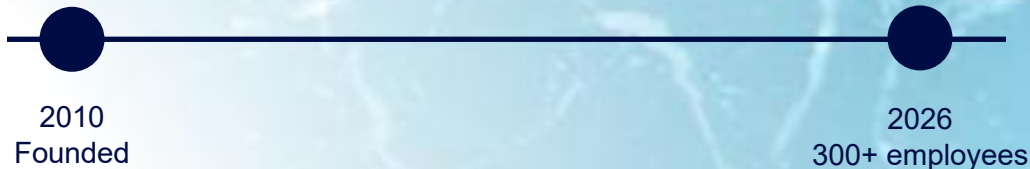


HARNESSING FARMED TROPICAL SEAWEED BIOMASS TO PRODUCE SUSTAINABLE FUELS

***Shrikumar Suryanarayan , Chairman & Managing Director Sea6 Energy
private limited, Bangalore India***

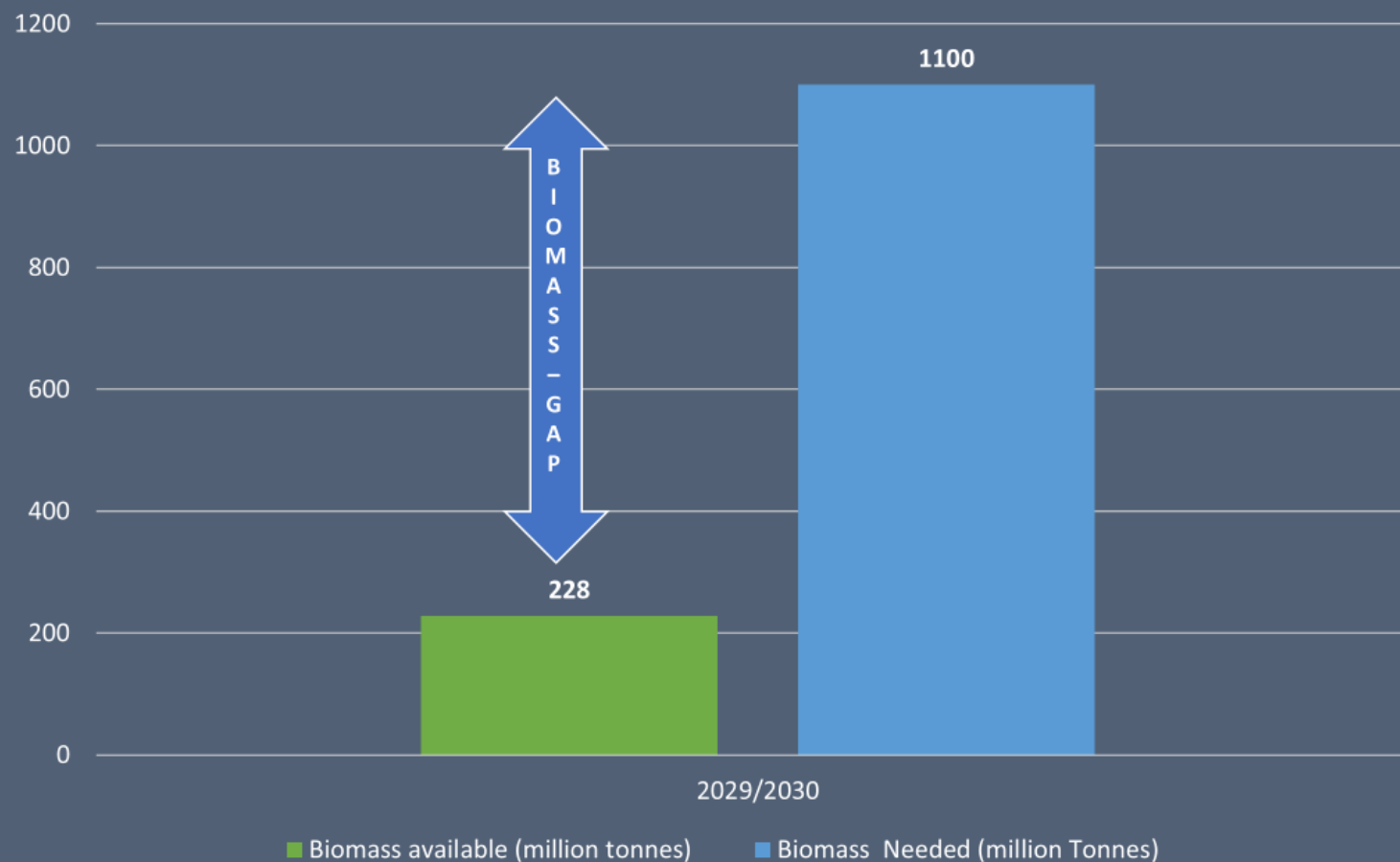
Sea6 is a pioneer in the ocean economy, transforming cultivated tropical seaweed biomass harvested through large-scale mechanised seaweed farming into carbon-negative, sustainable feedstock for large industrial applications in agriculture, food, materials & fuels.



OUTLINE OF THIS PRESENTATION

- **The problem we are addressing**
 - A looming shortage of biomass feedstock in India, to make biofuels.
- **The technical solution**
 - Farming our seas at scale using tropical seaweed
 - Converting this seaweed Biomass to fuels

INDIA –Replacing 2030 crude oil imports with Biofuel equivalent will require nearly 1100 million tons of feedstock* - And less than 25% of what is needed is available from land based agricultural surplus



INDIA - Estimated Petroleum demand : 2029/30 = 300 m tons

*About 3.67 tons of biomass needed to make 1 ton of petroleum equivalent

Can seaweed be the next major agri feedstock?

TODAY'S AGRI FEEDSTOCKS



Sugarcane



Wheat



Corn



THE CANDIDATE



Seaweed

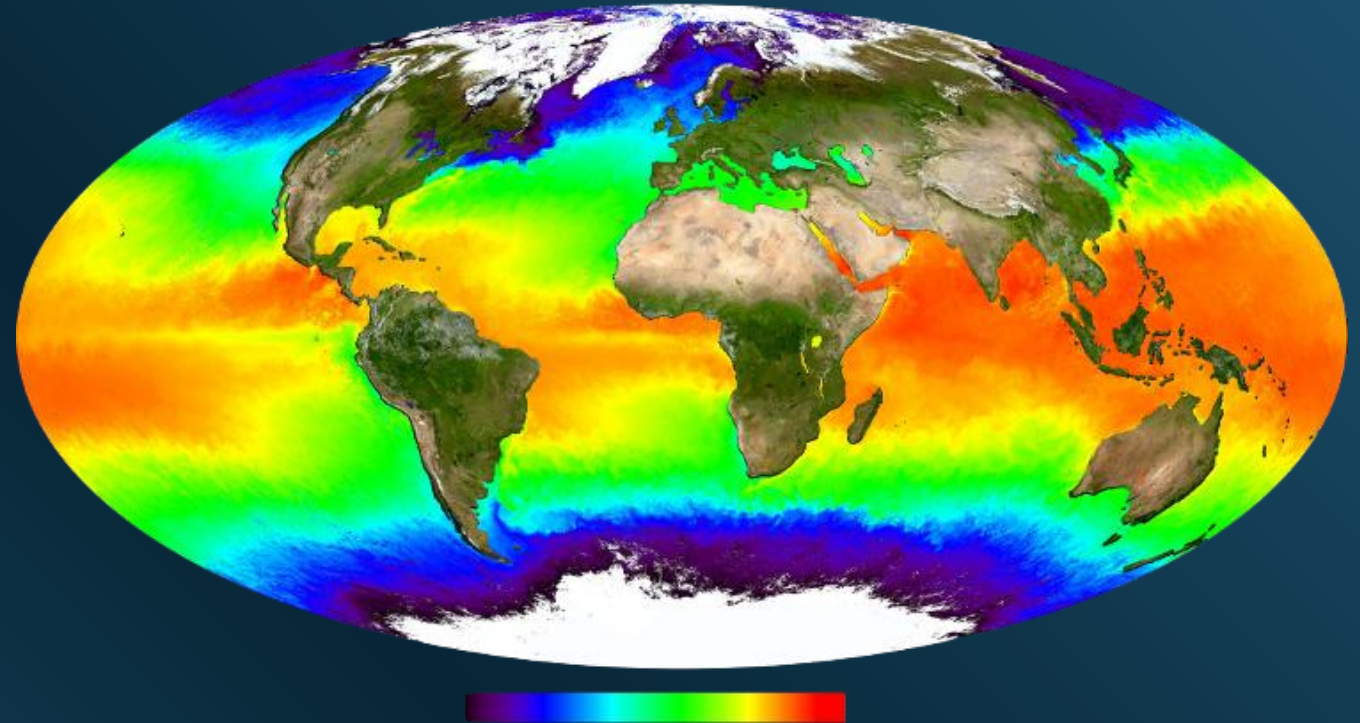
Pros

- + Stable temperatures year round
- + Water availability year round
- + Large contiguous areas for expansion
- + Heavy logistics on water is efficient

Cons

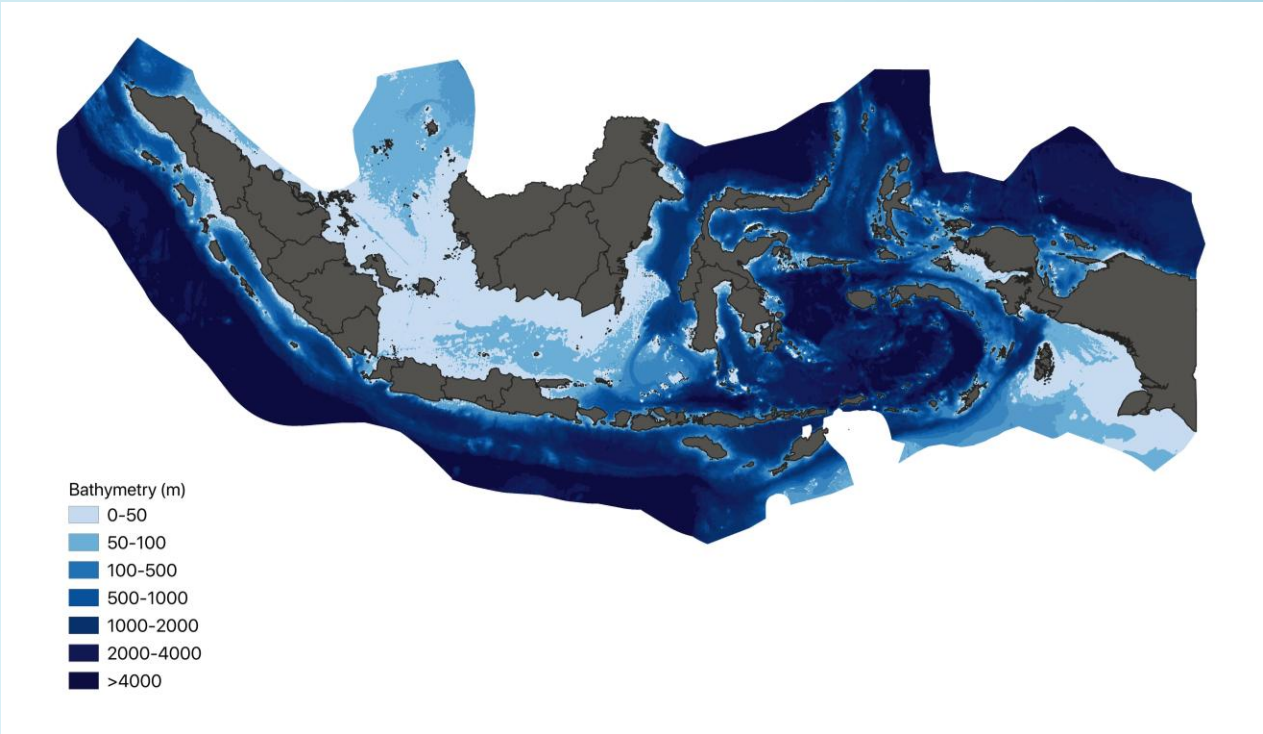
- Yields to be demonstrated at scale year round
- Engineering to be demonstrated at scale and cost

Warm tropical waters allow for year-round cultivation



Low variation of solar insolation during the year in the tropics allows for year-round cultivation of tropical seaweeds.

Scalability potential & Regulatory frameworks

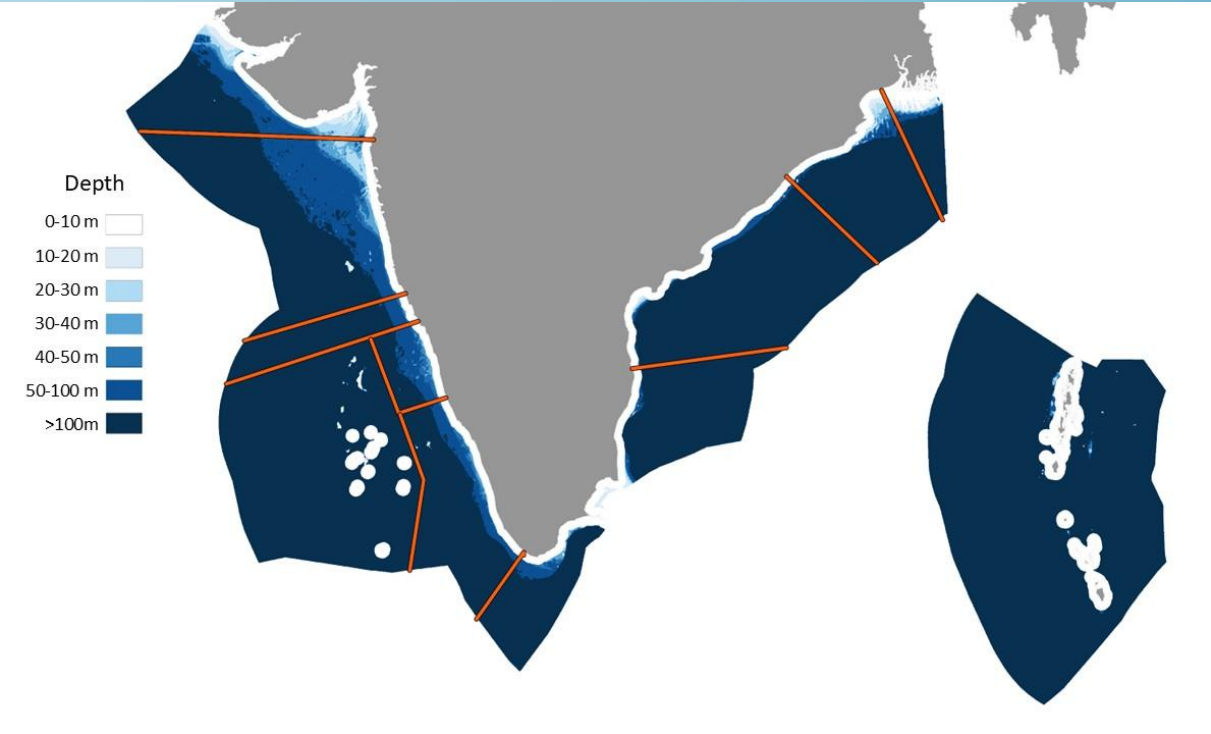


Exclusive economic zone ~ 10 million Sq.km
Potential cultivable area (0-100m) available: 1.6 Million Sq.km

Regulatory in Indonesia:

Regulatory frameworks for leasing sea space in Indonesia are well established. Sea6 has already obtained sea lease for 64 Ha of sea for seaweed farming within a 1 Sq.km area in Ekas Bay, Lombok, Indonesia.

Process and Timeline: Online single window system, takes approximately 6 months to obtain the permit



Exclusive economic Zone ~ 2 million Sq.km
Potential cultivable area (0-100m) available: 372,000 Sq.km

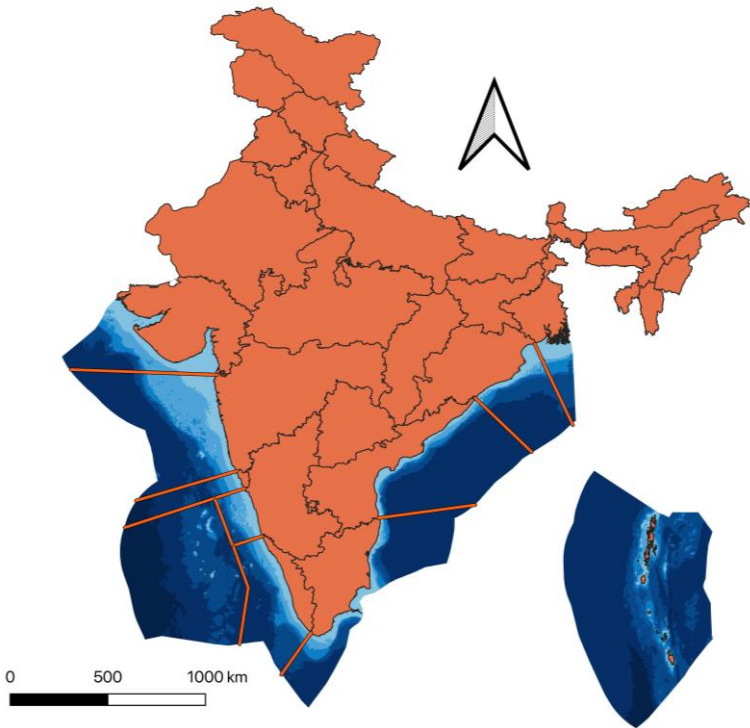
Regulatory in India:

Regulatory landscape in India is evolving in favour of large scale lease for seaweed farming with the Government promoting pilot projects in this space.

Reference: Sea6 analysis of GEBCO Global bathymetry data set.

INDIA'S POTENTIAL FOR SEAWEED FARMING IN THE EEZ.

Sustainable fuels & food security for the world's largest population



*Farming about 50 SqKm of Ocean area (about 0.002% of EEZ) could produce the feedstock needed to produce Biostimulants for India's Agriculture.
Benefits - Climate resilient agriculture, improved soil health & yield increases*

Farming about 5,000 SqKm of Ocean area will make about 1 Million Tonnes of Sustainable Aviation Fuel, which will meet the 10% blend beyond 2030 as mandated by the CORSIA requirements.

*Farming about 150,000 SqKm of Ocean area (about 6.5% of – EEZ) could produce enough feedstock to replace 300 million tons of crude oil equivalent *
Benefits – Strategic Energy independence; Climate change mitigation*

Employment - Each SqKm of Ocean farm area can give rise to 100 jobs for farming activities alone – thus creating a potential for millions of NEW blue - economy jobs.

EEZ = 2.37 million sq km

	Area (km^2) **										
DEPTH (M)	Gujarat	Maharastra	Goa	Karnataka	Kerala	Lakshadweep	Tamil Nadu	Andhra Pradesh	Orissa	West Bengal	A&N islands
0-50	54,456	34,442	3,291	12,048	17,841	1,844	26,418	17,315	15,839	15,103	14,822
50-100	22,589	68,874	4,509	12,054	15,173	617	9,268	8,062	4,809	2,439	10,365
100-500	10,713	16,515	3,658	6,037	12,497	4,602	12,540	8,449	5,261	7,431	22,520
500-1000	2,663	7,222	2,053	3,783	7,160	4,987	6,707	5,921	4,080	2,047	35,766
>1000	50,363	1,55,304	49,763	7,976	87,964	3,63,921	1,65,280	2,09,427	96,919	18,459	6,05,352

*Ref: Nallasivam et al [Bioresource Technology 346 \(2022\) 126515](#)

**Source: GEBCO gridded bathymetric data set 2022

But tropical seaweed farming comes with its own set of problems!

Lack of any scientific research coupled with labour intensive farming methods result in unpredictable, inefficient, and limited supply



THE FULL STACK OF TECHNOLOGIES FOR MECHANIZING SEAWEED FARMING HAS BEEN DEVELOPED BY SEA6



FARM INSTALLATION

Unique farm installation systems and **custom-designed** anchoring equipment to install reliable SeaFarms with accurate positioning



AUTOMATED SEEDING

Patented Machines developed to automate the process of attaching and detaching seaweed from the substrate lines, improving labor productivity



HARVESTING AUTOMATION

Custom workboats and equipment designed to move over SeaFarms to install and harvest seaweed lines



SEACOMBINE PLATFORM

Custom-designed vessel which provides a platform to enable all seaweed farming activities offshore

With these technologies, seaweed farming can be expanded to deeper and rougher waters and can be made less labour intensive. The feedstock cost can also be reduced.

MACHINERY & EQUIPMENT OVERVIEW



Video of traditional seeding



Video of seeding by tangler

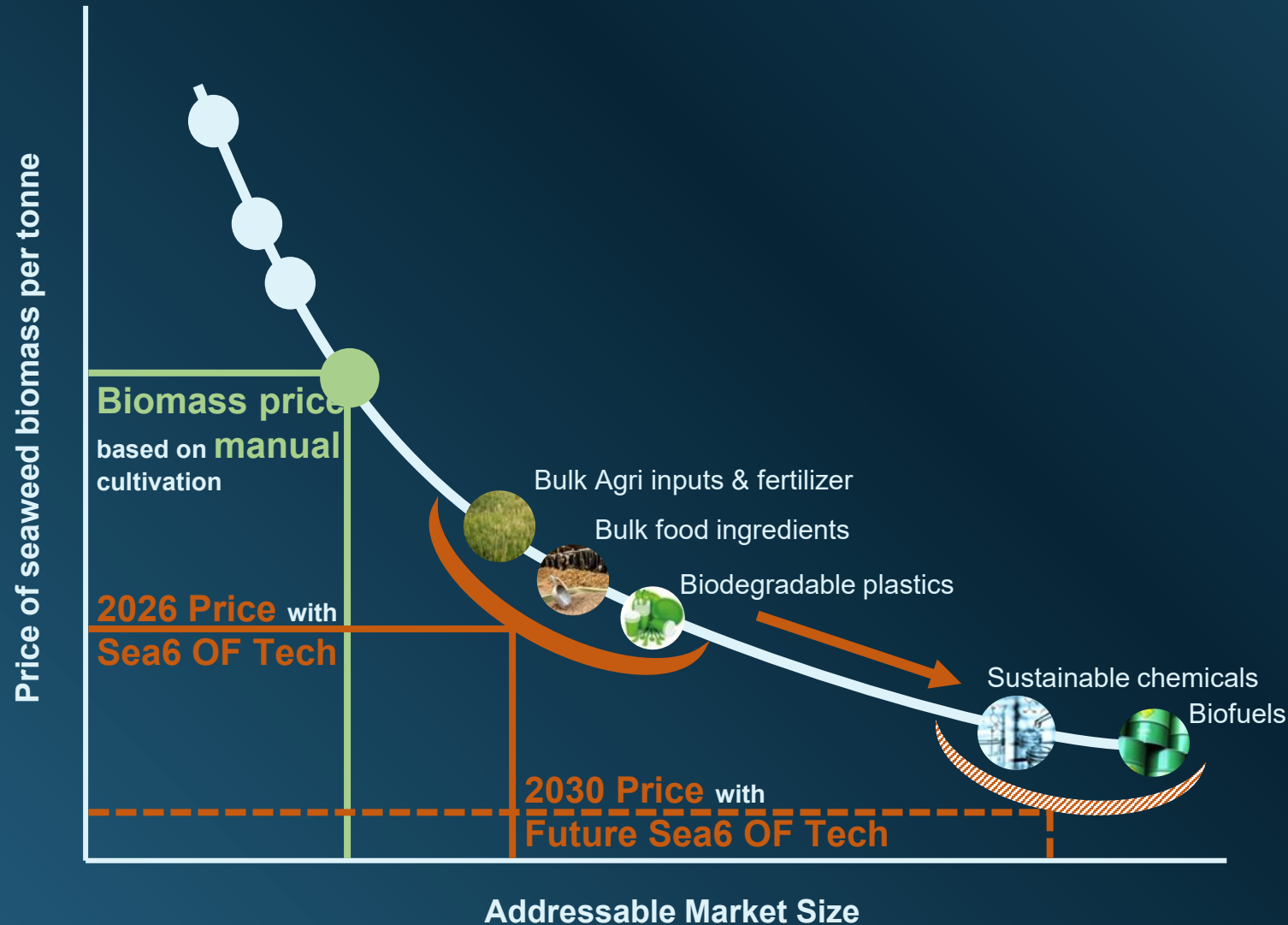
Tangler and Untangler

Tangler and Untangler equipment can increase productivity by up to 5X for seaweed seeding and deseeding operations.

These technologies have been implemented in world's first 1 sq km mechanized tropical seaweed farm set up in Lombok, Indonesia (Feb, 2024)



MASSIVE MARKET EXPANSION OPPORTUNITY AS WE COME DOWN THE COST CURVE



MARKET OPPORTUNITY



Agri inputs & fertilizer
\$10+ billion



Bulk food ingredients
\$10+ billion



Biodegradable plastics
\$50+ billion



Sustainable chemicals
\$500+ billion



Biofuels
\$1+ trillion

SEVERAL DOWNSTREAM PROCESS TECHNOLOGY PLATFORMS TO PROCESS FEEDSTOCK TO PRODUCTS

FRESH SEAWEED
HARVESTED FROM
MECHANIZED
SEAFARMS



“DSF” FEEDSTOCK
DERIVED VIA PROPRIETARY
PRIMARY PROCESSING



TRACEABLE &
CONSISTENT QUALITY

PRECISION
HYDROLYSIS



PLANT & ANIMAL
HEALTH
(BIOSTIMULANT,
BIO DEFENCE)

CONTROLLED
BIOREFINING



NOVEL FOODS &
BIOPLASTICS

THERMO CHEMICAL
TRANSFORMATION



CHEMICALS &
FUELS

THERMOCHEMICAL PROCESSES CAN TRANSFORM SEAWEED CARBOHYDRATES TO : CHEMICALS & FUELS



Fresh red seaweed



Seaweed Feedstock



Acid Catalyzed conversion

Platform chemicals like
Furfurals & Levulinic acid;
Humins & Activated Carbon

Hydrothermal Gasification

Direct Gasification of wet substrates to
Methane & Carbon dioxide (Biogas)

Hydrothermal Liquefaction

Direct conversion of wet biomass to
Liquid fuels like
Bio-crude

Chemicals, Solvents,
Fuel additives

Sustainable aviation
fuel

Marine bunker crude,
cracking to more
chemicals

Not an exhaustive list,
Not an exact one to one map



Wet Seaweed pulp



HTL process:

350deg C
300 bar
30 mins



HTL Bio-Crude

Valorization of red macroalgae biomass via hydrothermal liquefaction using homogeneous catalysts

J. Nallasivam^{a,b,1}, P. Francis Prashanth^{a,b,1}, S. Harisankar^{a,b}, Srisailaja Nori^c, Shrikumar Suryanarayan^c, S.R. Chakravarthy^{b,d}, R. Vinu^{a,b,*}

^a Department of Chemical Engineering, Indian Institute of Technology, Madras, Chennai 600036, India

^b National Center for Combustion Research and Development, Indian Institute of Technology, Madras, Chennai 600036, India

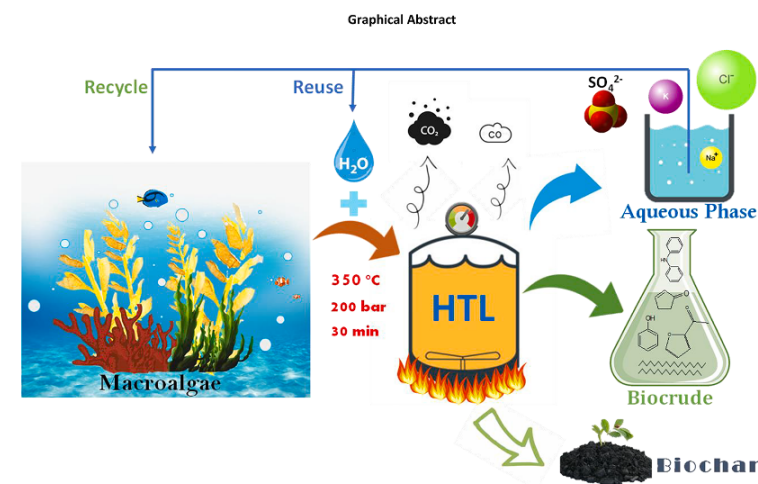
^c Sea6 Energy Pvt. Ltd, 2nd Floor, C-Camp, NCBS-TIFR, Bellary Road, GKV Post, Bengaluru 560065, India

^d Department of Aerospace Engineering, Indian Institute of Technology, Madras, Chennai 600036, India

HIGHLIGHTS

- Use of alkali catalyst produced 62% deoxygenation in bio-crude from *Kappaphycus alvarezii*.
- 99% energy recovery was observed in bio-crude and biochar from *Eucheuma denticulatum*.
- Catalytic treatment resulted in high bio-crude yield (~16 wt%) from both macroalgae.
- High selectivity to cyclic oxygenates (84%) was observed in the bio-crude with K_2CO_3 .
- The use of catalysts enhanced the release of sulphates, chlorides, and cations like Na^+ , K^+ .

GRAPHICAL ABSTRACT



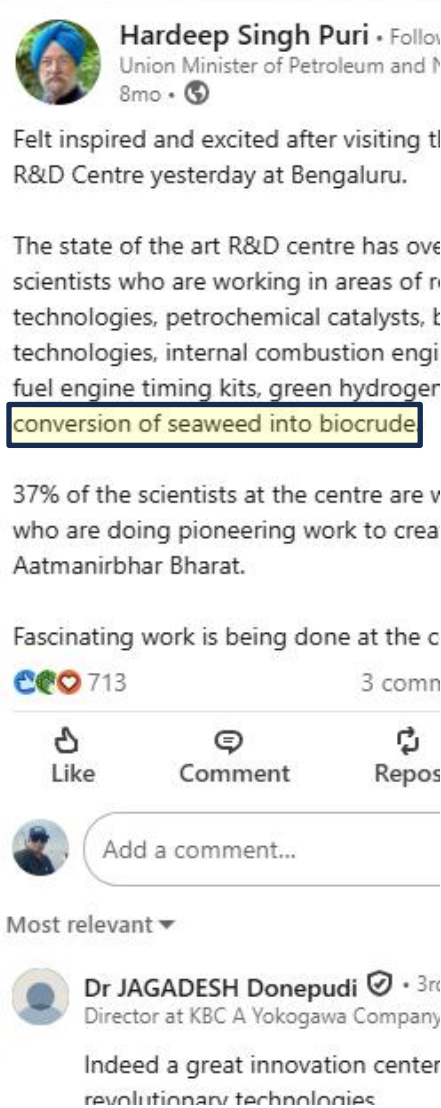
STRATEGIC COLLABORATION: SEA6 & HPCL



Sea6 Energy & Hindustan Petroleum Corp. Ltd sign a significant MoU under the aegis of the Hon. Minister for Petroleum & Natural Gas, India, Mr Hardeep Singh Puri on 9th Dec 2024.

“To develop renewable biofuels and chemicals from tropical red seaweed”





Continuous HTL pilot plant at HPCL R&D Center, Bengaluru
&
Seaweed to sustainable fuels -HPCL Display: India Energy week 2026



THANK YOU

www.sea6energy.com

