Biopolymers – Business opportunities for a sustainable future

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A set of global and local issues urges us to develop a more sustainable way to leverage our resources, work, and live together

Global issues

- Protecting against resource scarcity
  - Securing adequate supply of energy, water, etc., increasingly difficult/ expensive
- Avoiding negative effects of climate change
  - Need to drastically reduce GHG emissions across all industries and geographies

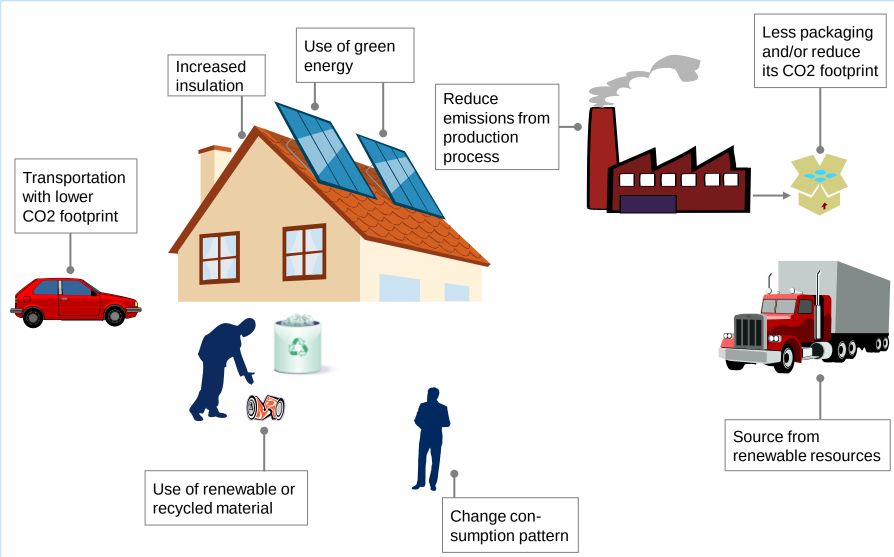
Need for economy and society to develop/provide sus-tainable solutions for the way we work, produce and live

Local issues

- Adoption to shifting consumer and customer preferences
  - Increasing demand for sustainable products/ services
- Meeting social responsibilities
  - Providing opportunities for economic develop-ment, e.g., in rural areas

SOURCE: McKinsey

Companies and consumers have multiple options to these challenges



Bioplastics are part of the solution

	Conventional plastics	Bioplastics
Are produced from …	▪ Oil ▪ Natural gas	▪ Starch or sugar (today) ▪ Agricultural waste (tomorrow)
… which are …	▪ Fossil, non-renewable resources	▪ Renewable resources
Over their entire lifecycle they …	▪ Increase the CO_2 concen-tration in the atmosphere	▪ Are close to carbon neutral

Environmental and social sustainability questioned

FT, 25/03/2010

Cargill in threat to palm oil group accused of deforestation

By Anthony Deutsch in Jakarta

Cargill, the world's largest trader of agricultural commodities, has become the third company to reconsider its relationship with a top Indonesian palm oil supplier over allegations it is tearing down protected forests to make way for plantations.

Demand for palm oil has soared in recent years due to its use as a biofuel and in food and household products.

Indonesia and Malaysia account for the vast majority of global output.

Cargill said it would stop buying from Sinar Mas if allegations of improper land conversion or illegal planting in deep peatland forests were confirmed. The Roundtable on Sustainable Palm Oil, a certification body, is investigating the claims.

The review was prompted by a Greenpeace report published in December on alleged illegal land-clearing activities by Sinar Mas, which the company has denied. Sinar Mas said it aimed to "continuously preserve biodiversity" and was confident the contracts would be reinstated after the review.

The report was accompanied by an online campaign that targeted Nestlé's use of unsustainable palm oil in its products.

Nestlé said it would switch suppliers, while Unilever, the world's largest buyer of palm oil, scrapped a $33m contract with Sinar Mas after Greenpeace published the report.

Dorab Mistry, director of Godrej International, a London-based trading company, said other companies might follow suit because it would enhance their images to spend $10 a tonne more to buy environmentally friendly palm oil and not be associated with deforestation.

But he said Greenpeace's tactics were "extreme measures" that "only make the Indonesians more defensive".

The country's forests are the largest and most biologically diverse after the Amazon basin and their destruction on Borneo and Sumatra has made Indonesia the third-largest emitter of carbon after the US and China.

Deforestation by palm oil producers is considered the largest threat to endangered wildlife and native plants in Indonesia, but the industry is also a significant source of wealth and employment.

The country sold 20.8m tonnes of palm oil in 2009, up 7.6 per cent on 2008 and nearly 50 per cent higher than in 2004.

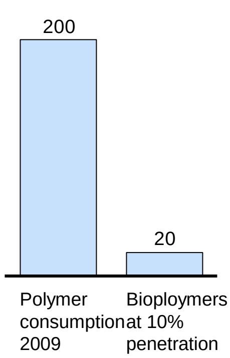
Producers in Malaysia are also feeling the pressure. Yesterday, Finnish refiner Neste Oil said it would investigate whether IOI, its supplier, had cleared land illegally on Malaysian Borneo following allegations by Friends of the Earth.

SOURCE: Financial Times

To replace 10% of today's plastic consumption by bioplastics would require <0.5% of the are currently used for food production

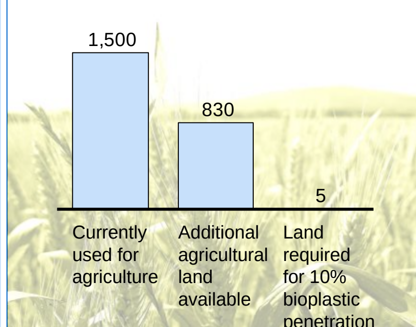
To replace 10% of current plastics by bioplastic ...

Global consumption[1]
Mt



... a area corresponding to <0.5% of today's agricultural land would be required[2]

Area[2]
million Ha



Area will be even less once technology for conversion of agricultural waste is available

1 Covers ABS, LDPE, LLDPE, HDPE, EPS, PS, PET, PC, PP
2 Under the assumption of replacement by PLA using cassava and sugar cane as feedstock for equal amounts of PLA

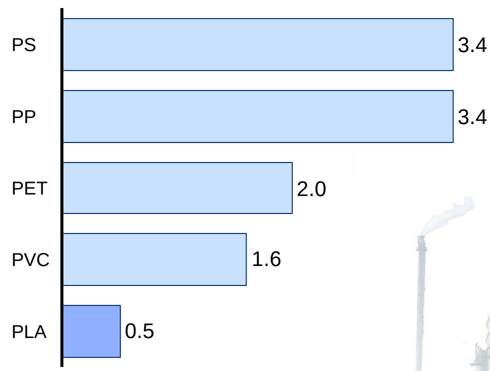
SOURCE: SRI, FAO, McKinsey

Globally bioplastics can help reduce CO2 emissions – example PLA

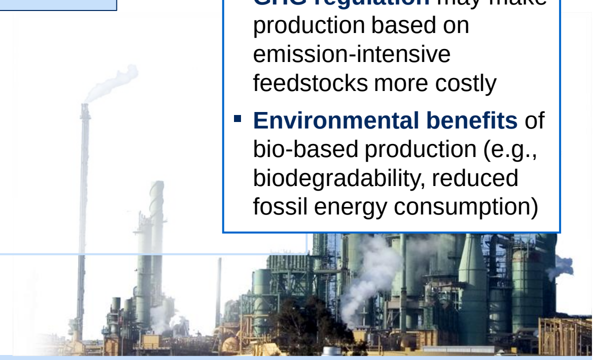
Emissions from production of common polymers

t CO_2e/t of product

ESTIMATES



- Massive differences between **carbon intensities** of feedstocks
- **GHG regulation** may make production based on emission-intensive feedstocks more costly
- **Environmental benefits** of bio-based production (e.g., biodegradability, reduced fossil energy consumption)

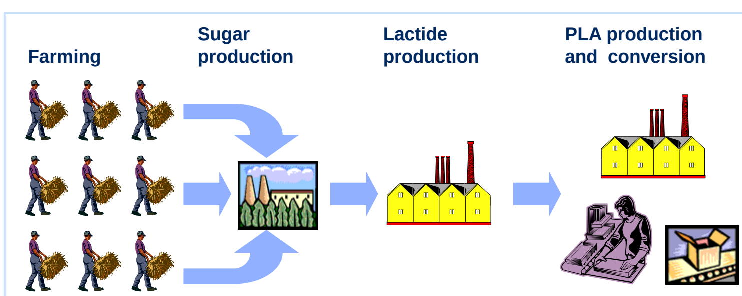


1 Assuming no change of land use (e.g., deforestation)

SOURCE: SRI; Team analysis

Bioplastics provide local economic development opportunities, job creation potential, especially in the rural areas

THAILAND PLA EXAMPLE



Jobs linked to 70 kt lactide plant (estimates)

- 2,500 farmers produce 600 kt of cassava
- 550 workers in sugar plant to produce 115 kt sugar
- 150 workers in fermentation of lactic acid and production of lactide
- 500 workers in conversion of lactide to PLA and other downstream activities

- **Single lactide plant has a the potential to create 3,700 jobs**
- **Additional jobs from construction of plants, infrastructure and logistics, etc. not included**

SOURCE: McKinsey

Most of the hurdles for a broad application of bio-based polymers are being addressed and are partially solved

Concerns from the past	Situation today	Prognosis for 2020
▪ Only basic set of Biopolymers can be produced	▪ **Variety of available polymer is growing** – **Different grades can be produced** – **Copolymers are becoming available**	▪ Fully functionalized biopolymers are available
▪ Biopolymers display low quality	▪ **Biopolymers start to compete with conventional polymers** – **E.g., PLA through blends and/or use of D-(-)-lactic acid**	▪ Biopolymers can be used as substitutes in all classes of polymers
▪ High production costs of Biopolymers	▪ **Costs for some biopolymers are on/close to competitive level with classical polymers** – **Progress through more efficient fermentation and downstream optimization (e.g., separation of products)**	▪ Some biopolymers can be produced at lower costs than classical polymers

SOURCE: McKinsey

Competitiveness of bioplastics versus conventional plastics can further increase via three different levers

Cost reduction of bioplastics which are still at the beginning of the learning curve

- Use of economies of scale throughout the entire value chain
- Better fermentation organisms
- Improved downstream processing
- Optimized feedstock supply chain

Cost increase of conventional plastics through rising cost for oil and gas

- Demand possibly outgrowing supply
- Oil futures market expecting rising oil price reaching USD 105/bbl in 2018

Additional value of bioplastics

- Green price premium for “green” products through some consumers
- Material properties that lower the cost of ownership for stakeholders in the value chain, e.g., enhanced product lifetime that reduces loss to retailers and consumers
- Regulatory support of more sustainable products, e.g., via exemption of bioplastics from recycle tax

SOURCE: McKinsey

Governments have recognized the importance to support the further growth of the bioplastics industry

EXAMPLES

Governments strongly push the use of renewables through mandates, subsidies and grants

- EUR 90 million grant from French Industrial Innovation Agency to promote IBT[1]
- USD 385 million grants from the Department of Energy to develop 2nd generation biofuels; extra USD 200 mln of "competitive grants" available
- 
  Global mandates may result in consumption of as much as 55 billion gallons of biofuels
- EC 7th framework programme (2007-2013) for sustainable non-food products and processes ("Food, Agriculture, Biotech") (EUR 1.9 bn)
- DOE grant to DSM, Abengoa, Los Alamos Laboratory and Sandia National Laboratory for an extensive enzyme development program (2008-2012)

- Chinese government (NDRC) is supporting development of **bio-based chemicals** for energy security reasons
- Obama to **boost biofuels** in the US: 36 bn gal by 2022 incl 21 bn gal from advanced biofuels (those that cut GHE by at least 50%)
- Thai government has been promoting **Bioplastics** to ease environment and support agriculture farmers

1 Resulting, e.g., in the DSM/Roquette partnership to produce fermented succinic acid based on starch in France
2 Billion gallons per year – corresponds to ~ 220 million tons of bioethanol and 60 million tons of biodiesel

SOURCE: McKinsey

With its four part "Road Map for the Development of Bioplastics Industry" Thailand has defined a pathway to support its growth

	Focus	Example measure	Budget Million bath
Strategy 1	"Sufficient Supply of Biomass Feedstock"	▪ Increase average cassava productivity by 1.3 t/ha, e.g., by providing farmers with high yield seeds ▪ Fund contingent loans and lending system for farmers	100
Strategy 2	"Accelerating Technology Development and Technology Cooperation"	▪ Provide funding for R&D, e.g., in – Fermentation – Polymerization technology – Conversion	1,000
Strategy 3	"Building Industry and Innovative Businesses"	▪ Subsidize zero interest loans for construction or expansion of factories	475
Strategy 4	"Establishment of Supportive Infrastructure"	▪ Establish industry standards and testing facilities	225
			Total 1,800

SOURCE: National Roadmap for the Development of Bioplastics Industry (National Innovation Agency)

Thailand is in a great position to become a major hub for bioplastics and other biobased technology and production

Access to sustainable feedstock, potentially at low cost	▪ Strong agriculture with excellent condition to produce important feedstocks like cassava and other starch crops ▪ Large sugar producing industry ▪ Headroom to increase land productivity
Regulatory support	▪ 4-step "Road Map for the Development of Bioplastics Industry" by the National Innovation Agency ▪ Funding of bath 1.8 billion available
Proximity to major markets	▪ Fastest growing economies of China and India are easily accessible and could be supplied with bio-based materials from Thailand – China has limited land resources and does not allow large scale use of agricultural products for non-food applications
Existing activities in this field that can serve as nucleation point for further growth	▪ Construction of 70 kt lactide plant (Purac) ▪ Announced a plan to conduct a joint study for business development of PBS with PTT Public Company Limited in September, 2009 (Mitsubishi Chemical) ▪ 100 kt p.a. glycerine-to-epichlorohydrin (GTE) plant on the Map Ta Phut industrial estate ramping up (Solvay)

Also other countries with access to low cost feedstock are in similar position

SOURCE: Thai government Web sites; company Web sites; press search; FAO; McKinsey

PLA takes a special role among bioplastics given its development status

	PLA	PHB	Starch-based
Properties/ applications	▪ Properties similar to PET, PP ▪ Temperature resistant up to 200°C	▪ Low temperature resistance ▪ Little control over molecular weight	▪ Mostly for applications with short life span
Volume kt	▪ Industrial scale	▪ Pilot scale	▪ Industrial scale
Economics	▪ Close to break even with conventional plastics	▪ Still far more expensive than conventional plastics	▪ Competitive in some applications today

PLA with special position
- Versatile in its applications
- Well developed
- Large
- Promising economics

SOURCE: Pro-Bip, McKinsey

PLA is already today used in many different applications

Key properties of PLA

- Multiple conversion technologies feasible
  - Thermoforming
  - Spinning
  - Foaming
  - Etc.
- Large range of application temperatures
  - PLA -70°C
  - sc-PLA – 200°C
- Biodegradable

Current applications of PLA

Cups and lids

Gift cards

Bottles

Labels

Consumer-goods packaging

Containers

Bedding

Apparel

PLA is starting to replace polyester (PET) on the basis of costs and performance

The market size for PLA is estimated to reach ~ 3,000 kt in 2020

ESTIMATE

Segments with highest penetration potential for PLA

Packaging

- Largest market for PLA
- Simple application with high visibility for consumers relying on price premium and lower recycling tax than oil based polymers

Fibers

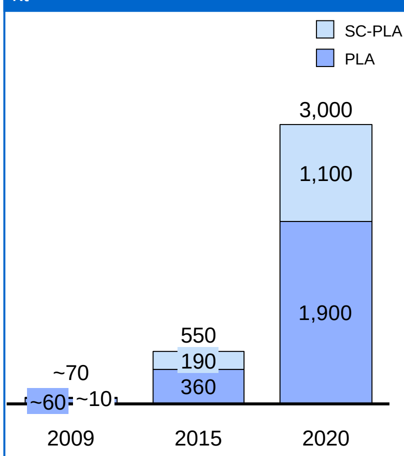
- Close match of PLA and PET fiber properties, need for high temp resis-tance prompting for high temperature PLA (sc-PLA)
- Penetration in high end apparel mar-kets and some non-woven products

Consumer products

- Mostly PS replacement in durables

Estimated market potential for PLA

kt



Biopolymers – Business opportunities for a sustainable future

- Bioplastics part of the solution to provide sustainable solutions for the way we work, produce and live, and represent a significant opportunity for economic development
- Most of the hurdles for a broad application of bio-based polymers are being addressed and are (partially) solved
- Thailand, like other low cost sugar countries, is in a great position to become a major hub for bioplastics and other biobased technology and production
- PLA takes a special role among bioplastics given its development status

SOURCE: McKinsey