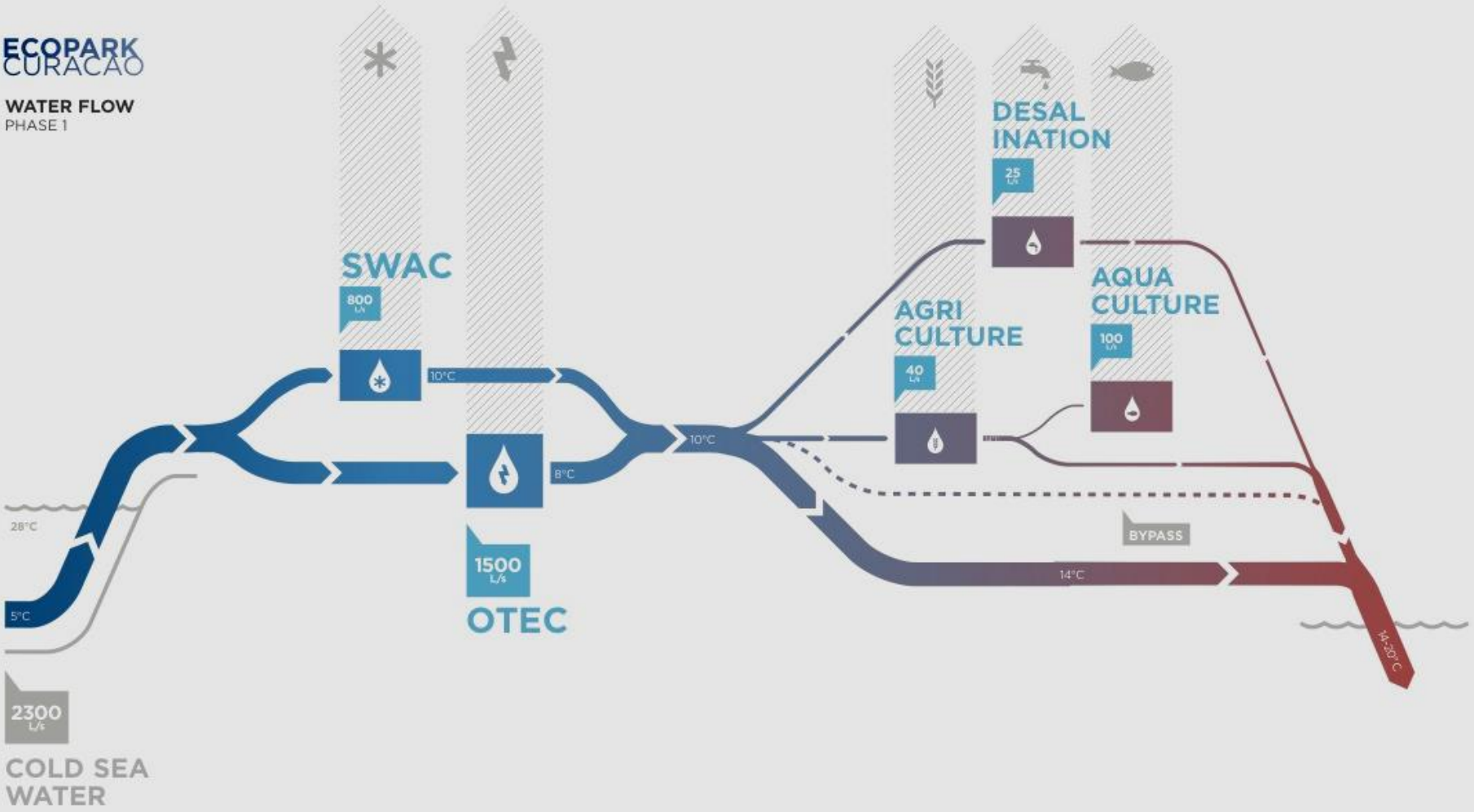
- Ecopark utilizing the clean, cold, nutrient rich seawater
  - Area of 20-60 hectares for the production of food and water
  - Area will be rented by tenants, who will run their business
  - R&D facilities

- OTEC
  - Electricity production using warm and cold seawater
  - 500 kW pilot installation
  - 1st in the world on this scale

Ocean Ecopark Curaçao

Sustainability as a **Strategic Advantage**

Ocean Ecopark Curaçao modular water flow



Ocean Ecopark

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Research and Development

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Community Outreach

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Ocean Ecopark Curaçao economic impact

	Economic impact	Jobs	CO2 reduction	Key characteristics
SWAC cooling	7 M$	20	14.000 ton/y	✓ 12,000 ton A/C peak Seawater capacity ✓ Current average consumption: 1,800 ton A/C ✓ Significant expansion possible
OTEC electricity	1 M$	15	2.500 ton/y	✓ 500 kW electricity production (own use only)
Agriculture	30 M$	125	2.500 ton/y	✓ 20-60 hectares of local food and local jobs ✓ Export potential >10,000 ton/year of Ocean Ecopark produce
Aquaculture	20 M$	180	1.000 ton/y	
Algae	15 M$	60	1.500 ton/y	
Other	5+ M$	40+		✓ R&D, conference location and restaurant
Total	**75+** M$/year [1]	**400+** jobs [2]	**-22.000** ton CO2/year	

1) Direct output
2) Permanent jobs, both direct and indirect

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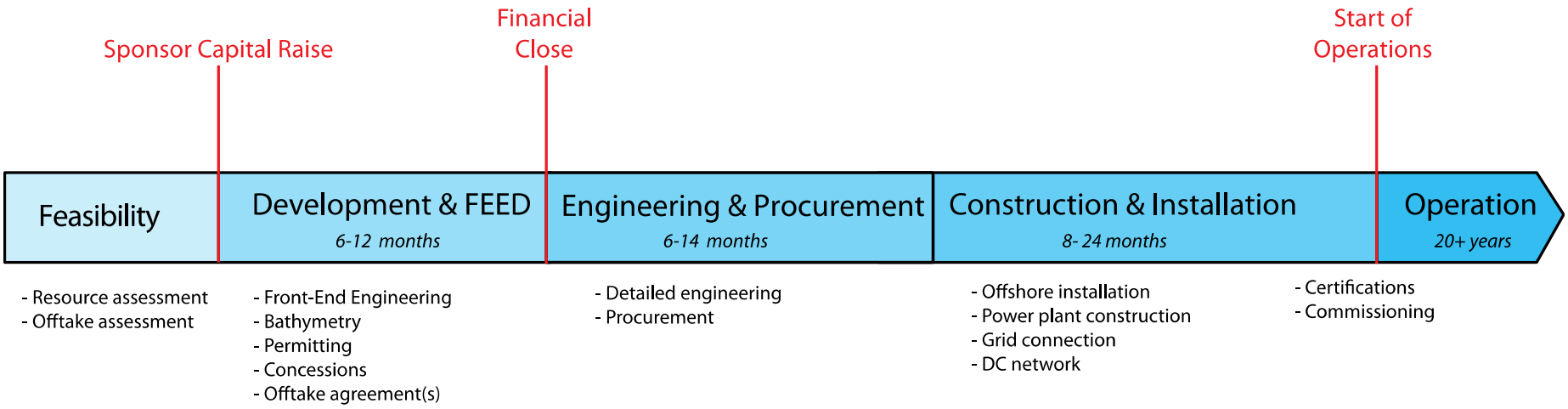
Project phasing

Typical project **roadmap**



Bluerise philosophy

- Active engagement with local and international stakeholders and thought leaders from day one
- Perform thorough feasibility study of project
- Setup local SPV with local partner
- Sponsor equity comes from local sources or international – both financial and industry partners – e.g. contractors and equipment suppliers
- Project Equity & Debt – OTEC & SWAC are attractive for impact investors due to applicability in developing regions – e.g. developing banks, pension funds

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Bluerise activities

Technology development

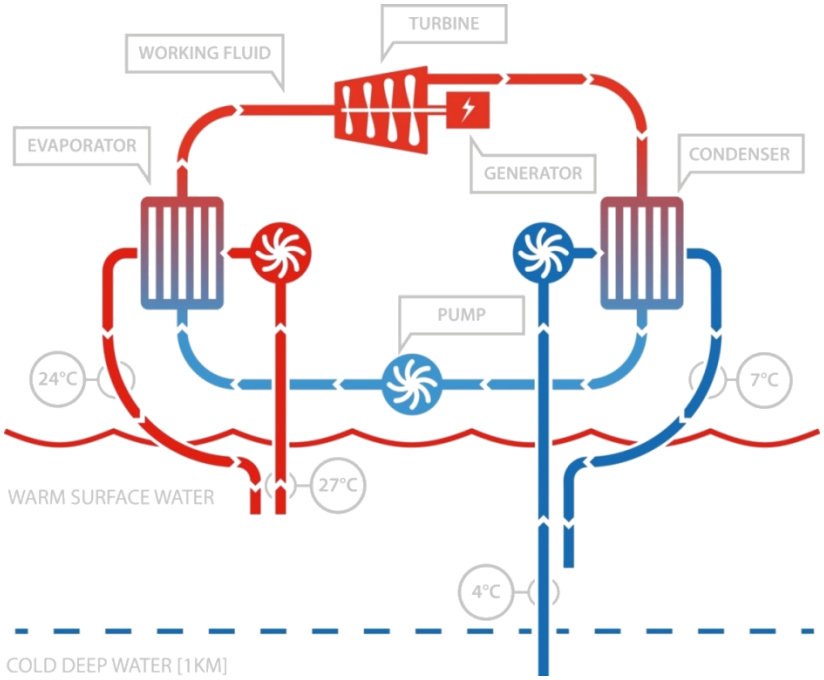
Technology

- Operational OTEC development system
- Development programs for 500kW and multi-MW scale OTEC
- R&D program covering a range of topics
  - Working fluids & Cycle design
  - Heat exchangers
  - Cold water pipe

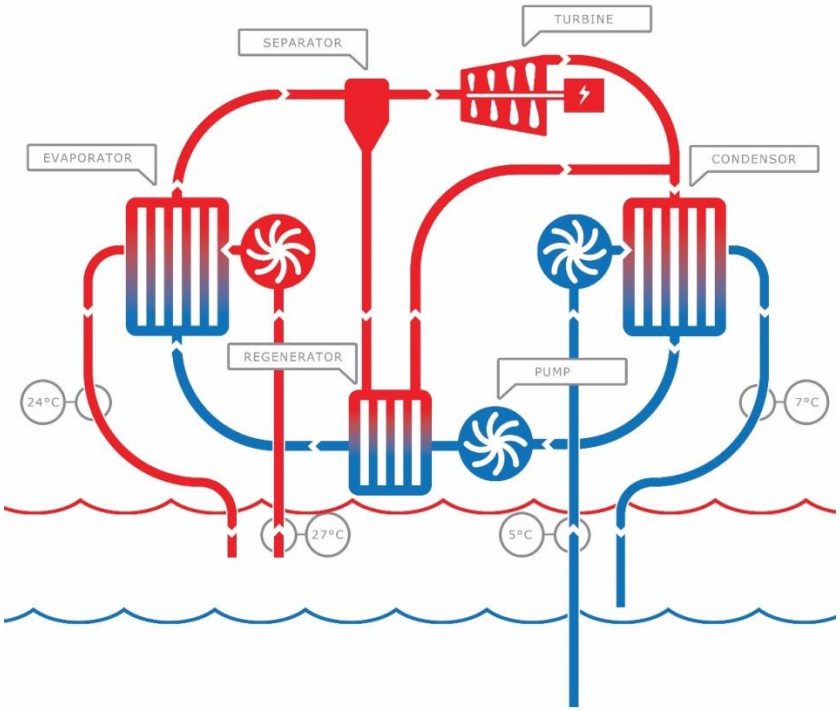
Transforming the ocean's temperature differential resource into electricity is the core of Bluerise's technology activities.

Power Cycle Development

Increasing the **effectiveness**



Pure fluid Rankine Cycle

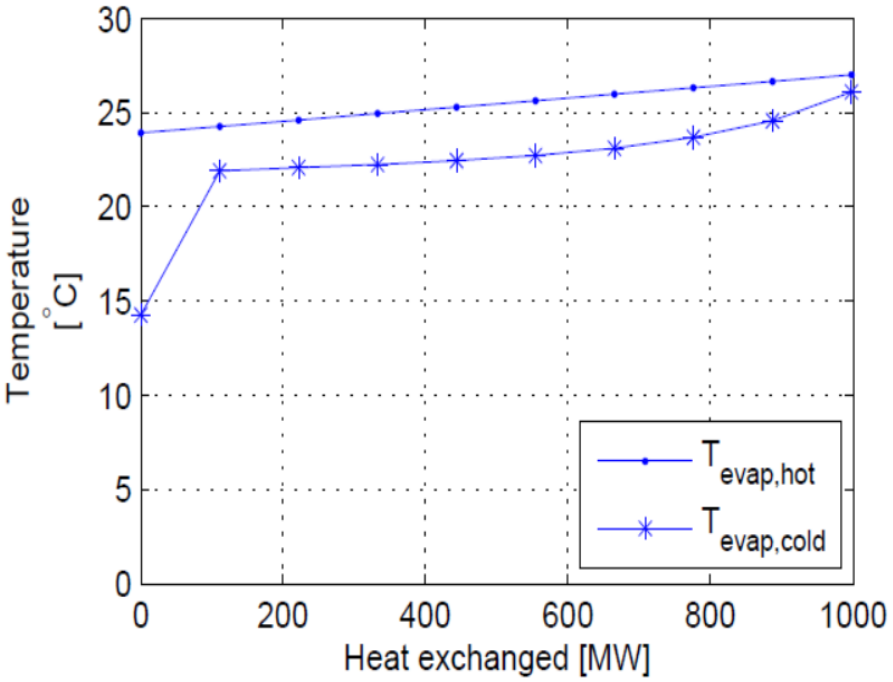


Mixed fluid advanced Cycle

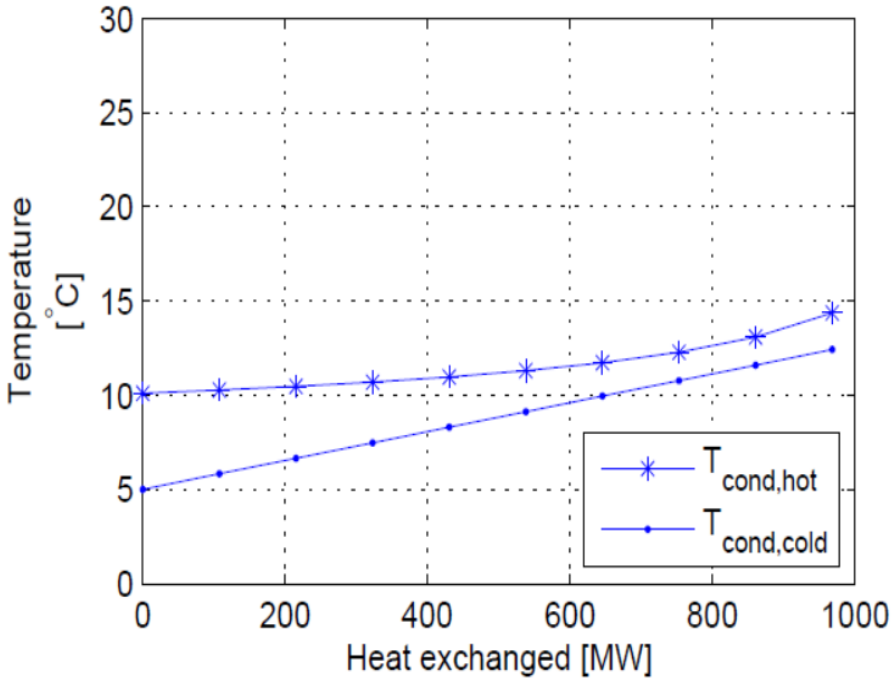
up to 20% higher efficiency

Mixed Fluid OTEC cycle

Evaporator



Condenser



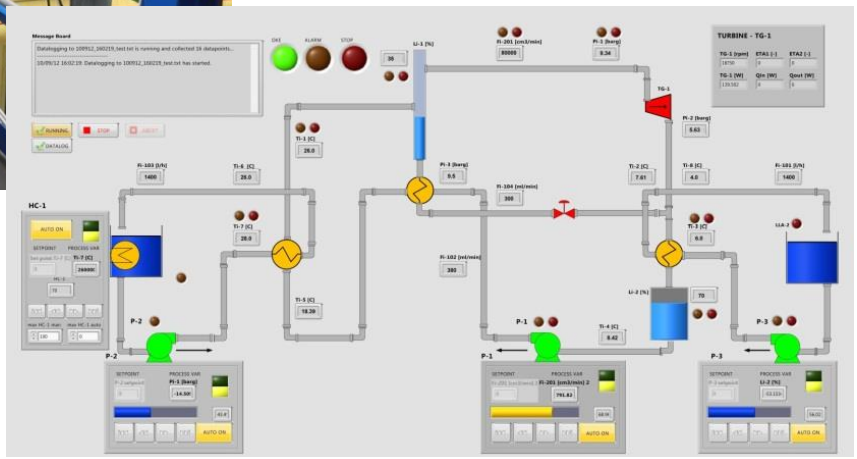
Heat exchanger mixture performance

OTEC mixed fluid setup

Running for over 2 years, gathered large quantity of data

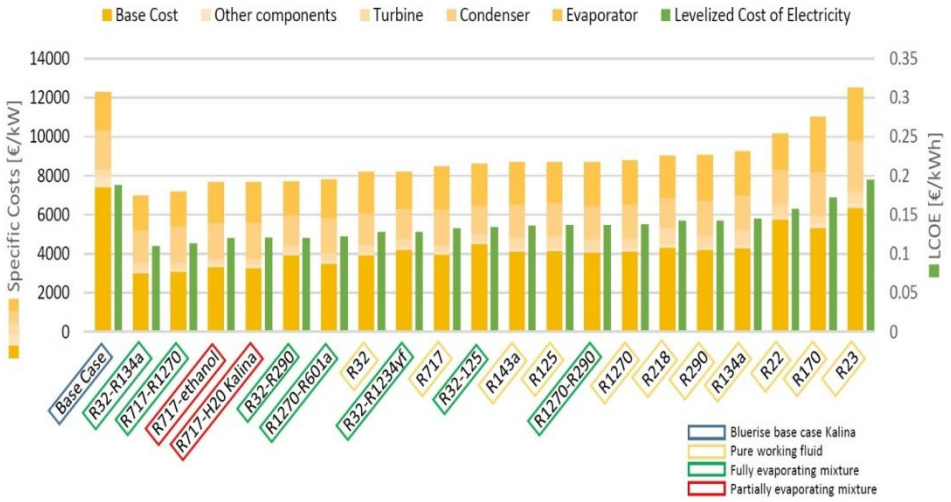
Validation of OTEC performance models

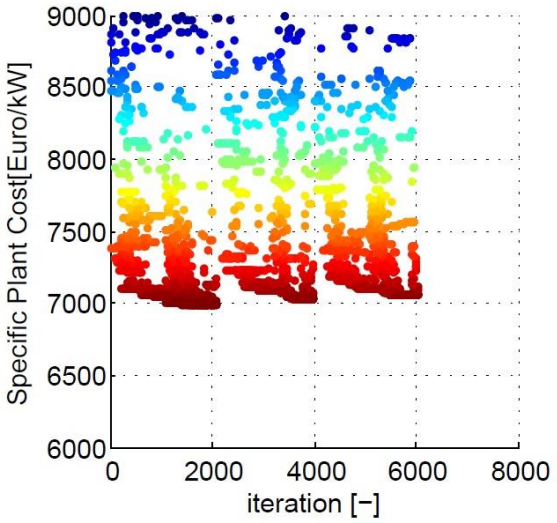
Development of real-time control system



Power plant optimization

Getting **more power** for **less money**





Influence of working fluids on costs

In-house developed automated system optimization tools

Heat exchanger development

- Heat exchanger design analysis using Computational Fluid Dynamics (CFD)
- Research program with Delft University of Technology

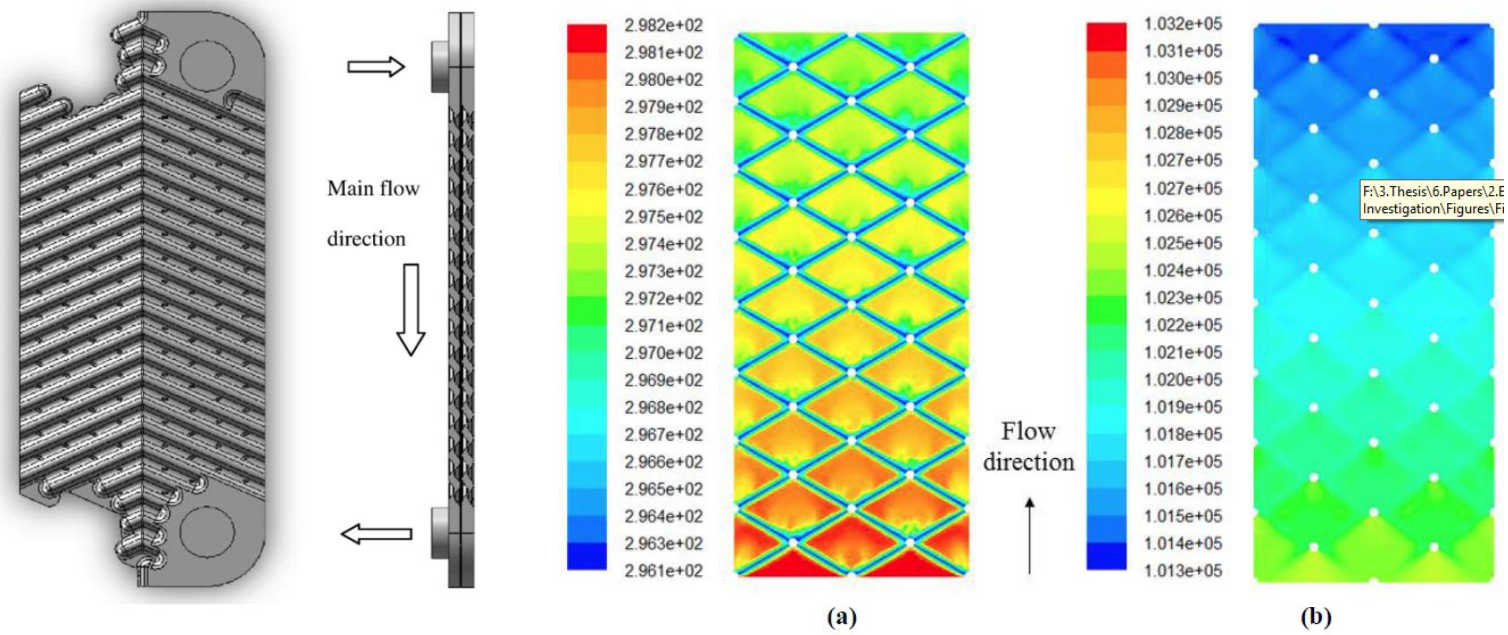


Fig. 3.25: Contours of (a) static temperature of the plate and (b) absolute pressure of the plate (Unit: K, Pa)

Software Development

Software

- Online OTEC resource assessment tool

http://my.oceanpotential.com

Global datasets can provide great insights in the potentially available resource for any given location

Ocean Energy platform
Delft University of Technology

Henk Polinder

Wave Energy

Berend Jan Kleute

Thermal Gradient (OTEC)

Antonio Larquin Laguna

Tidal/Current Energy

Peter Mooij

Aquatic Biomass

Kornelis Blok

Chairman

Elisabeth Insam

Student - Energy Club

Lily Li

Senior Project Manager DEI

Eveline Zeegers

Office Manager DEI

http://oceanenergy.tudelft.nl/

Bluerise

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B Corps are certified by the nonprofit B Lab to meet rigorous standards of social and environmental performance, accountability, and transparency.

Bluerise is one of the “founding” European B Corps

Corporation
bcorporation.net

What makes us a better company?

B Impact Report

Certified since: September 2014

Summary:	Company Score	Median Score*
Governance	9	10
Workers	19	22
Community	54	32
Environment	28	9
Overall B Score	110	80

80 out of 200 is eligible for certification
*Of all businesses that have completed the B Impact Assessment
*Median scores will not add up to overall

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