Indigenous Algae: Potential Factories for Biodiesel Production

Dheepak Maharajh

Introduction

- Fossil fuels – Environmental damage
- Crude Oil Prices peak - ~ $140
- Current biodiesel sources
  - Oil Seed crops

  (eg. 600% of US arable land required to

  fulfil biodiesel requirements from Soya)

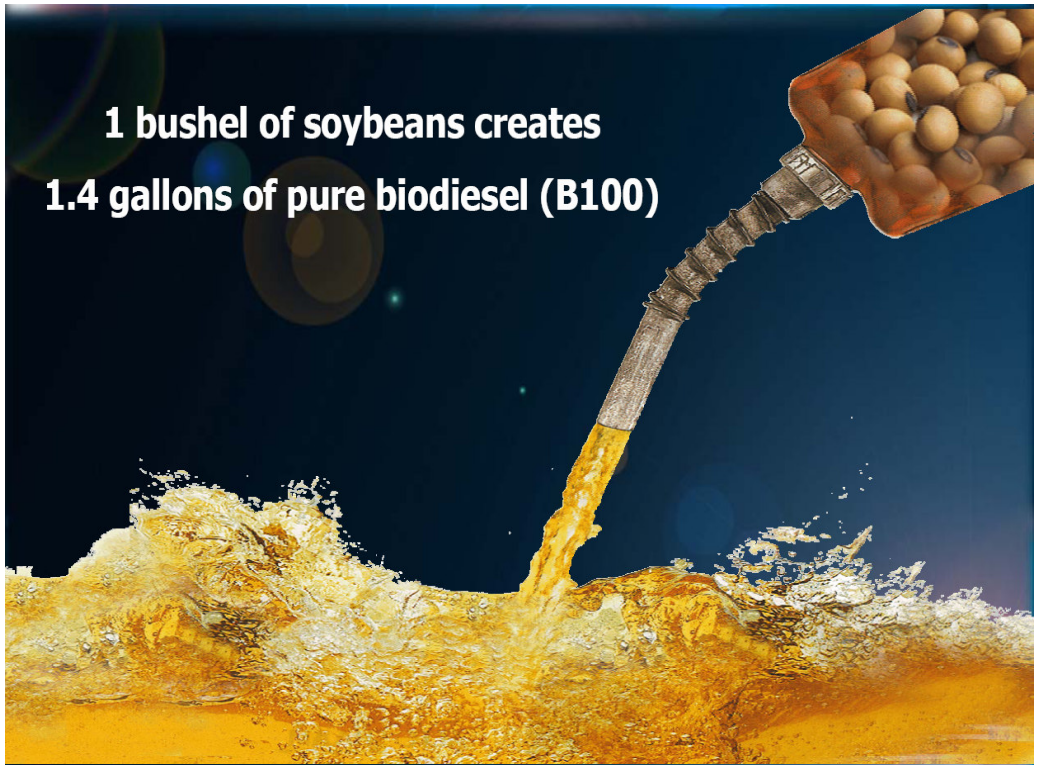
  First generation – low yields

  Food competitive

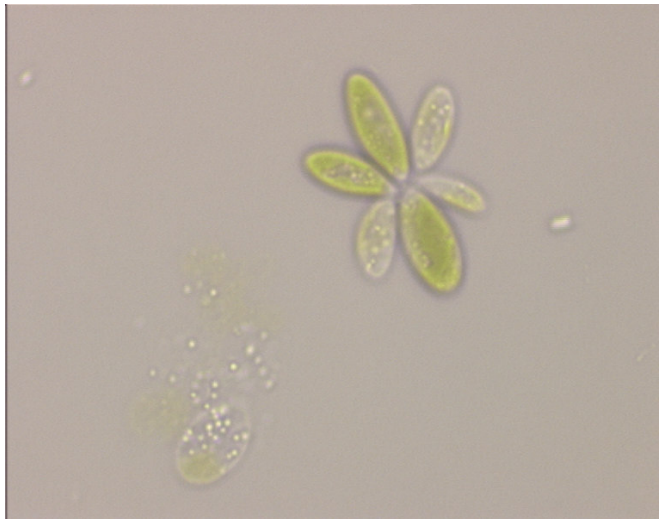
  Arable land use
  - Animal Fat and used cooking oils

  Limited quantities

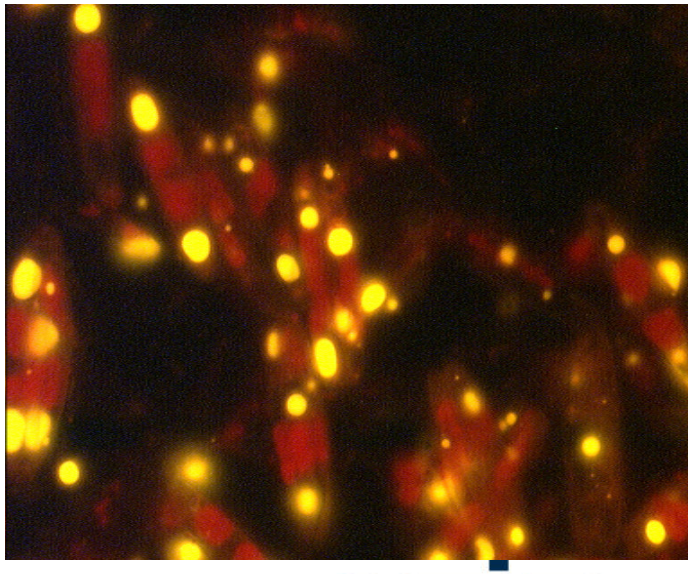
  Questionable quality
- **Algal potential**



Algae feedstock

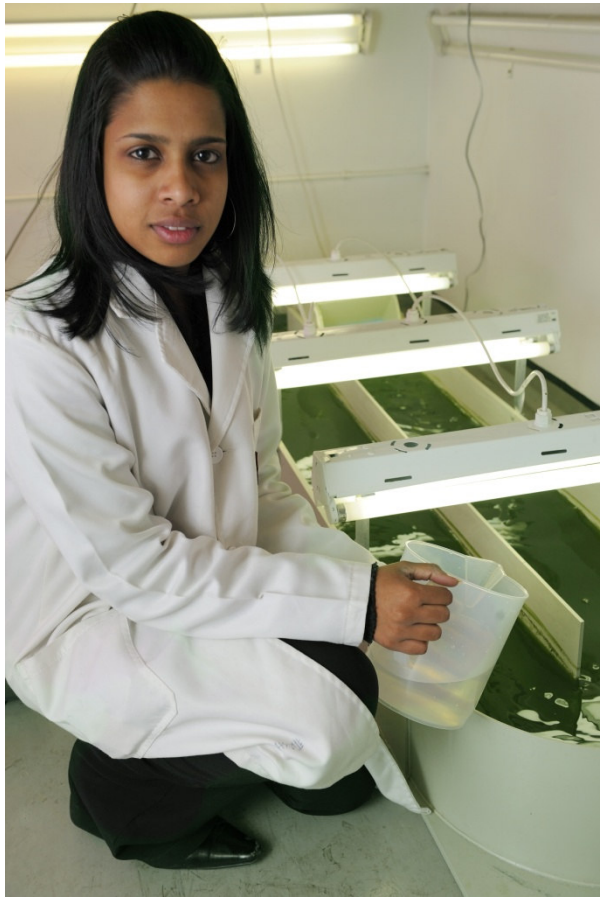


- Algae produce up to 70% lipid/DCW
- algae are more productive than terrestrial plants
- algae do not use arable land or affect food security
- capable of using CO_2 flue gas and waste-water effluent streams as nutrients
- address global environmental initiatives (Kyoto protocol)
- spent biomass has potentially high value
- energy security



Challenges facing South Africa

- Economic growth – energy shortages
- Less developed countries – larger virgin environmental footprint
- Protecting indigenous natural resources – global responsibility
- Economic burden on fuel imports- Affects balance of payments
- Food shortage still prevalent in developing countries
- Arable land shortage – SA 12% and lower yield
- Human nutrition
- Unemployment – skills shortage
- Waste water remediation
- Limited R&D funding

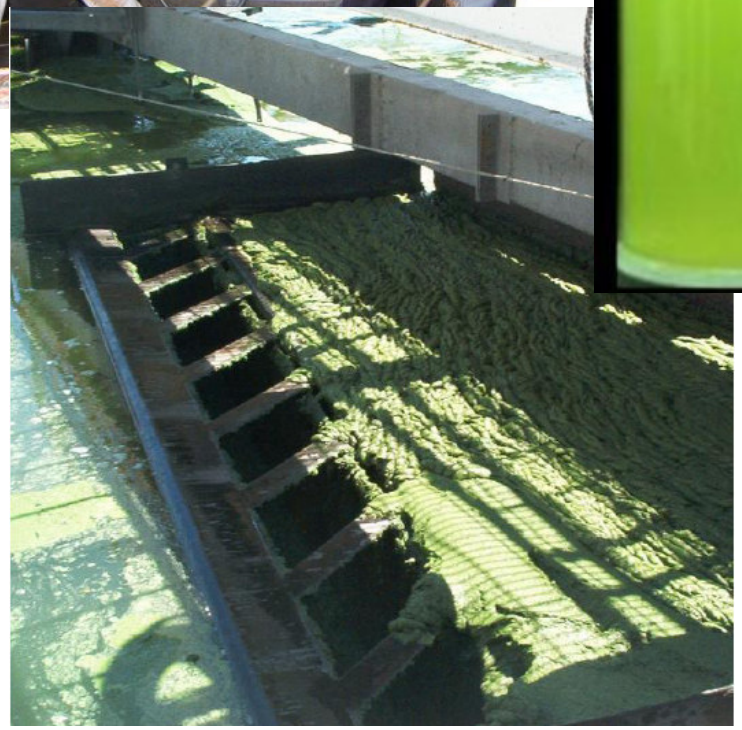


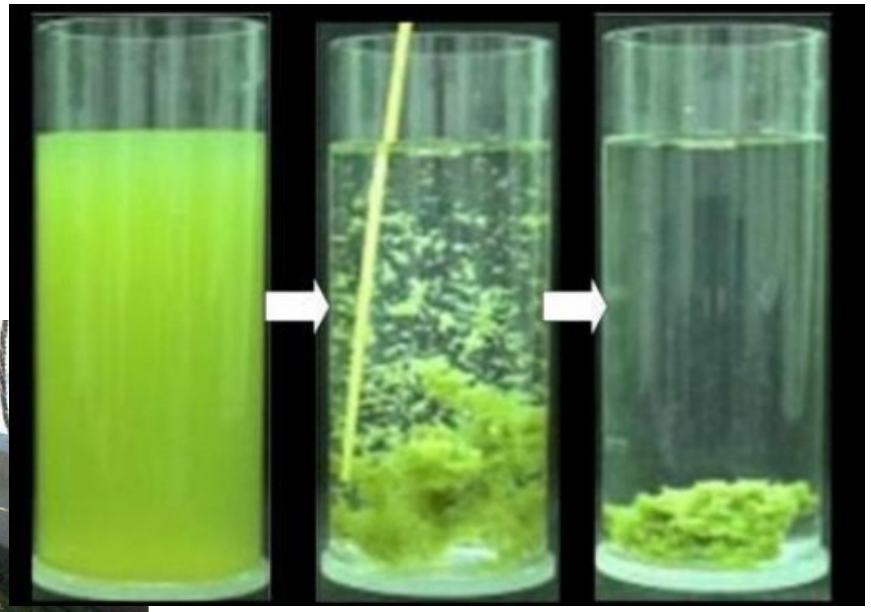

Algae to address challenges
Nutrition
Environment
Algal Technologies
Health care
Energy
Socio-Economic Challenges

What do we know about Algal cultivation?

Can we cultivate algae at large scale?

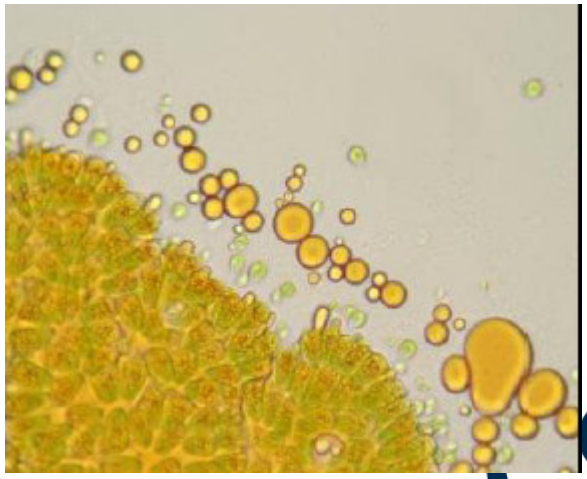
Can we harvest algae?





CSIR
our future through science

Can we extract oil from algae?



Can we make biodiesel from algal oil?

- Yes – 7 Jan 2009, Boing 737 test flew a 2 hr flight on algal fuel.

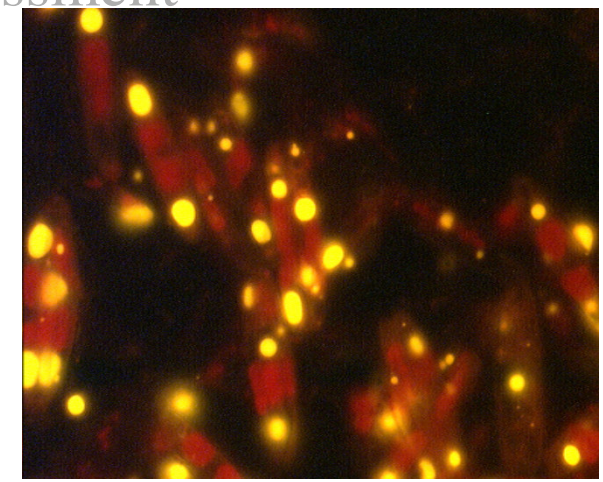
- **Why is not commercial yet?**

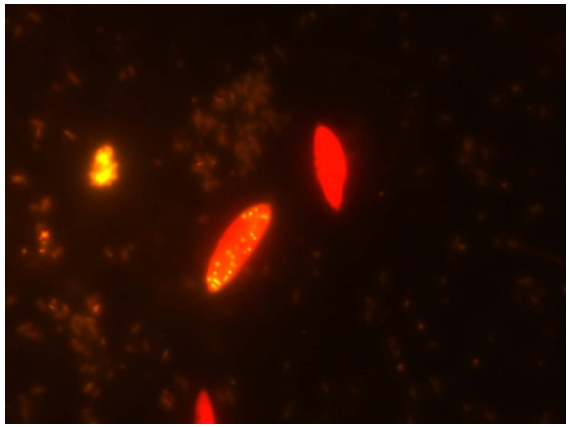
- **NOT FINANCIAL SUSTAINABLE YET**

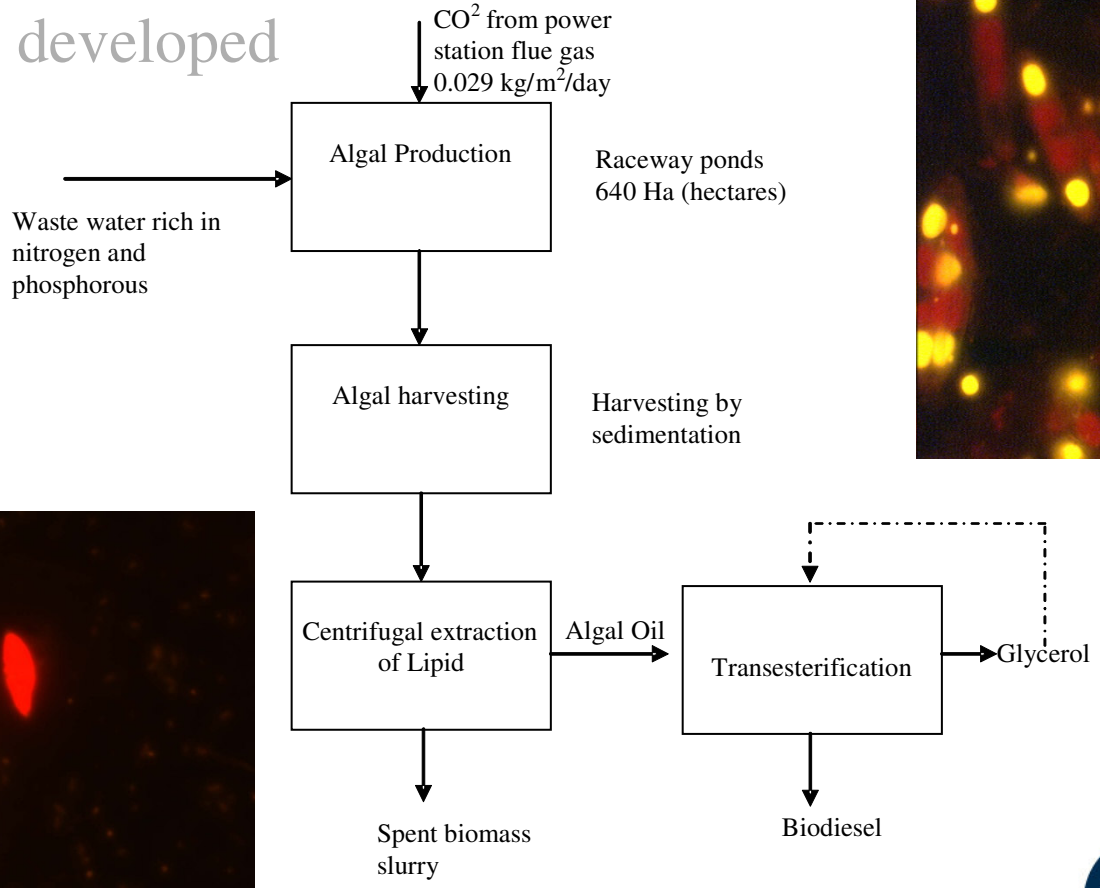
Can it be financially feasible?

CSIR – preliminary techno-economic assessment

- Model developed





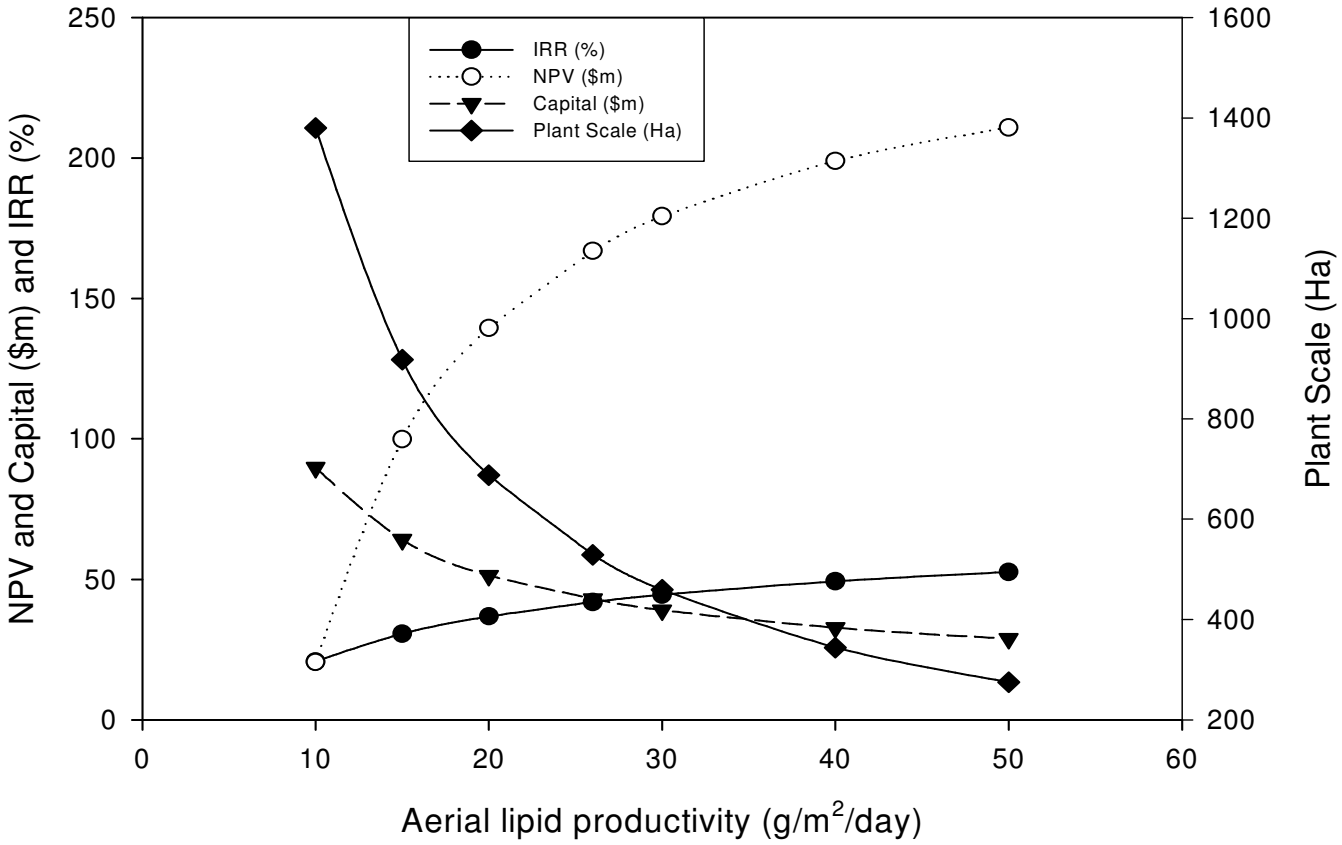


Model Assumptions

- Plant scaled to produce
- 10% of SA mandatory target for 2013
- Current SA low sulphur diesel price
- Assuming 1:1 CO_2 usage per biomass produced
- Lipid productivity variable between 10 to 50 g/m^2/day
- Waste water utilization
- Flue gas CO_2 utilization

Assumption	Amount	Units
Plant Scale	Variable	Ha
Inoculum biomass	6.4	Tons
Biomass Productivity	30	g./m^2/day
Lipid productivity	Variable	g/m^2/day
Final Biomass concentration	1.0	g/L
Production days per year	365	Days
Batches per year	46	#
Total biomass harvested per year	90514	Tons/yr
Lipid Content	40	%
Lipid separation efficiency	70	%
Biodiesel produced	40 000	kL/yr
Selling Price	1.15	$/L
Carbon dioxide used	90514	Tons/yr
Carbon trading price	26	$/ton

Model predictions



How can we make it feasible?

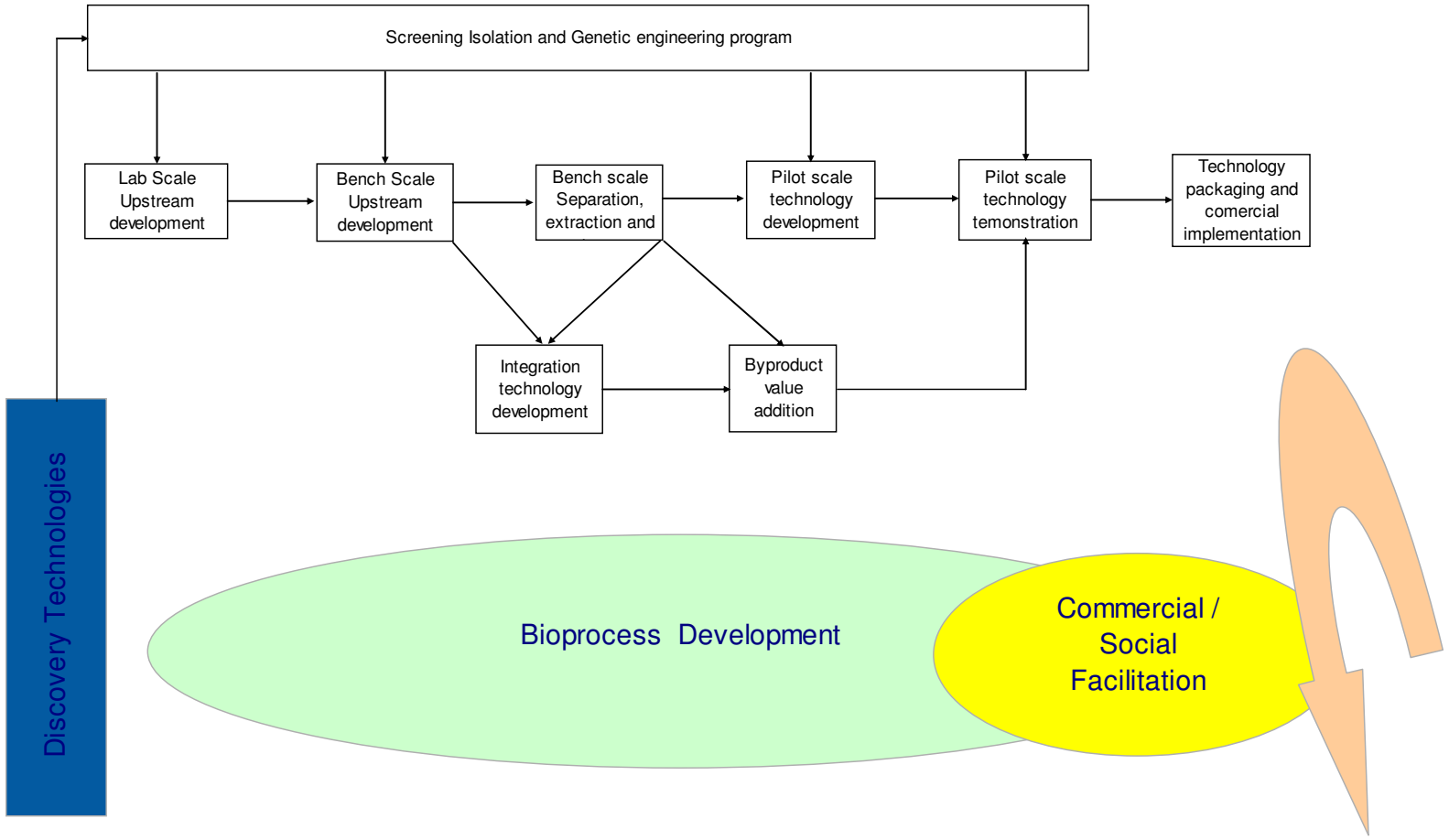
- Strain selection is critical
- No “ one size fits all” strain available
- Optimize harvesting and oil extraction
- **Process development**
  - Critical to engineer solutions
  - Optimize process for climate and strain at scale
  - Integrated solution

Rationalization of Algal Development

- Fuel security
- Environmental preservation
- Community beneficial technology
- Poverty alleviation
- Food and Nutrition
- Algal hub – exploiting competitive advantages

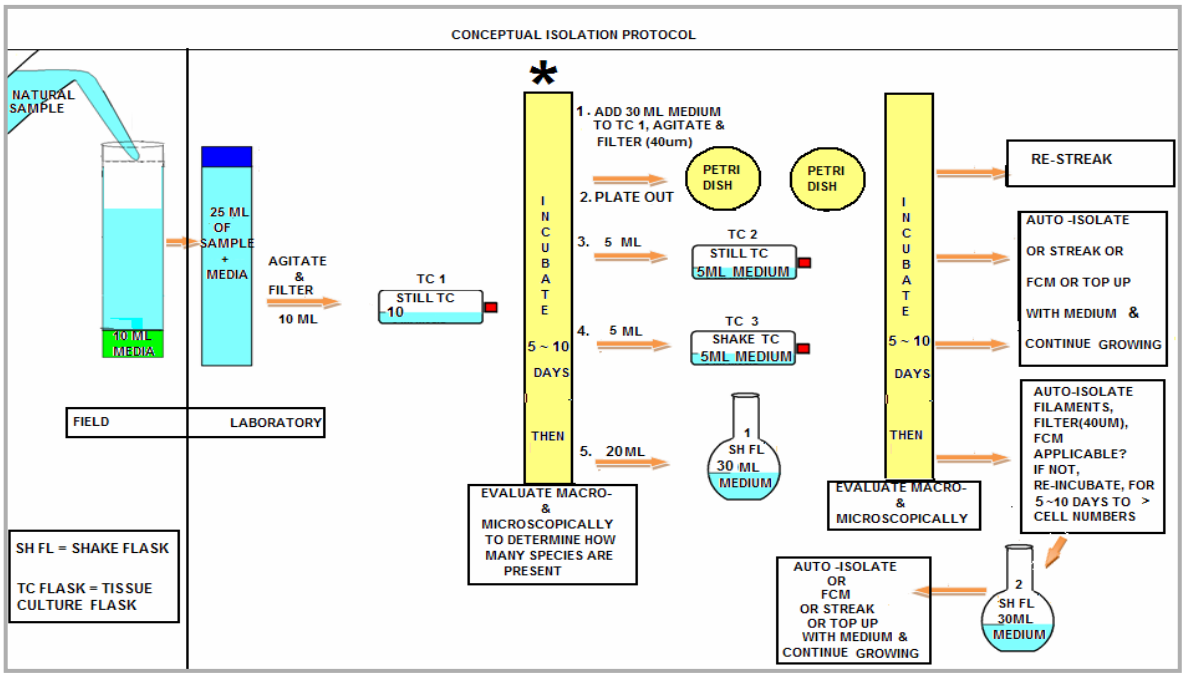
- Local isolates for implementation
- Exploit SA's biodiversity and climate
- Waste water and Flue gas utilization
- Integrated process

CSIR's Algal Fuel Research Plan



Method development

- Developed an integrated isolation and screening protocol to maximize time



- Isolated 115 isolates from 46 samples
- Isolated 94% of the potential isolates

Synthetic mix of cultures

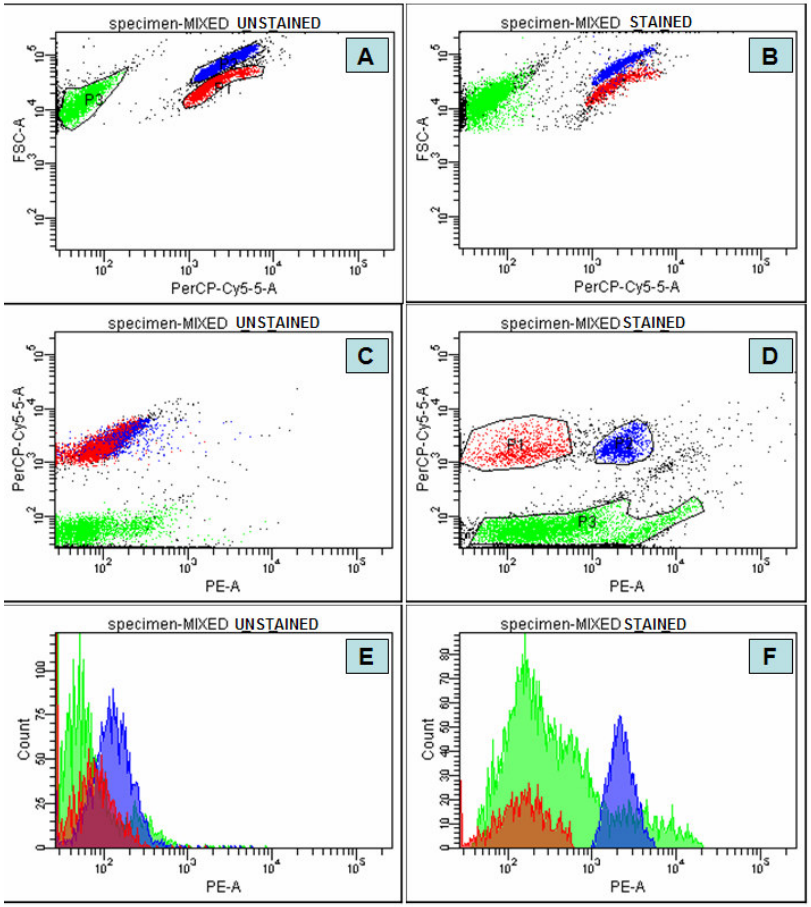


Figure 5: Flow cytometry plots of A26, A41 and A4 mixed sample

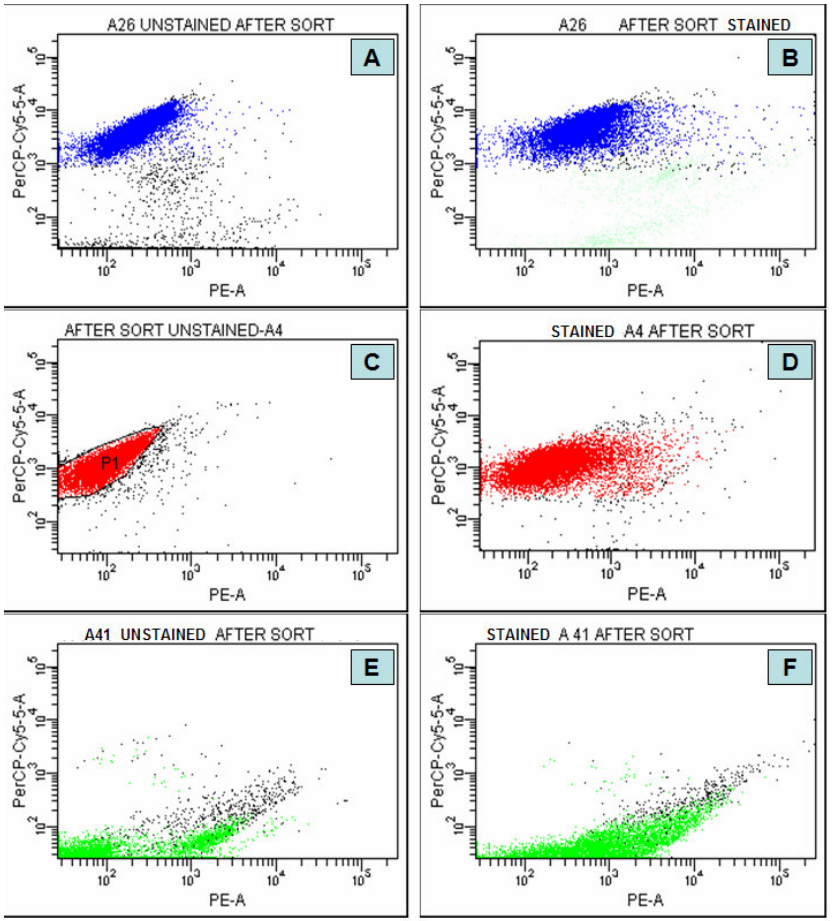
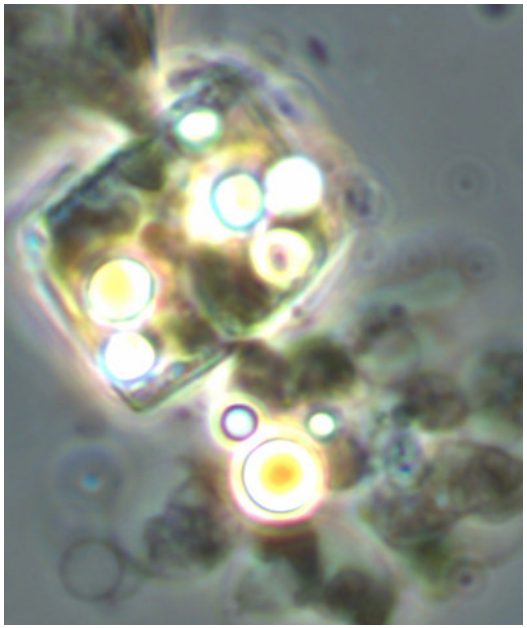
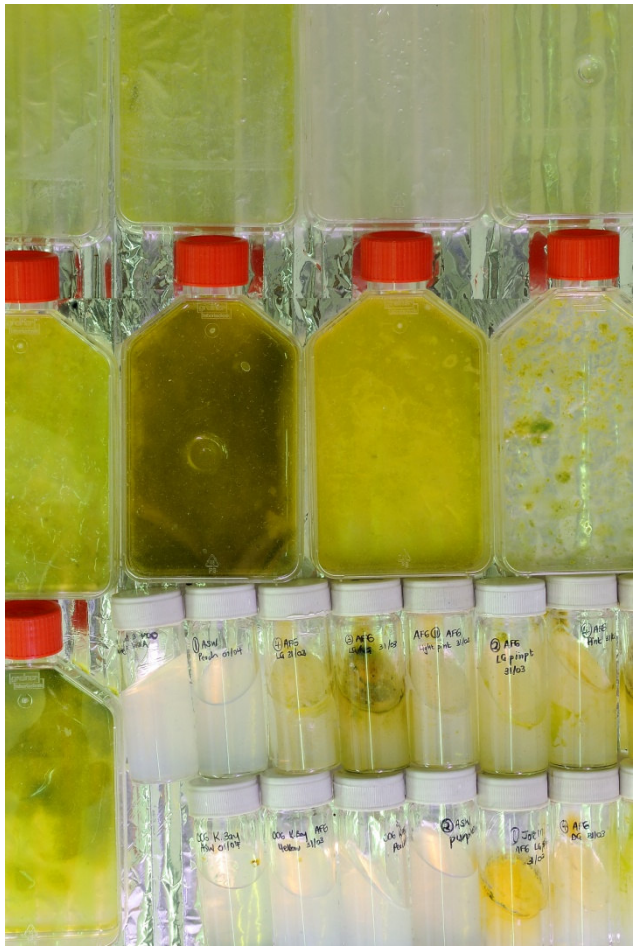


Figure 6: Flow cytometry plots of individual isolates after sorting with FCM

Database

- ~ 20% of SA waters screened
- ~300 algal isolates
- > 100 positive for lipid production
- ~ 20 demonstrate potential for application to process





Random mutagenisis – CSIR/UKZN

STRAIN	% LIPID PRESENT	% INCREASE
WILD TYPE	26.62	–
39F U1	36.38	36.66
39F U4	31.46	18.18
39F U5	34.85	30.92
39F E1	46.95	76.37
39F E2	41.97	57.66

IMAGES

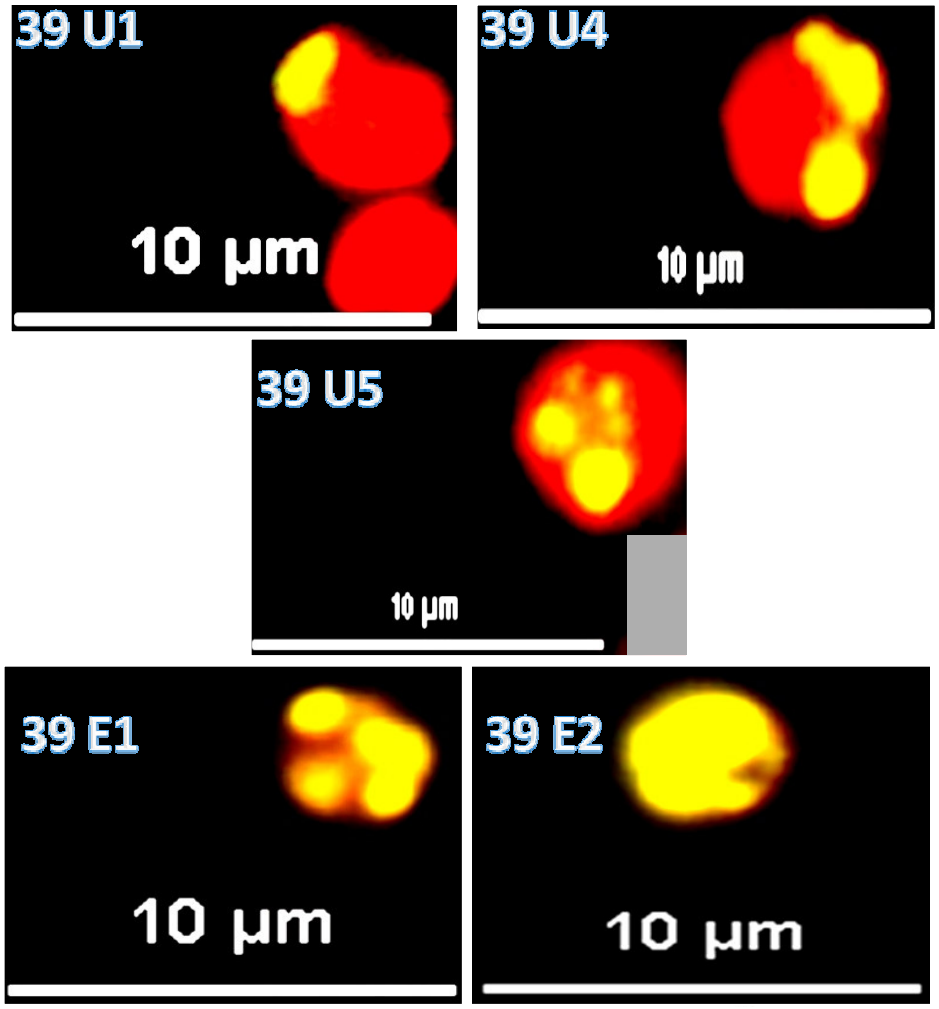
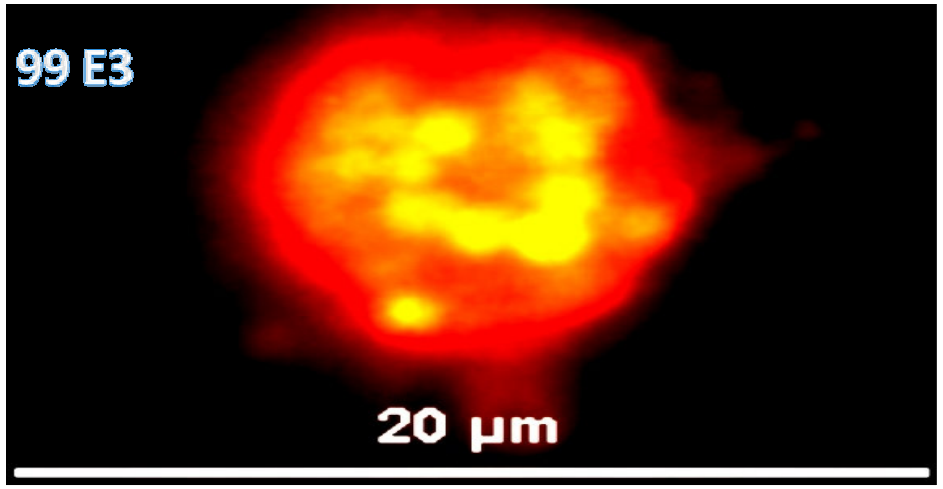
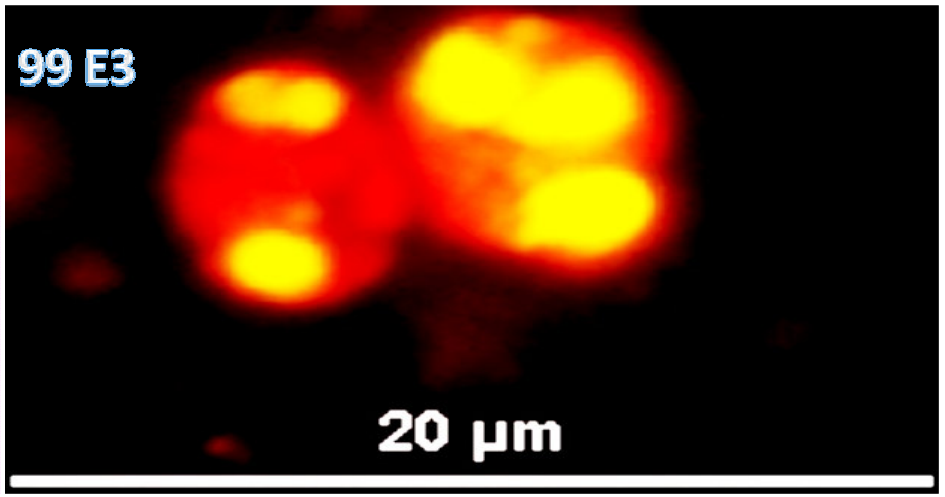


Table 2: Lipid content in wild type and mutant strains of isolate 99F

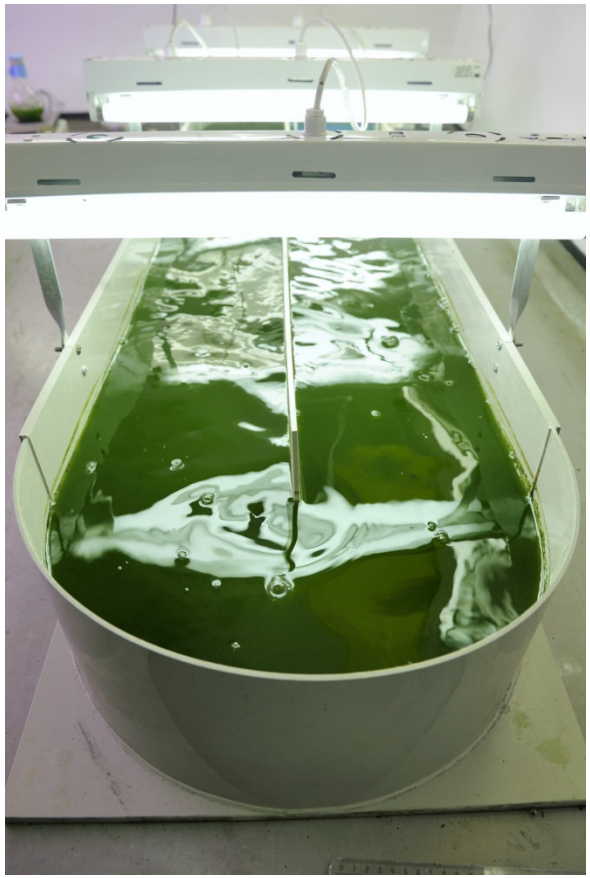
STRAIN	% LIPID PRESENT	% INCREASE	IMAGES
WILD TYPE	9.73	–	
99F U1	9.73	0.00	
99F E3	23.95	146.15	

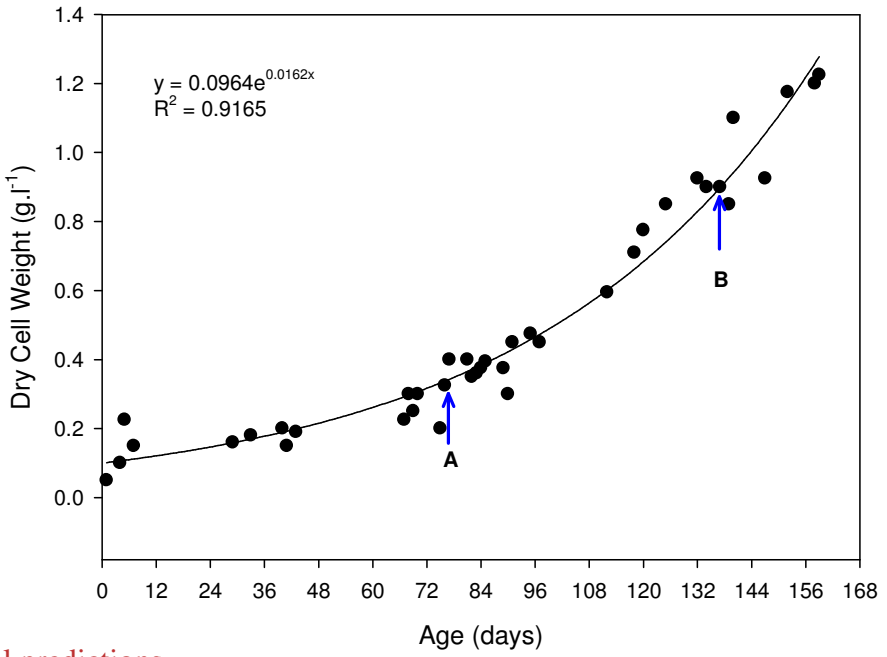




Laboratory Raceway

- First positive isolate scaled up to 100L lab raceway system





Model predictions

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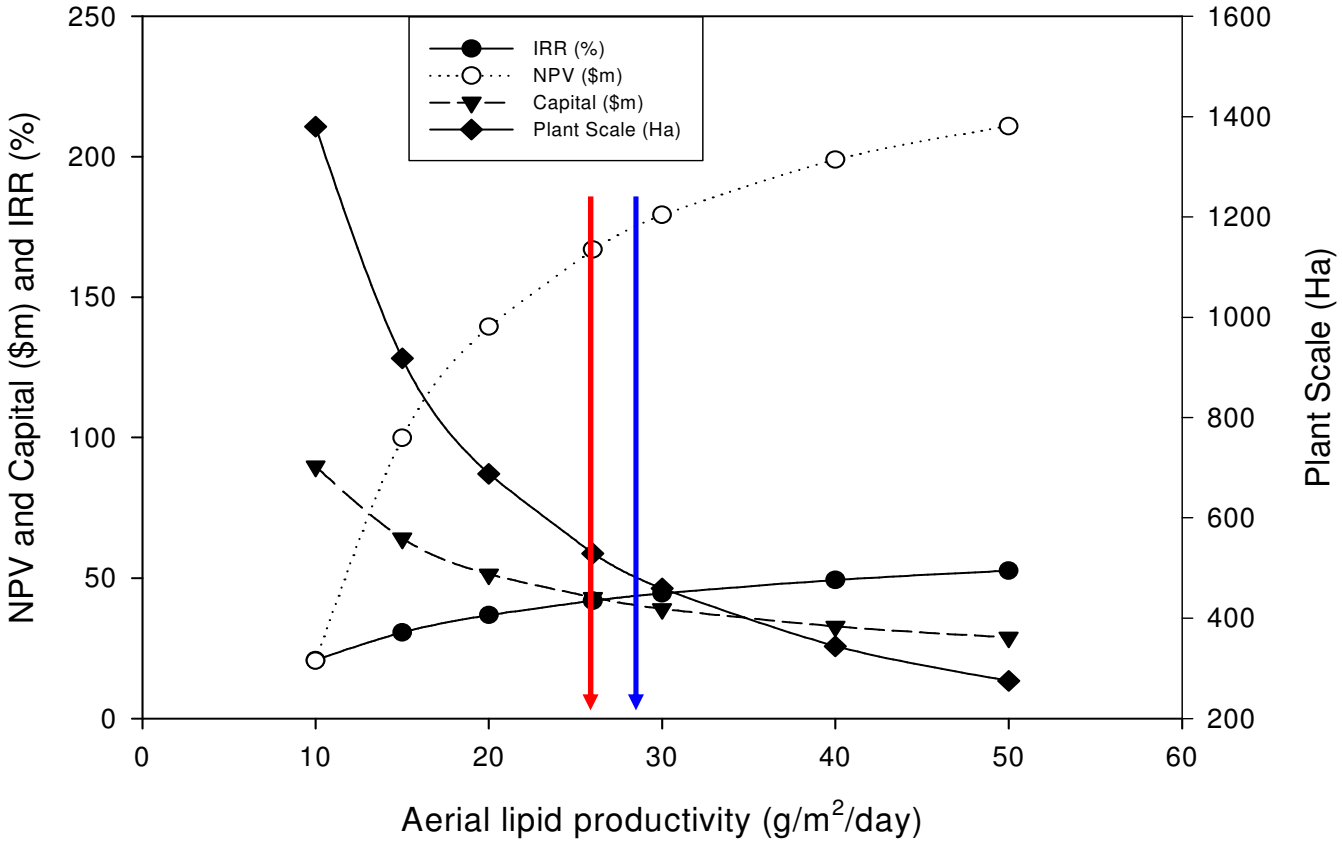
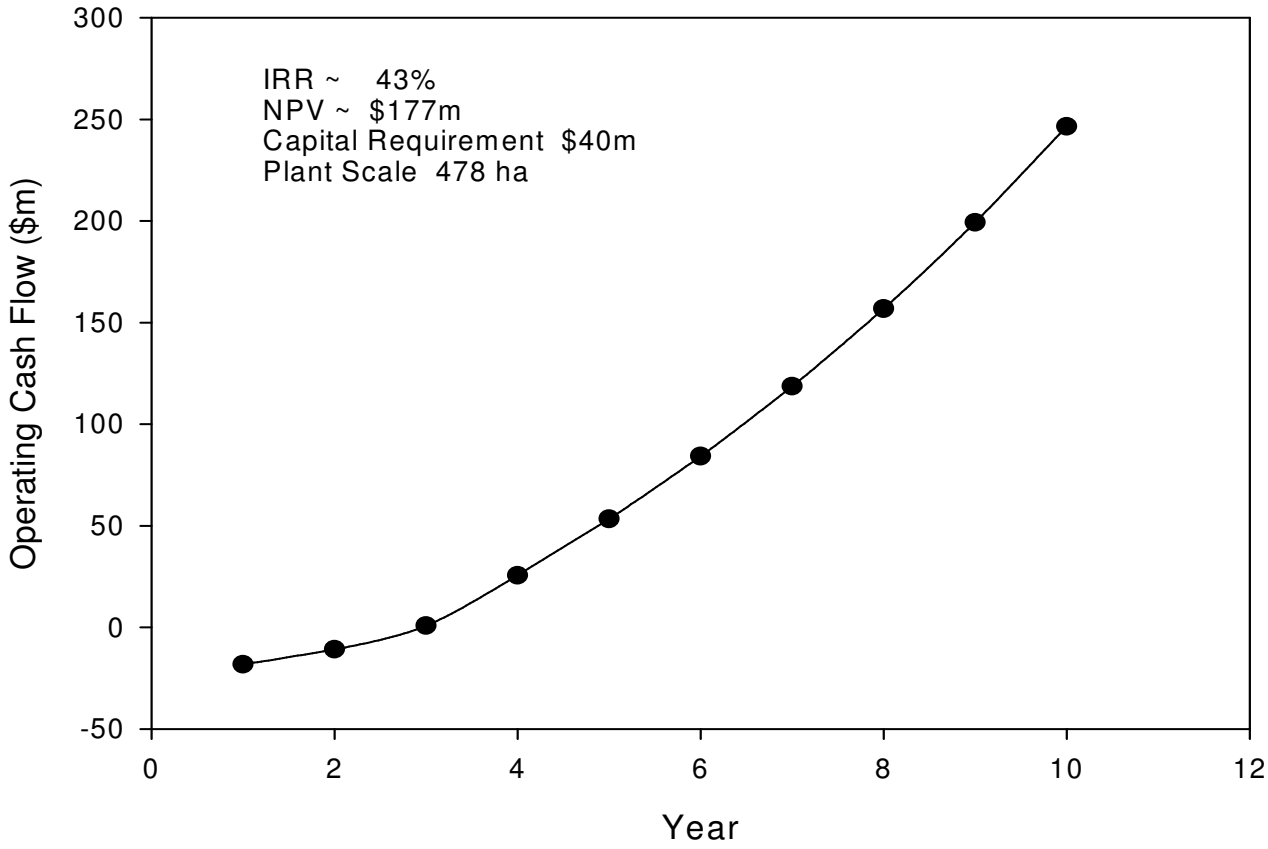
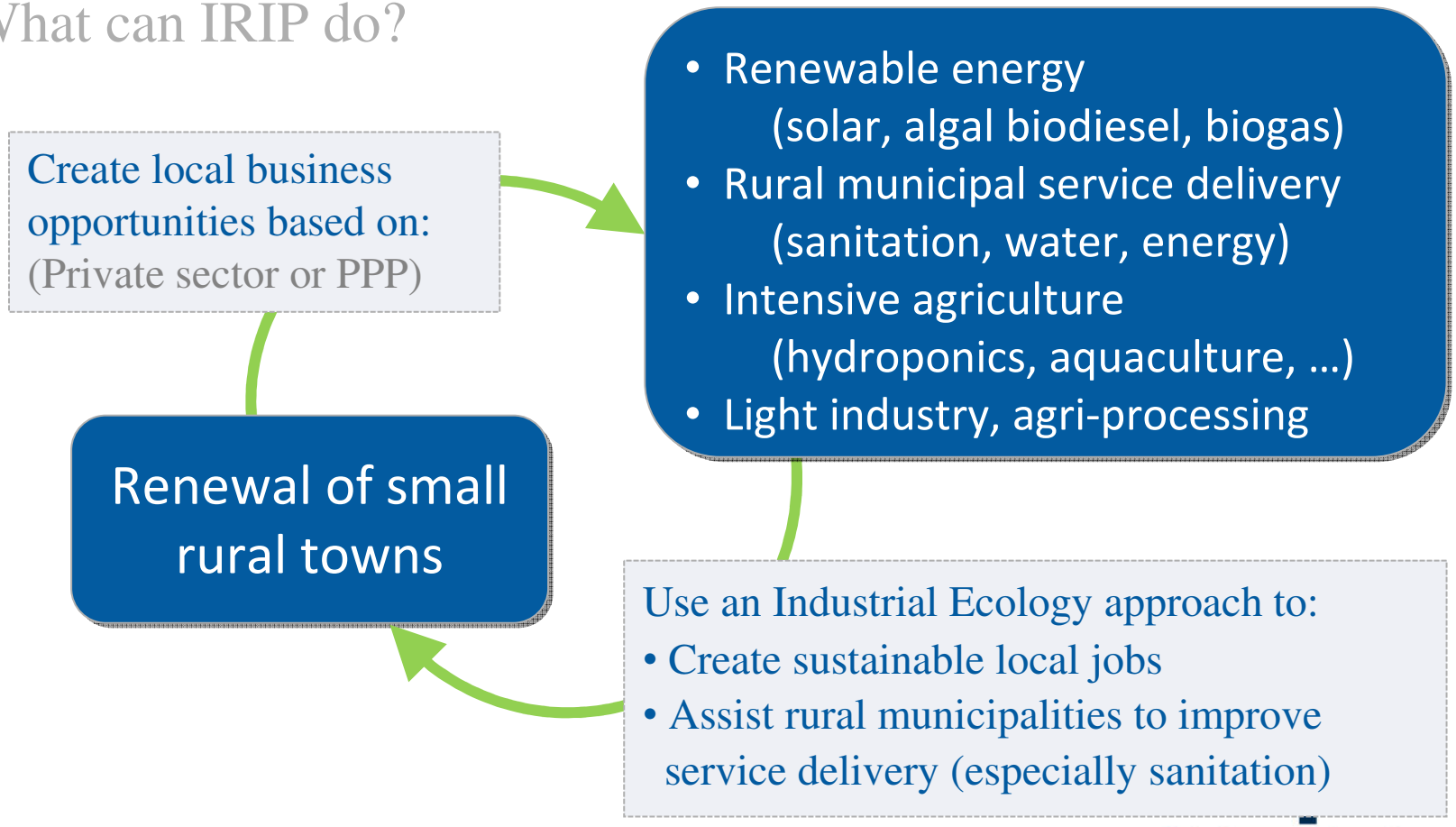


Raceway Economics

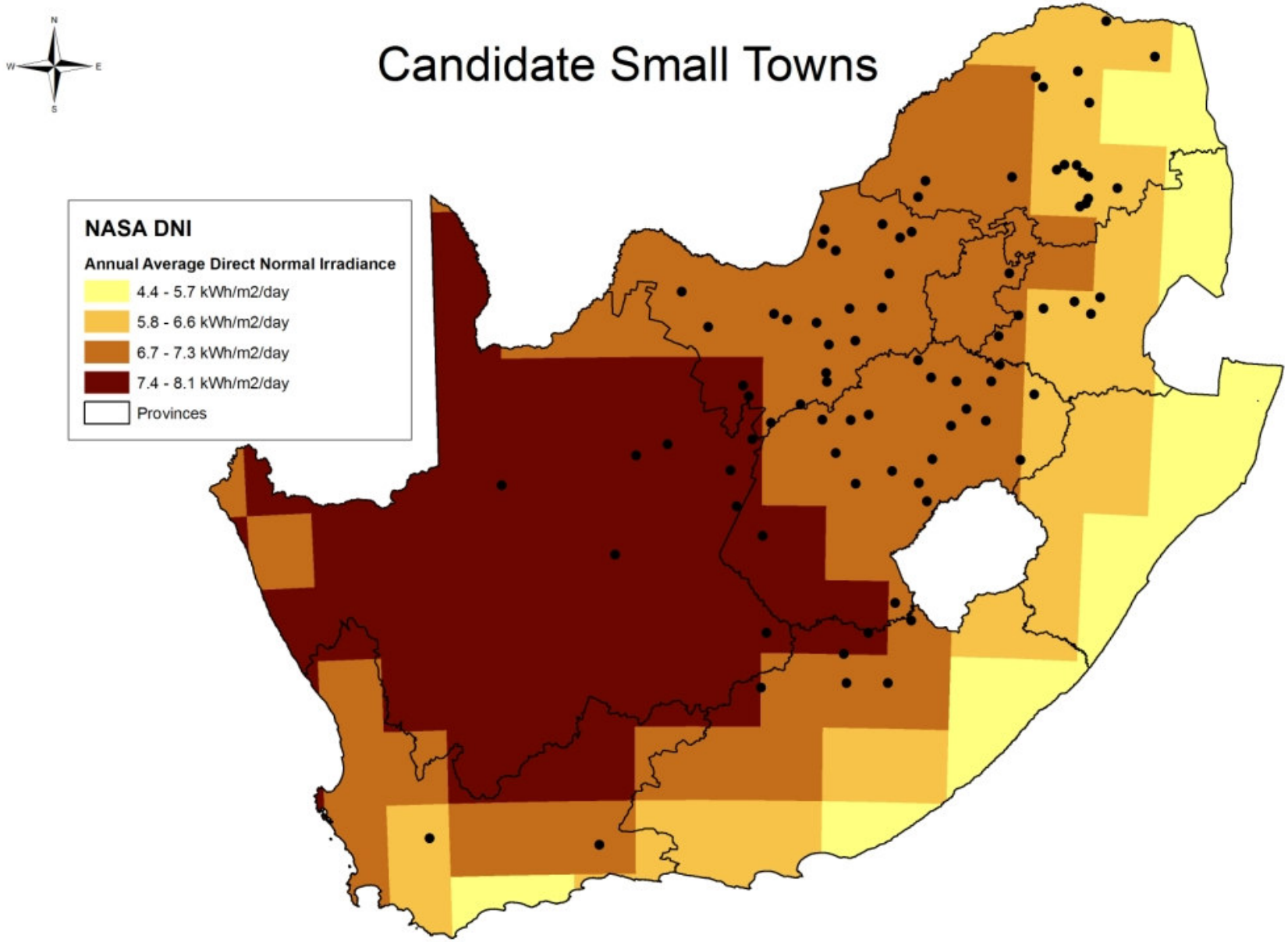


Process integration (IRIP)

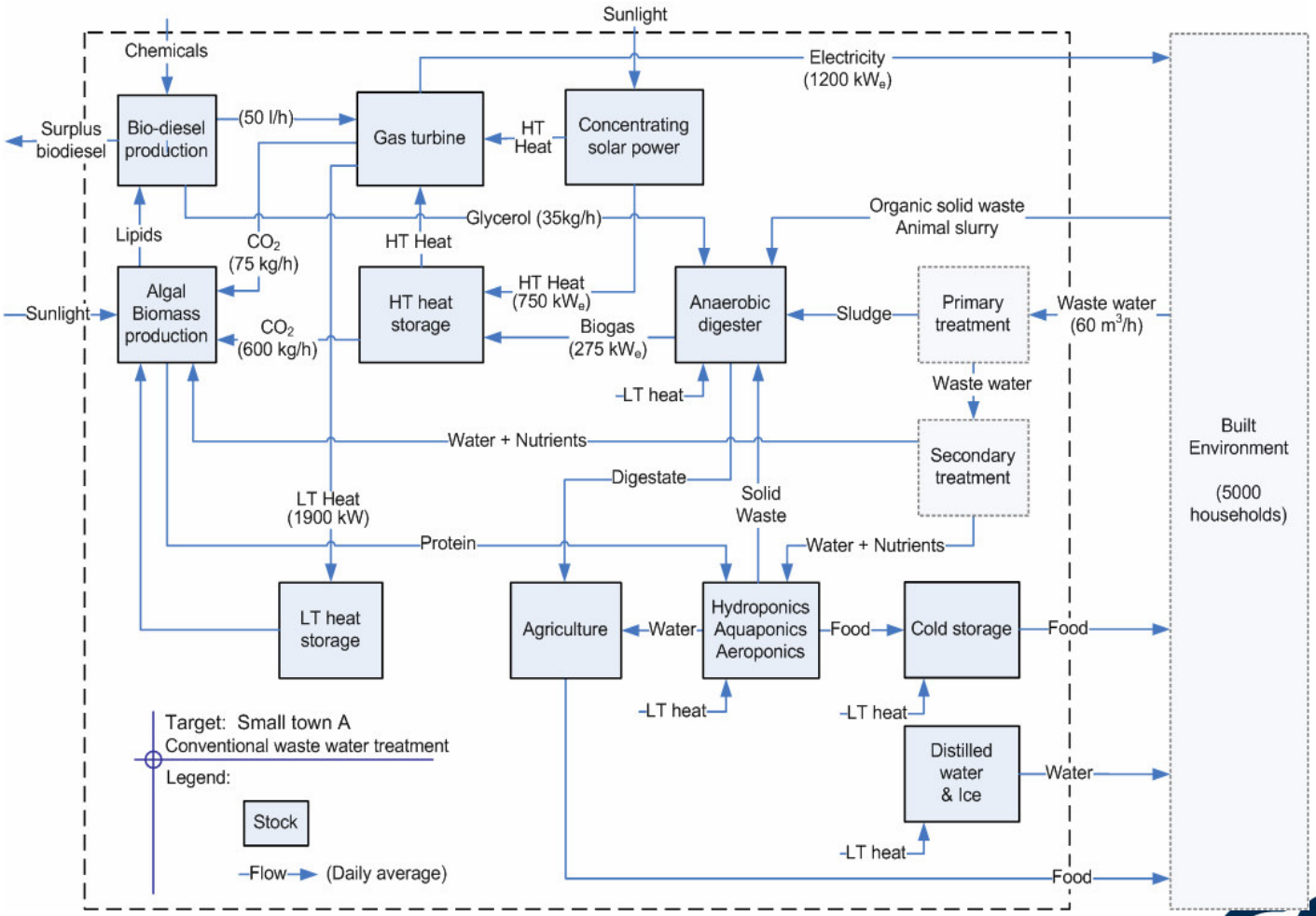
- Integrated Research Infrastructure Platform
- What can IRIP do?



Candidate small towns (pop. 10-30 000)



System configuration for a small town



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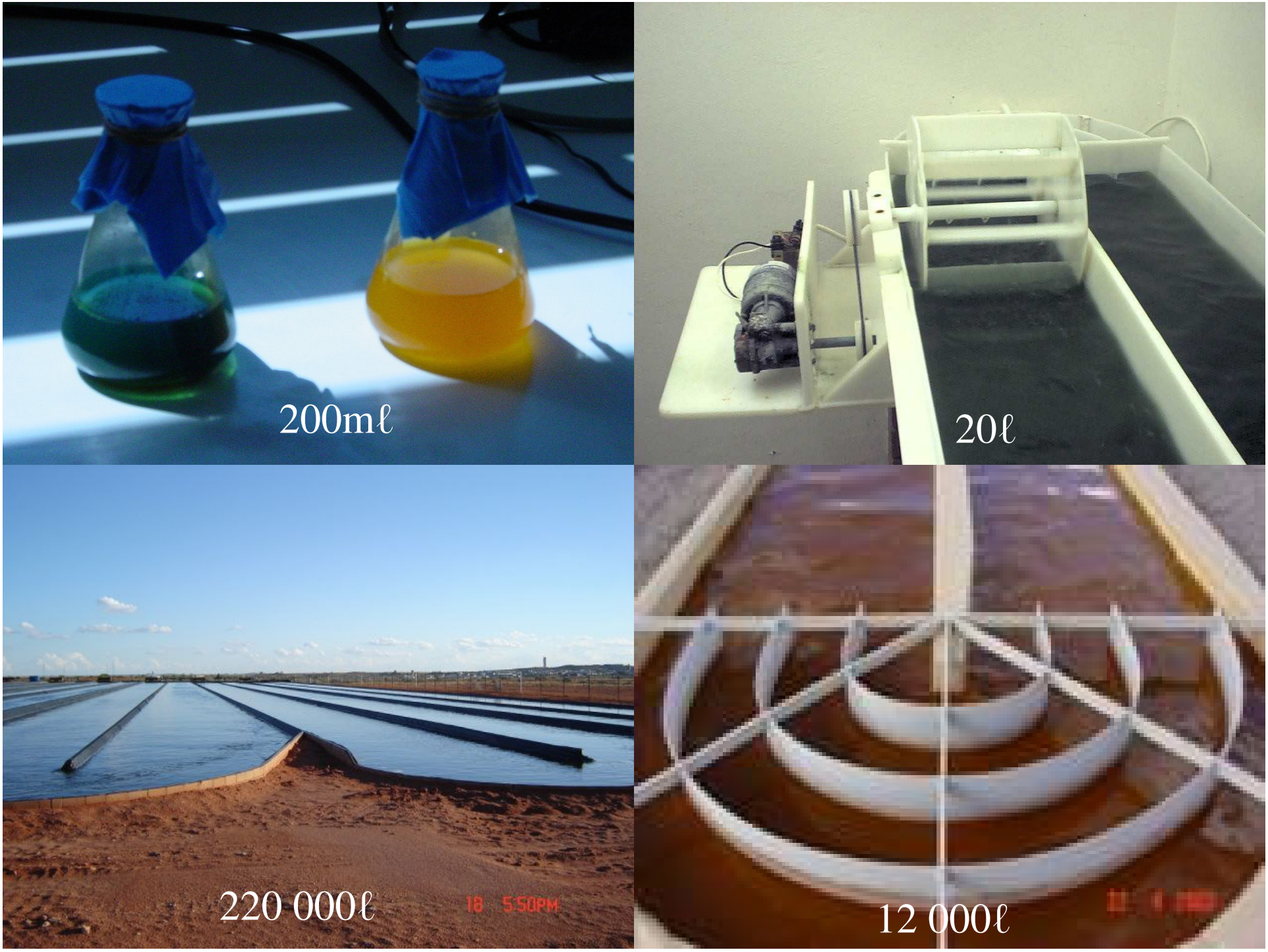
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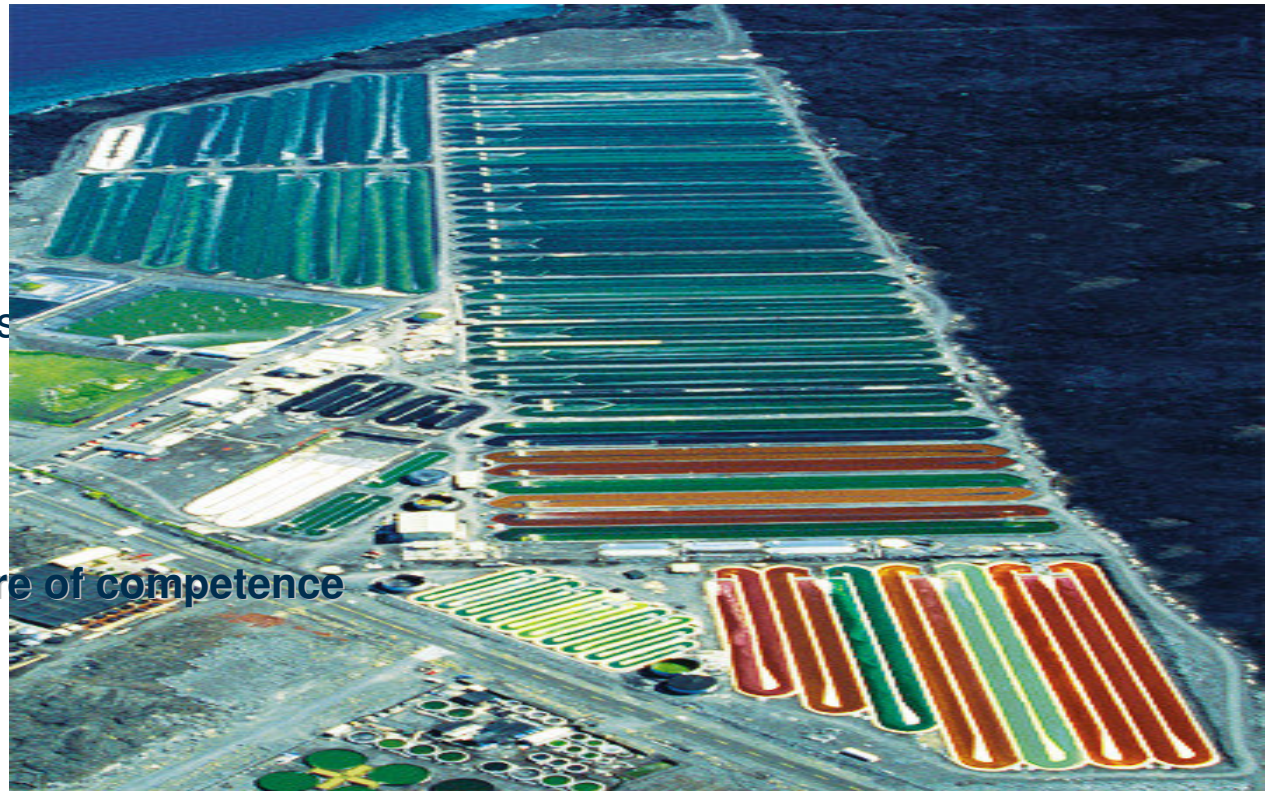
Algal Dream

- Community implementable technologies
- Poverty alleviation
- Exploit SA's biodiversity and climate
- Local isolates for implementation
- Integrated process
- Waste water and Flue gas utilization
- Environmental well being
- Fuel security
- **Food security**
- **Develop Algal fuel centre of competence**
  - Science councils
  - Academic institutes
  - Communities
  - Industry partners
- **Expand Algal biotechnology industry in South Africa**



Thank You

Dheepak Maharajh
CSIR Biosciences
dmaharajh@csir.co.za
Tel: +27 82 650 8542