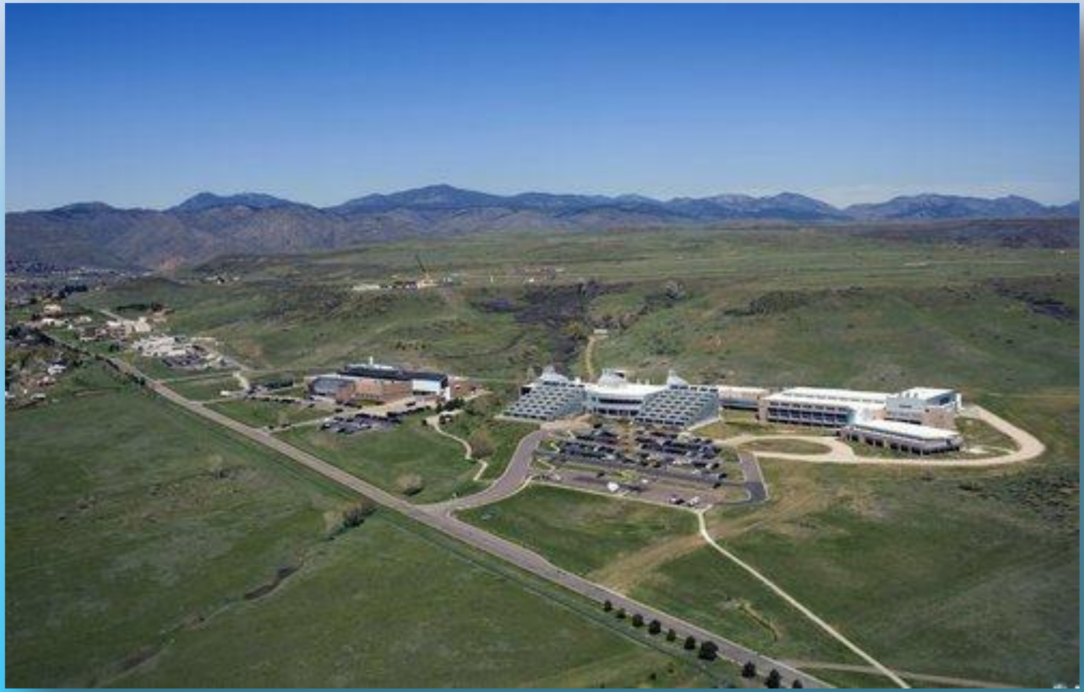
Energia renovável: o desafio tecnológico



Décio Luiz Gazzoni
Pesquisador da Embrapa Soja
Membro do International Scientific Panel on Renewable Energy

Energy uses

1. Transportation

2. Power

3. Heating

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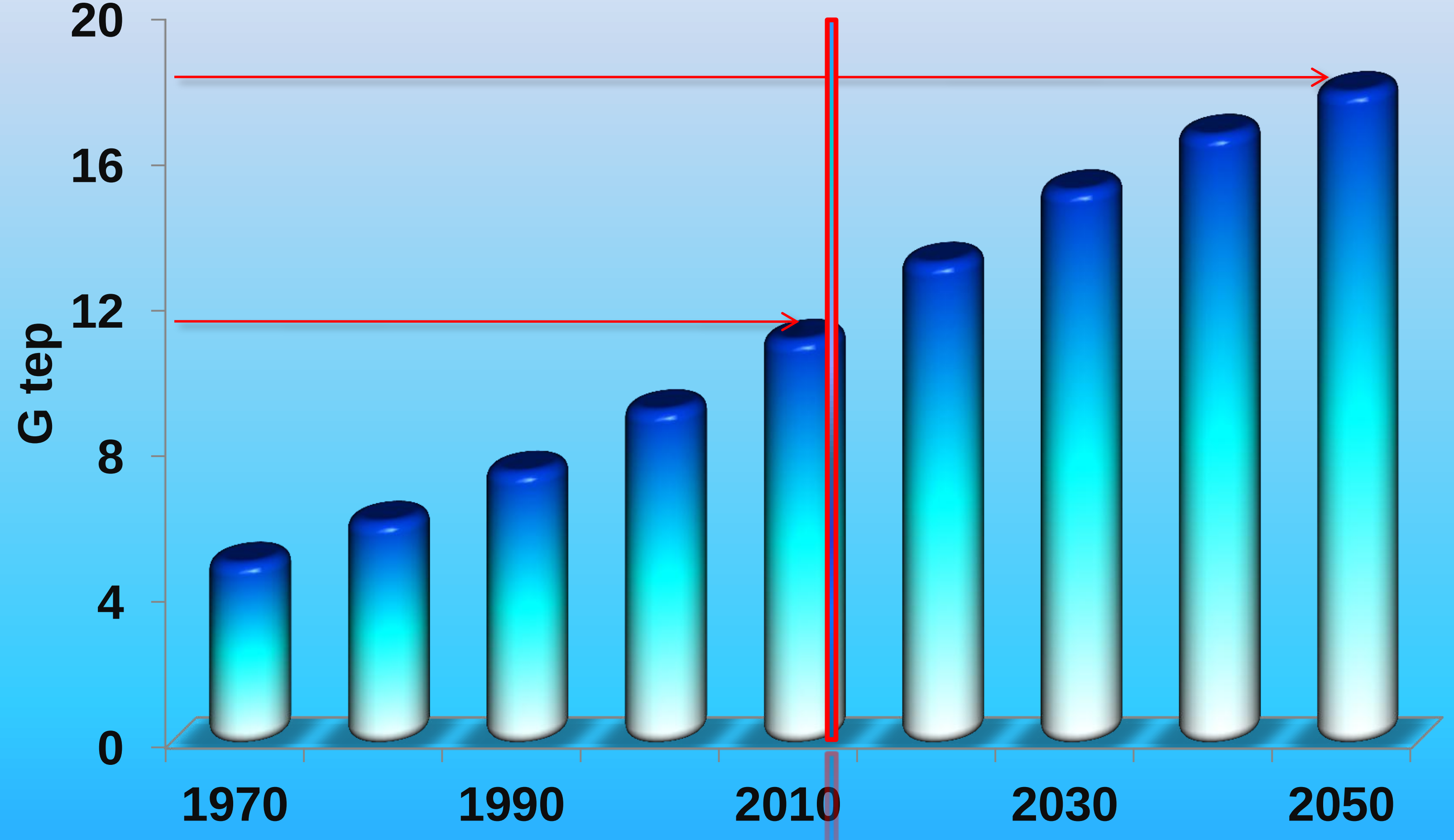
World energy demand



Fonte: EIA: "International Energy Outlook 2004"

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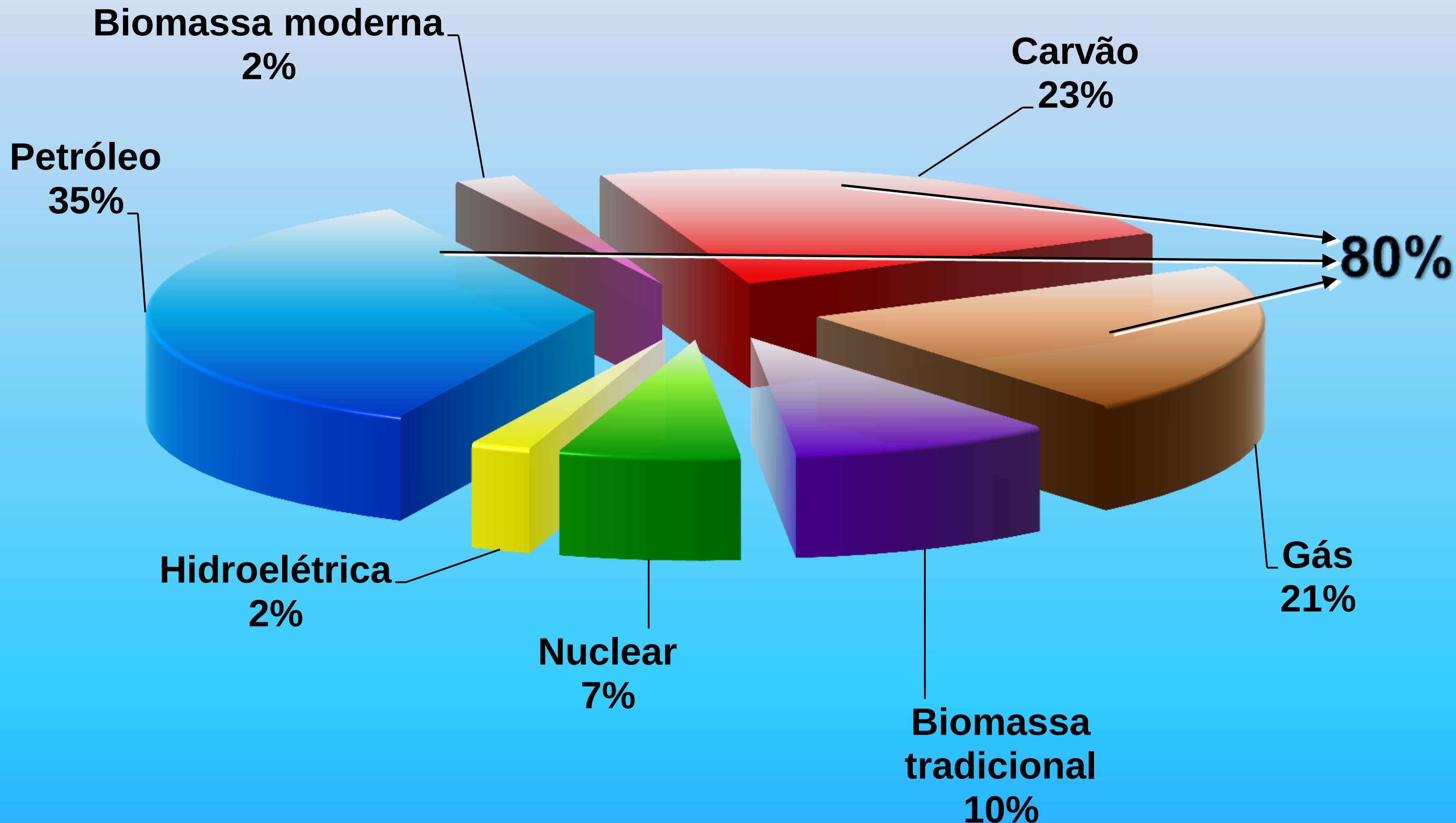
World energy matrix

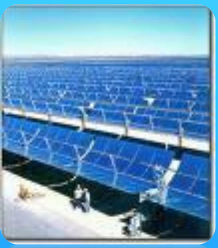


Fonte: EIA: "International Energy Outlook 2006"

Competitiviness

Source	Capacity factor(%)	Cost US$/KWh
Solar concentrated	43	0,06 – 0,16
Photovoltaics	17	0,06 – 0,28
Wind	40	0,03 – 0,07
Geothermal	90	0,05 – 0,10
Biomass	90	0,05 – 0,08
Hydro	**90**	**0,05 – 0,06**

Fonte: AIE






Years to go

Source	Proved	Potential
Coal	251	360
Gas	64	210
Oil	41	125
Nuclear	82	300

RE potential (TW)

Source	Technical	Theoretical
Biomass	9	92
Wind	20	190
Hydro	1,6	4,7
Geothermal	3,8	42
Solar	50	101.000

Present world demand = 15TW

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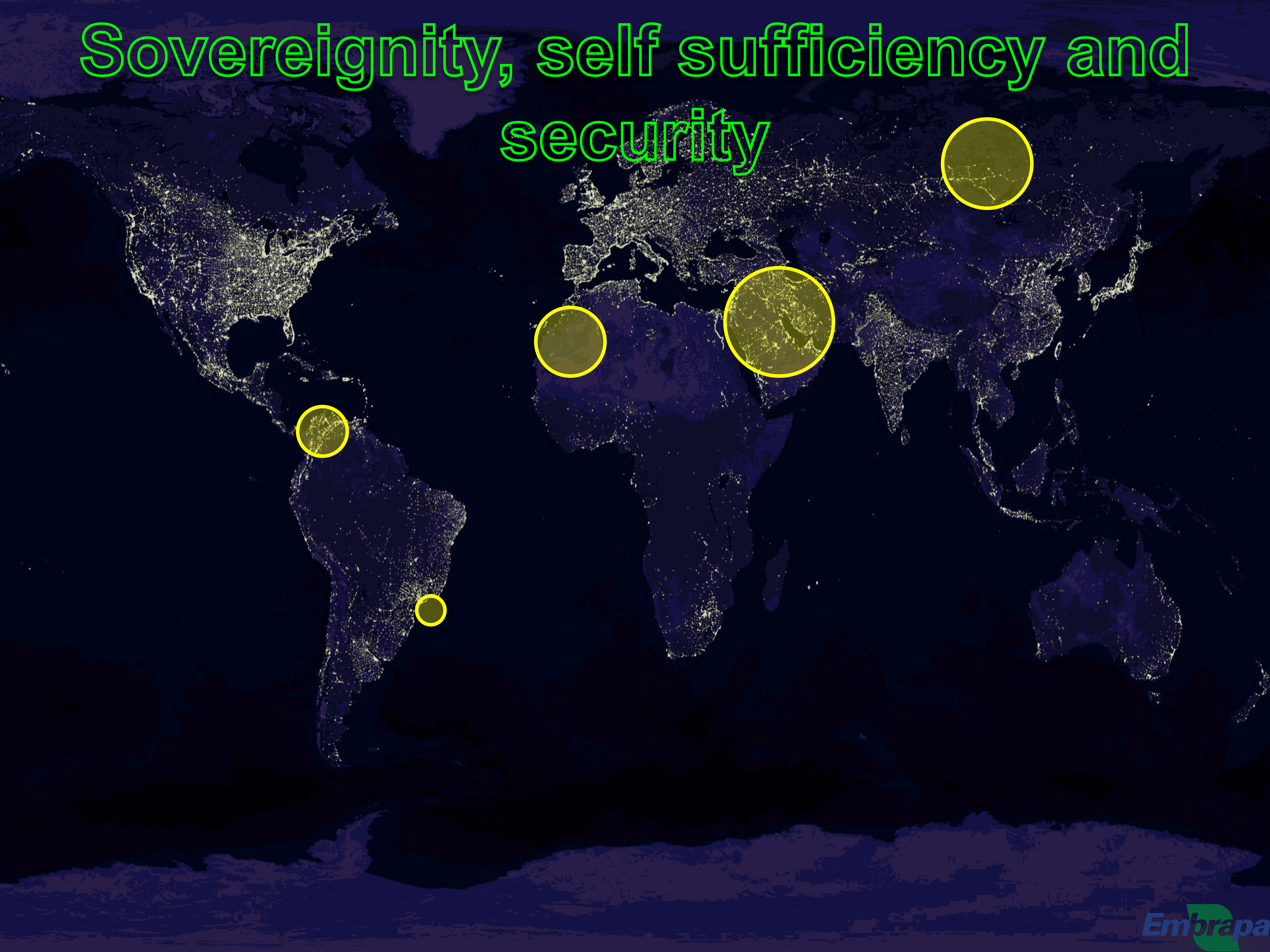
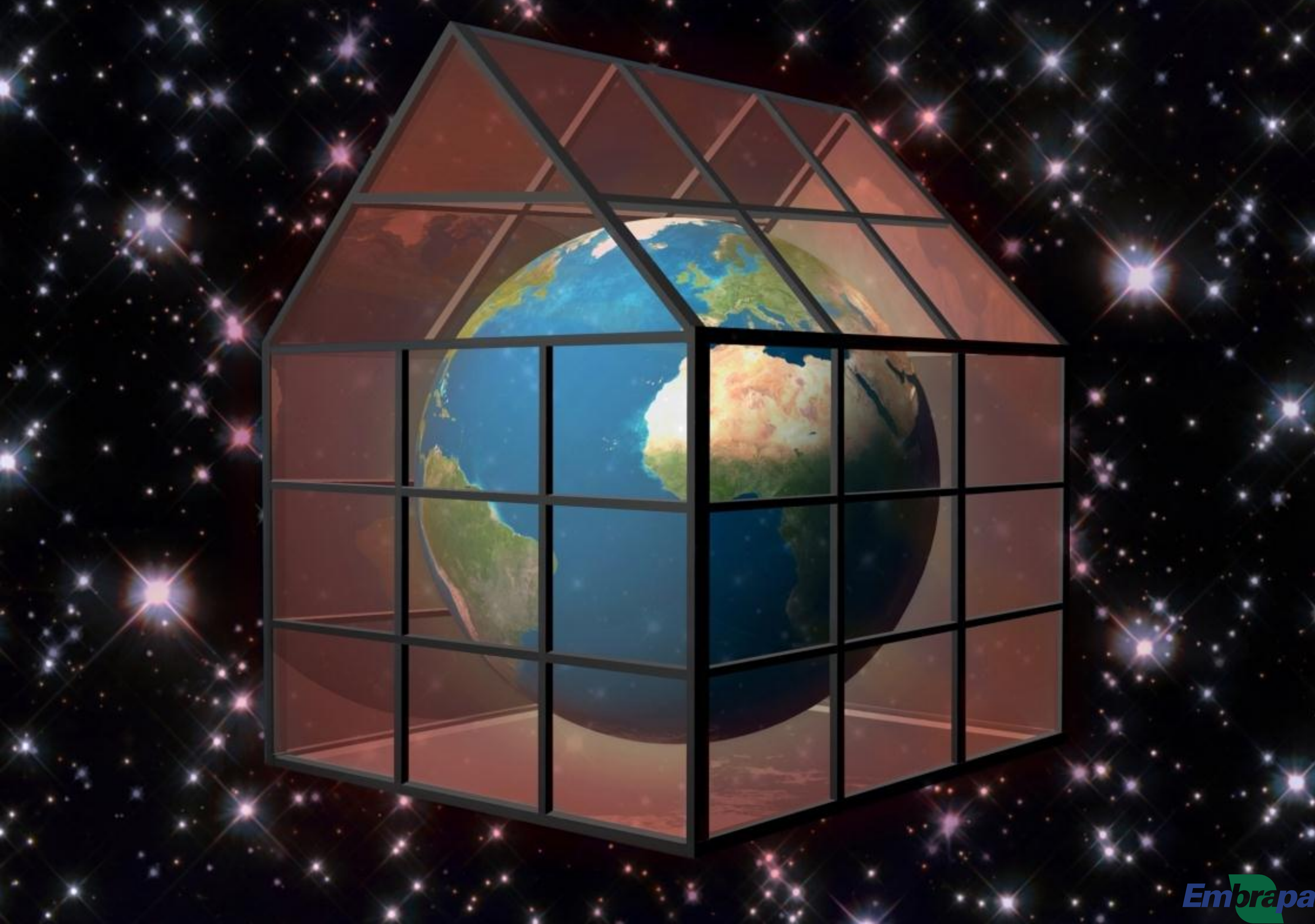
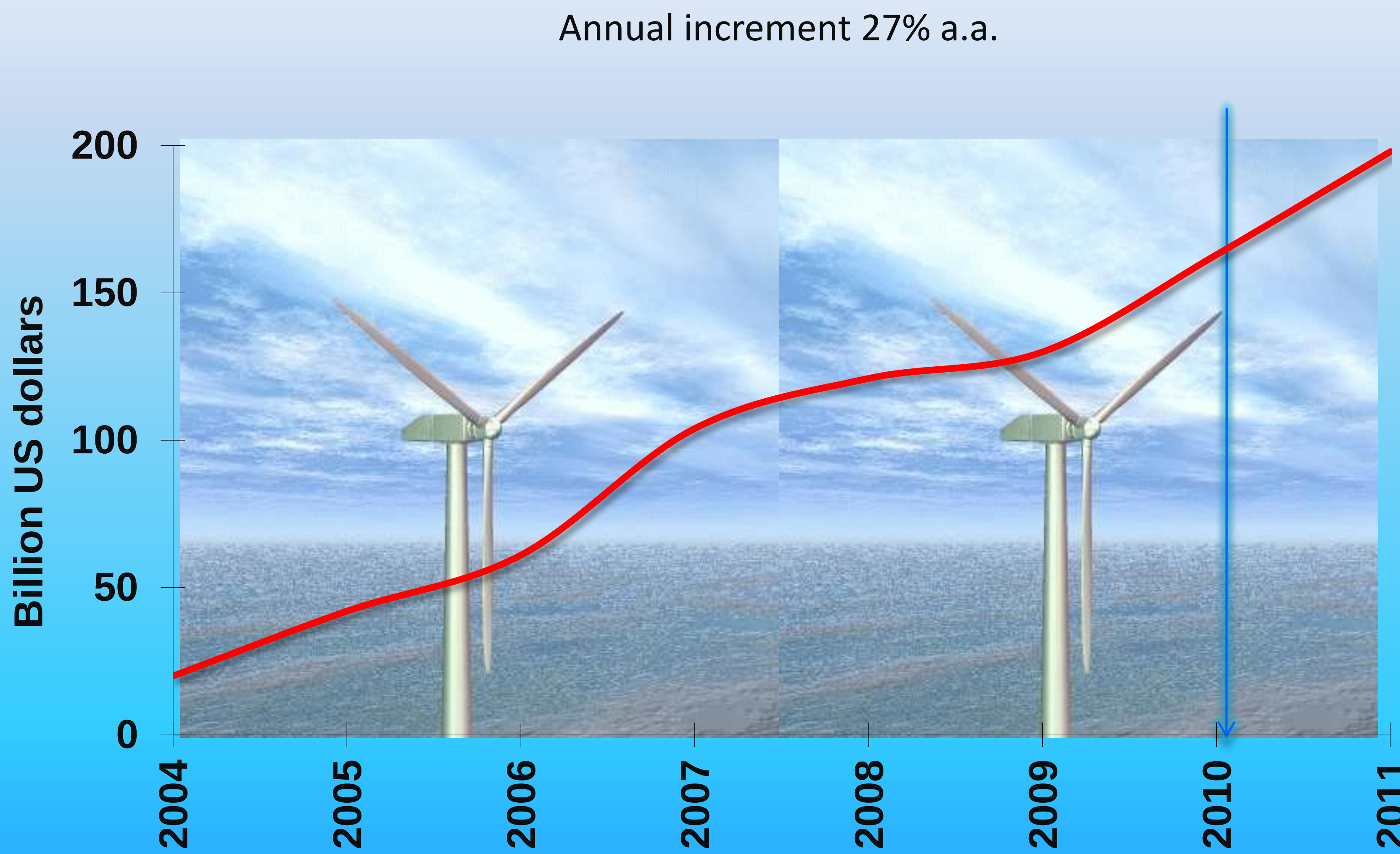
Sovereignity, self sufficiency and security



Efeito Estufa

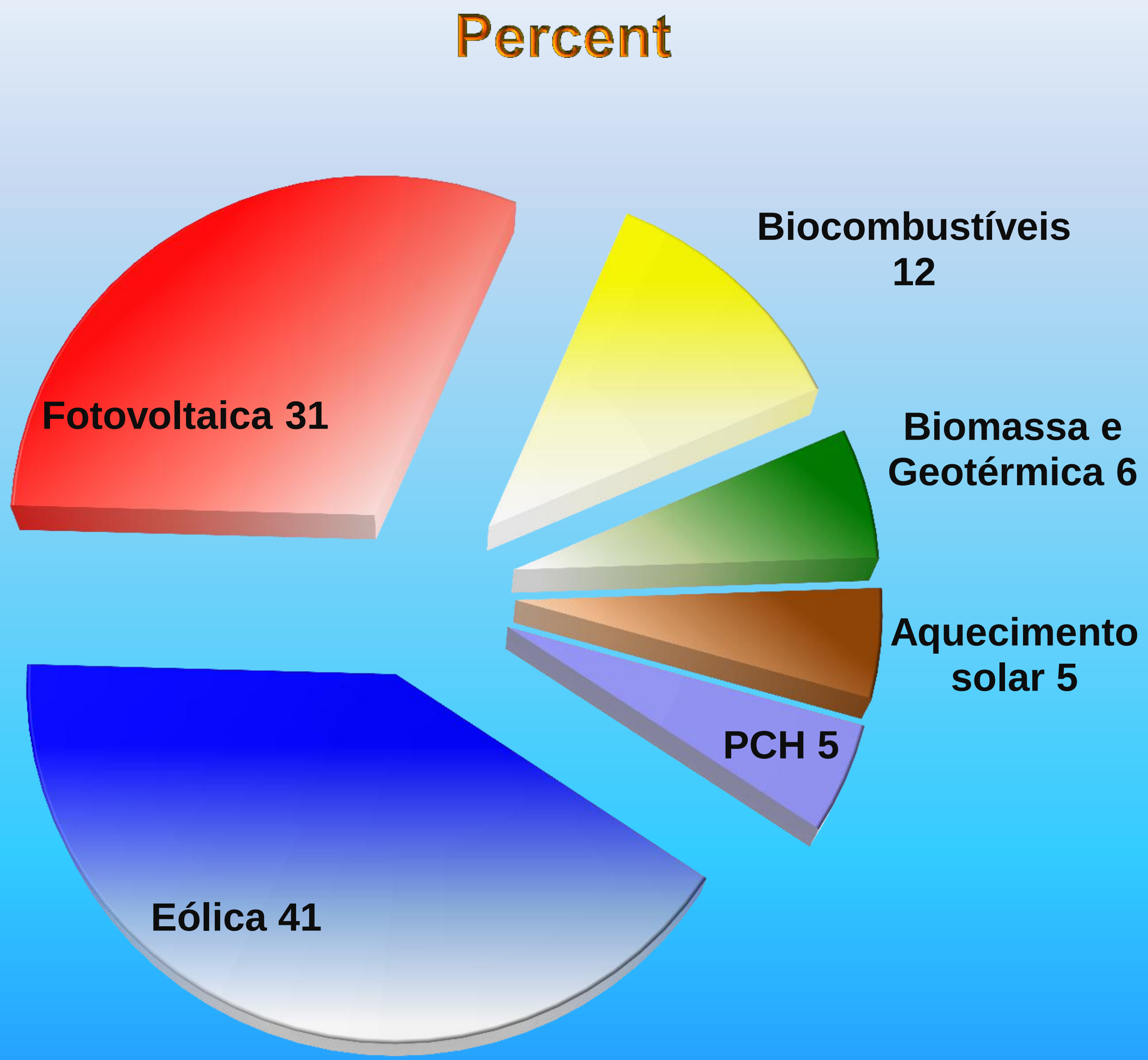


RE = Annual investments



Fonte: D. L. Gazzoni, com dados do REN21 (2009)

RE Investments - 2010



Elaboração: D. L. Gazzoni, com dados da New Energy Finance e do REN21

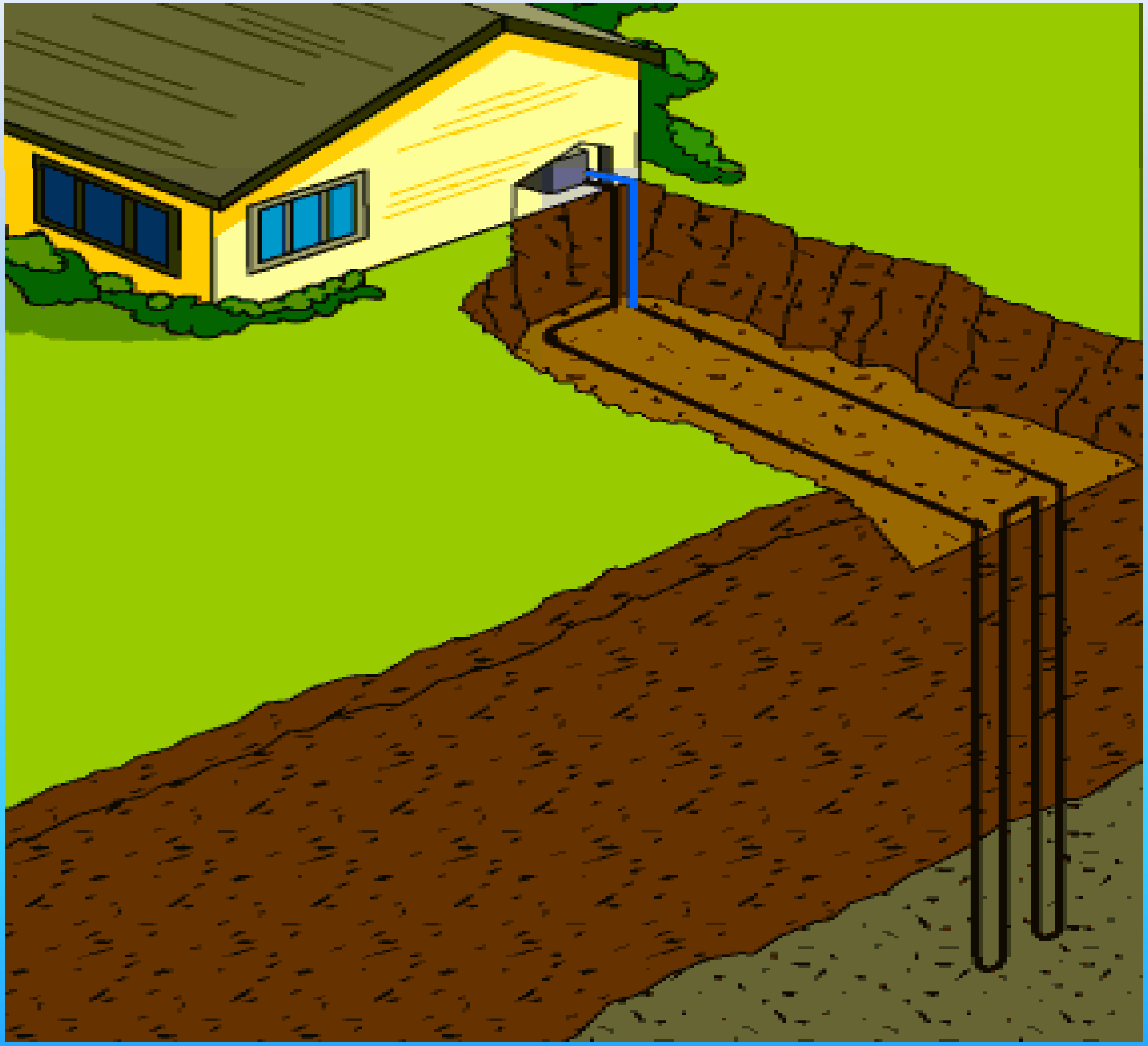
Animation

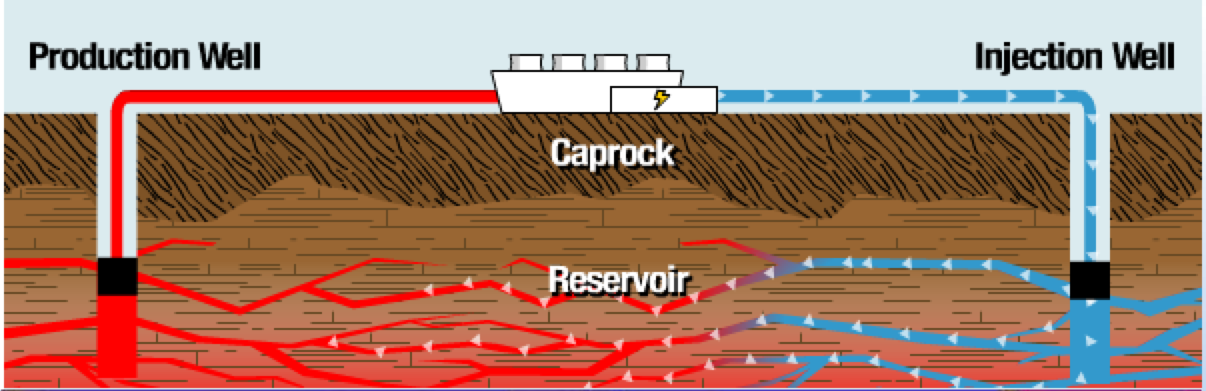
Animation

Animation

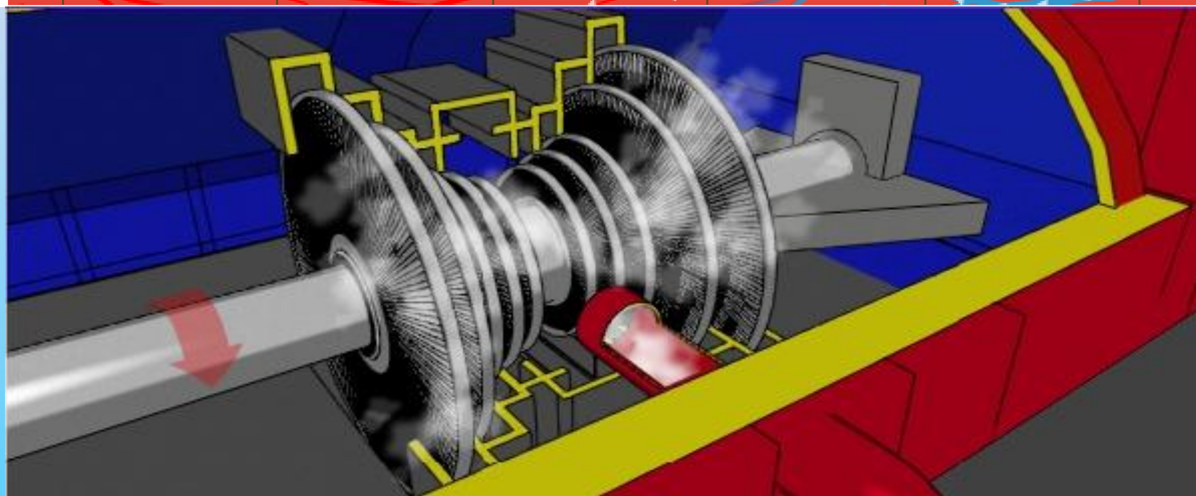
Embrapa

Geothermal – direct use

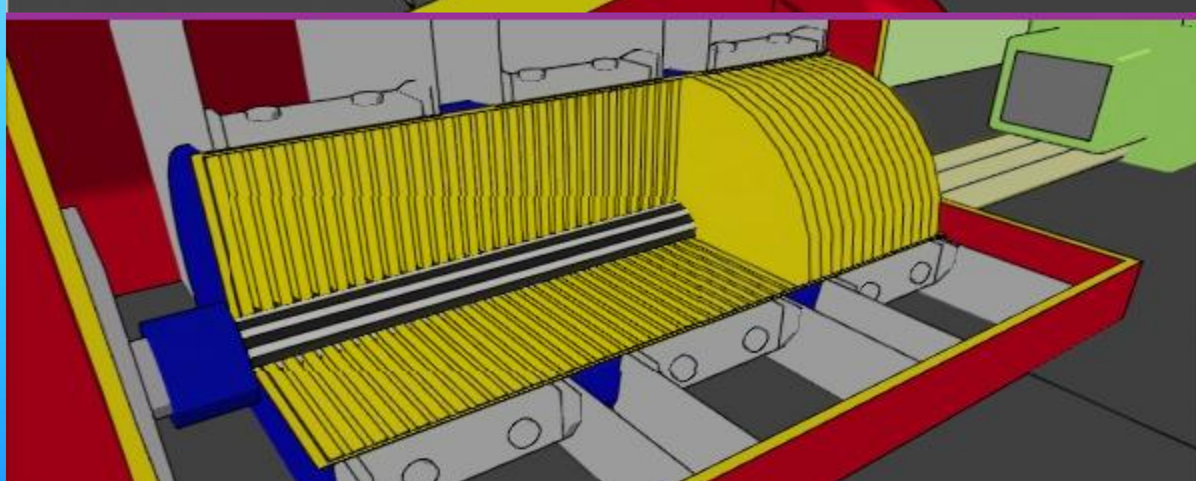




Vapour



Turbine



Generator

Technological challenges

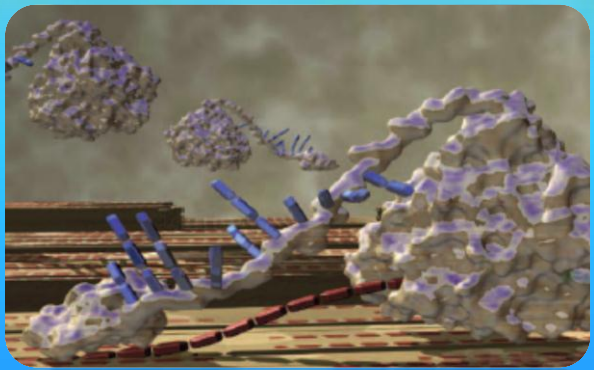
Biomass: Producing raw materials in large **quantities**, with high energy **density** and low cost of **lignocellulosic** material to generate energy at **costs** compatible with conventional sources, making **full use** of raw materials and **add value** to co-products

Photovoltaics: Increase the **efficiency** of converting solar radiation into electricity, reduce the **cost** of generation to be competitive with conventional sources and increase **capacity** and reduce the cost of energy **storage**

Wind: Reduce the **costs** of generation, decrease the cost of energy **storage**, achieve **scale** and **integrate** systems to compensate for the fluctuation generation

Most recent technologies

NREL
NATIONAL RENEWABLE ENERGY LABORATORY



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Energy Efficiency

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Zero Energy Constructions

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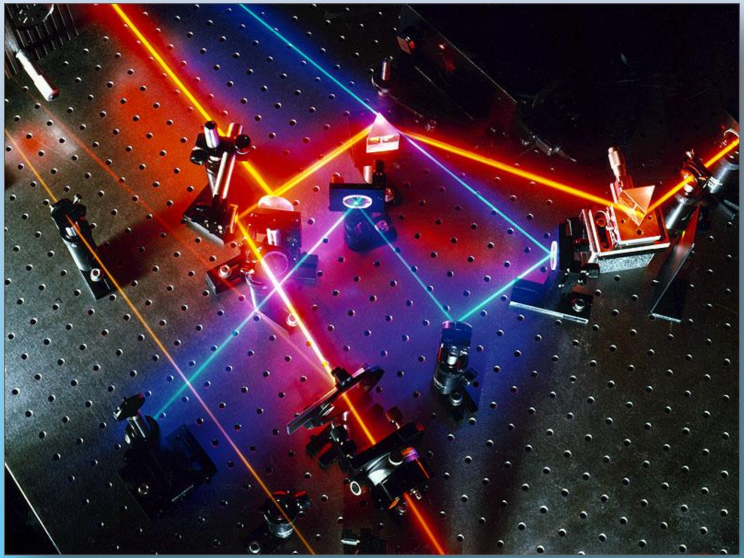
Green Light-Emitting Diode



1. Leds Lamp: the amount of light generated far outweighs the amount of heat produced
2. Blue or ultraviolet-emitting LED energizes a phosphorescent substance to indirectly produce white light
3. More efficient is the "Red-Green-Blue (RGB)" process—mixes the light from red, green, and blue LEDs to produce white light directly
4. "Green Gap" = inability of current LEDs to produce light in the wavelength range of 530 to 570 nm
5. NREL created a LED that emits light with a wavelength of 562 nm, composed of a gallium indium phosphide (GaInP) alloy grown on a gallium arsenide (GaAs) substrate

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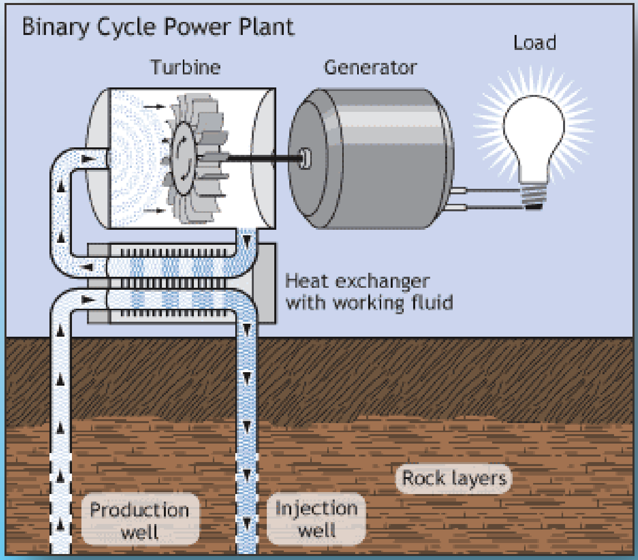
Advanced condenser for geothermal



Direct-contact condensers: The water and condensate mixture is pumped out to cooling towers to be recycled as circulating water, and noncondensible gases—including potential pollutants such as hydrogen sulfide—are removed.

Consumes too much steam during the removal of noncondensible gases and creating high back pressures that decreased turbine performance

NREL developed the ADCC system, replacing traditional perforated plates with a sophisticated geometric framework resembling a three-dimensional maze. This increases the surface area for interaction between cooling liquid and steam.

ADCC employs countercurrent flow to allow for maximum contact between the substances and to channel noncondensible gases more efficiently for removal.

Advanced heat transfer / cooler

A vehicle's power electronic components generate a lot of heat. This heat can decrease their performance and reliability, as well as that of other vehicle components, and lead to costly component failures.

NREL developed a heat exchanger that directs liquid cooling to the underside of electronic power devices attached to a copper-bonded ceramic surface.

This approach eliminates the need for thermal grease and significantly enhances direct heat transfer from the electronics.

A series of nozzles is used to direct jets of liquid coolant to the copper-bonded layer.

Improved air conditioning

NREL invented a technology that improves air conditioning, combining desiccant materials, which remove moisture from the air using heat, and advanced evaporative technologies to develop a cooling unit that uses 90% less electricity and up to 80% less total energy than traditional air conditioning

Significantly lower energy requirements—30% to 80% less thermal and electrical energy .

Improved comfort and air quality—control temperature and humidity independently, providing more comfort.

Reduced electrical peak load demand—uses thermal energy to offload this demand.

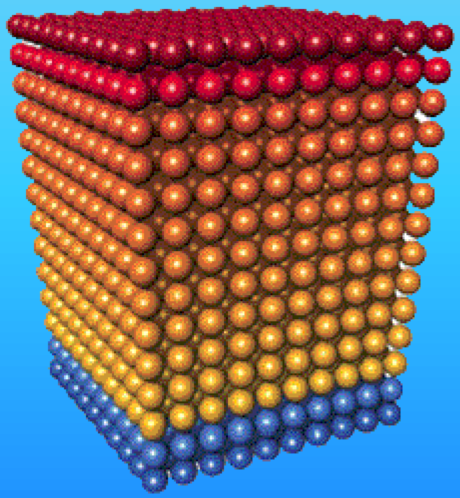
Decreased greenhouse gases—Eliminates the use of chlorofluorocarbons. Based on estimates of a 50% market penetration, the lower electricity and energy use could save more than 60 million metric tons of CO_2 annually.

Solar energy

Upside down solar cell

NREL's breakthrough approach is based on high-quality "lattice-mismatched" materials to achieve high-performance crystal structures with optimal bandgaps.

A bandgap is the range of energies that will excite the electrons within each semiconductor, and it corresponds directly to the portion of the solar spectrum that the semiconductor can convert into electricity.



The triple-junction cell with a structure of gallium indium phosphide / gallium arsenide /g allium indium arsenide (GaInP/GaAs/GaInAs), established two record efficiencies : 31.1% at one-sun intensity and 37.9% under concentrated light equal to 10 suns.

Recently, an improved variant of the IMM set a new world record of 40.8% efficiency.

Solar tree

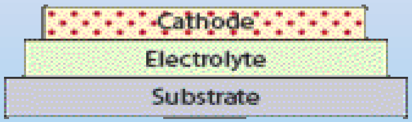
3.5 kW solar array that provides solar energy to cover a maximum of two parking spaces.

The system includes two AC outlets and produces around 5,000 kWh of energy a year.

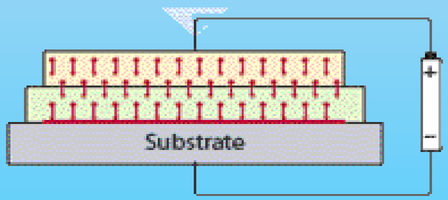
The tree displaces as much as 1,996 pounds of coal annually

NREL's modified Toyota Prius is capable of achieving 100 miles per gallon, and can travel up to 60 miles on battery power alone.

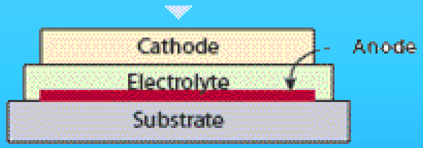
Buried anode on lithium batteries



Lithium batteries tend to degrade quickly because the fragile lithium metal anode is on the top of the battery, where any cracks in the encapsulant could lead to rapid failure



The buried-anode design involves depositing a solid-state electrolyte (lithium phosphorous oxynitride - LiPON), onto a substrate, followed by a cathode containing lithium, such as lithium manganese oxide ($LiMn_2O_4$). Applying an initial charging voltage to the battery causes the lithium ions to migrate to the surface of the substrate, where they form a lithium metal anode.



The new battery is rechargeable, highly compact (thin-film form), extremely long cycle life, high-speed production processes , no encapsulant needed.

Boosting solar power

CSP systems are heavy, difficult to assemble and to operate.

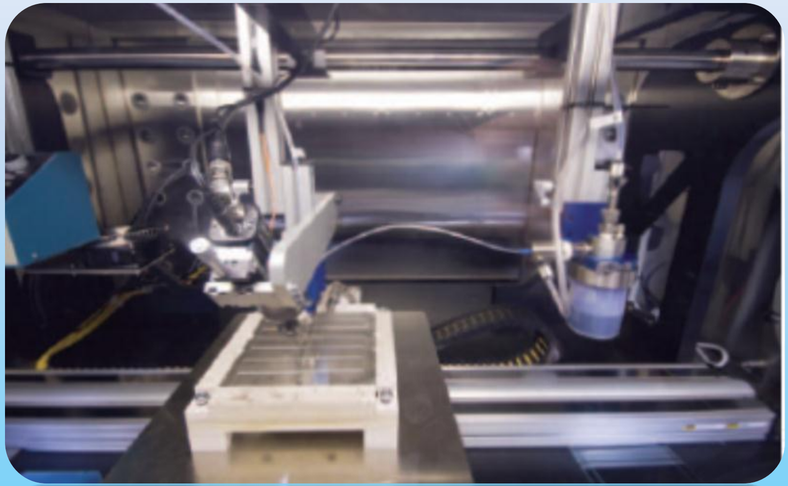
NREL developed a new structure substantially stronger and lighter than previous models, as well as easier and faster to assemble in the field

NREL developed lightweight, more cost-effective reflective films to replace heavier, more expensive glass mirrors.

Multiple polymer layers, with an inner layer of pure silver provides high reflectance over the full solar spectrum.

The design protects the silver layer from oxidation and other harmful effects (10 years of ultraviolet light exposure)

Ink Jet printing for thin film PV



NREL's patented inkjet printing technology allows hybrid copper indium gallium diselenide (CIGS) material to be deposited directly onto common building materials such as metal, glass, plastic, foil, and composites

NREL scientists created metals that can be deposited by metal-organic decomposition using inkjet printing. The conductive metal is attached to an organic molecule that delivers the metal. Depending on the ink composition, one can deposit metal like copper, silver, nickel, aluminum, platinum or palladium.

Quantum dots and PV

Semiconductor quantum dots have the potential to dramatically the efficiency of converting sunlight to electricity. The conversion process works via "multiple exciton generation (MEG)." When a single photon of light of sufficient energy is absorbed by the quantum dot, it produces more than one bound electron or exciton.

Varying the size of QDs can "tune" them to different wavelengths of light to optimize their performance.

QDs can be tailored to absorb or emit specific wavelengths of light simply by changing the size of the dot .

Compared with bulk materials, which have larger crystals and more atoms than nanomaterials, the light spectra emitted or absorbed by QDs will shift to the blue, which represents greater energy or shorter wavelength. Thus, the smaller the dot, the greater the shift.

Algae for biofuels

NREL has accumulated almost 400 different algal strains from differing environments - freshwater, brackish and saline. Higher throughput devices that allow to process samples very quickly.

Chlorella vulgaris was chosen as a model organism. Researchers at NREL are trying to get a complete view of its molecular biology and biochemistry

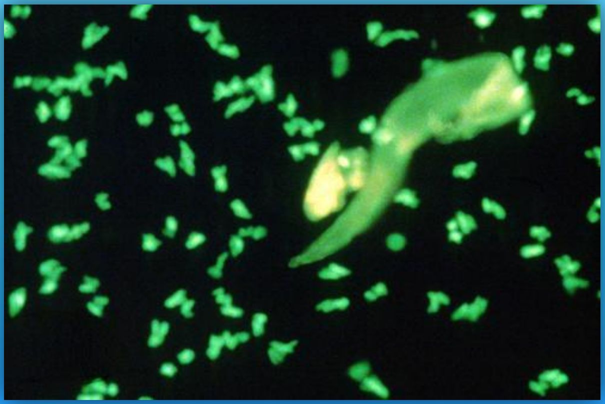
NREL is looking for an enzyme that can easily break down the cell wall, and engineer the algae to produce that enzyme just before it is ready to harvest

NREL was awarded $25 million to pilot a photo-bioreactor algal biofuel system

Cellulose and hemicellulose biofuels

NREL and DuPont developed unique processes for integrated pretreatment, enzymatic hydrolysis, and fermentation at the bench scale.

Zimomonas mobilis



The process use a proprietary organism developed by NREL and Genencor. The organism, based on NREL's patented bacterium *Zymomonas mobilis*, can ferment biomass derived sugars into high yields of ethanol with fewer by-products

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Recalcitrance screening

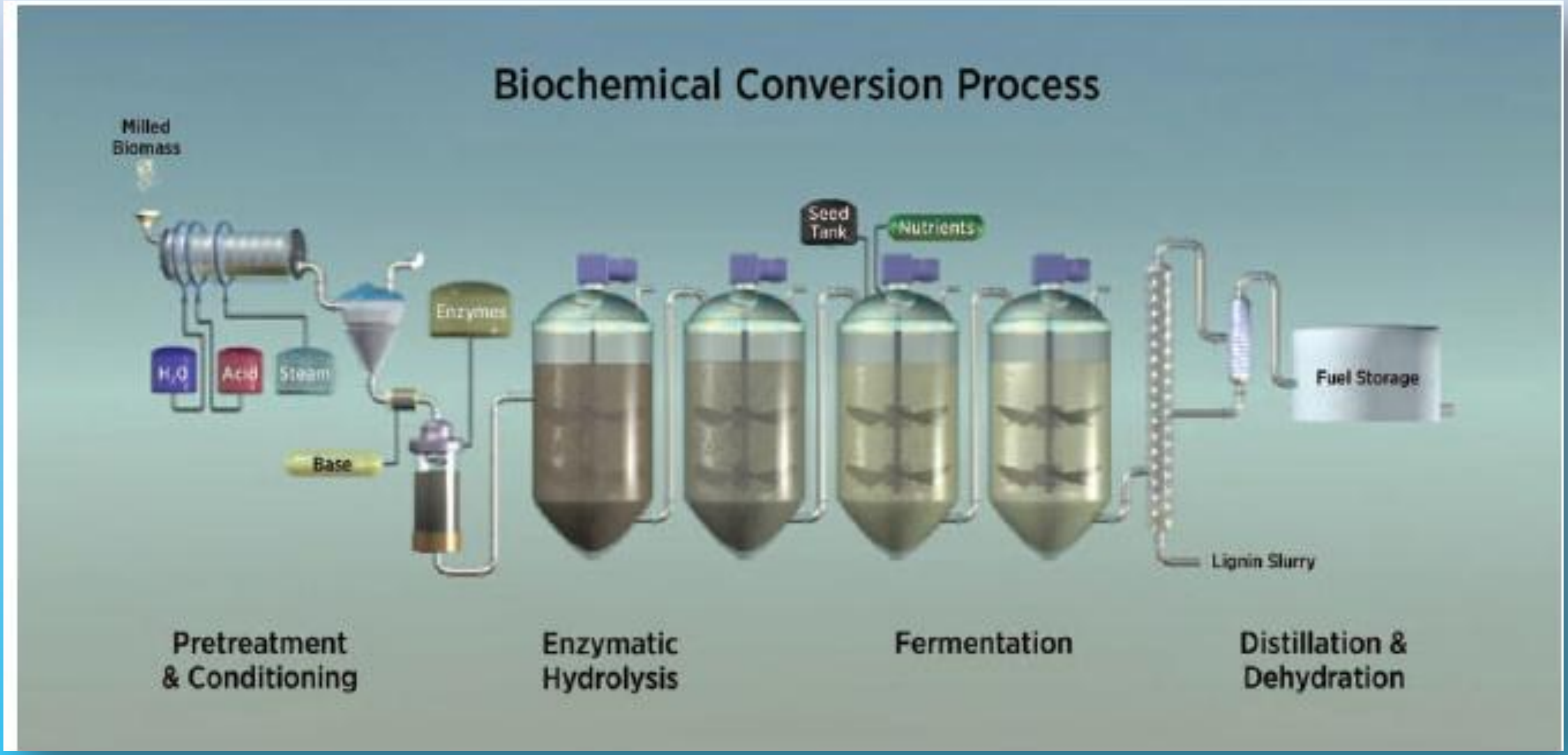
NREL and UCR developed a high-throughput (HTP) platform capable of identifying biomass samples, with uncommon cell wall chemistry and conversion characteristics, including those that would be easiest to convert to fermentable sugars.

System will allow much more rapid screening of large numbers of samples and identify the most promising biomass feedstocks for higher efficiency and lower cost biofuels conversion processes.

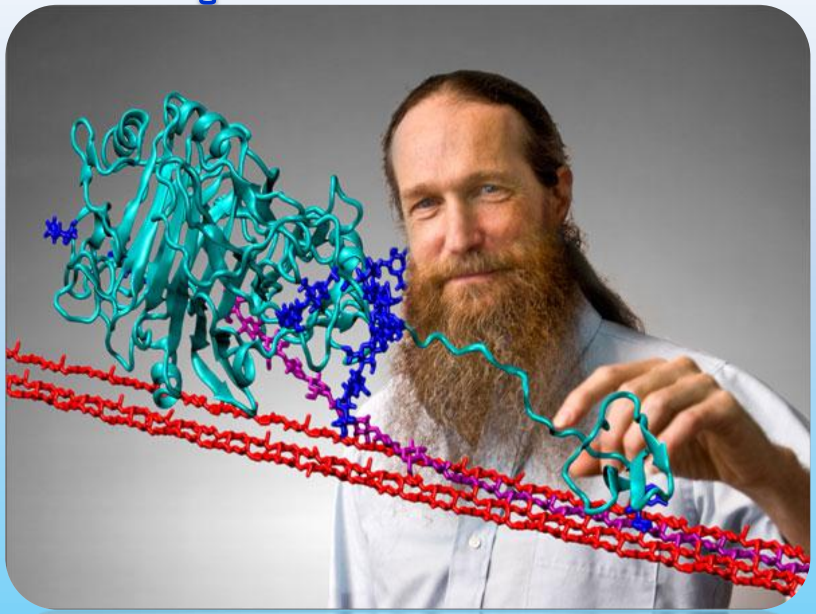
NREL will be screening thousands of variants of different biomass feedstocks to link genetic traits with environmental factors that can enhance biomass conversion efficiencies.

Identifying the genes controlling the anatomical, chemical, and morphological features of biomass is essential to develop the next generation of low-cost, easily convertible biomass feedstocks

Cellulose deconstruction



Biochemical steps



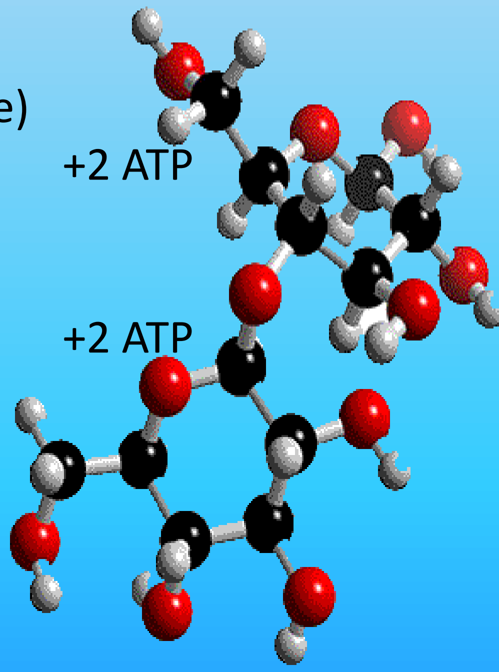
A. From celullose to celobiose

1. Endocellulases cleave the cellulose chain
2. Cellulose hidrolisys on aminoacid active sites
3. Cellulose end chain looses a molecule of H_2O
4. Mark end of a cellulose chain
5. CBH I Exoglucanase recognizes end of a cellulosic chain
6. Cellulose chain enters active site tunnel
7. Cellulose chain is cleaved into cellobiose units (disaccharide with the general formula $C_{12}H_{22}O_{11}$)
8. Cellobiose units are realeased for conversion by microrganisms

Biochemical steps

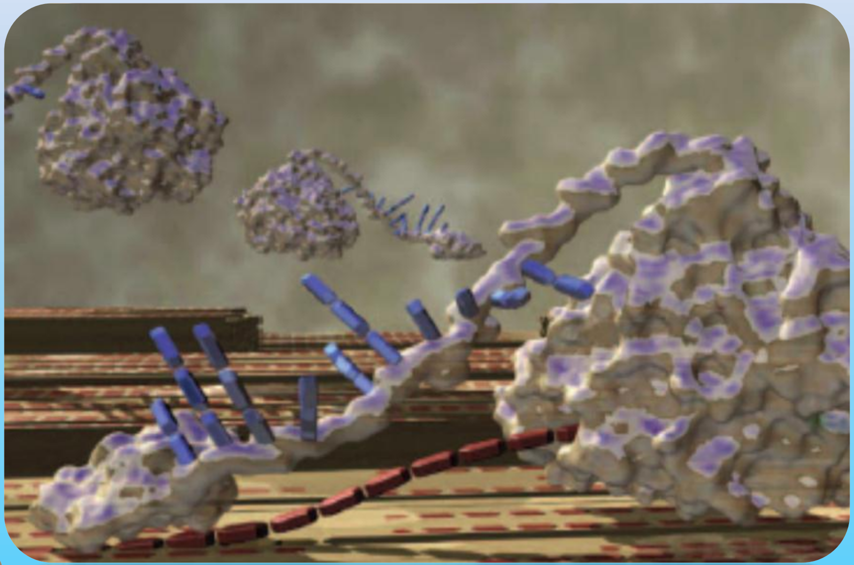
B. From cellobiose to ethanol (glycolytic pathway)

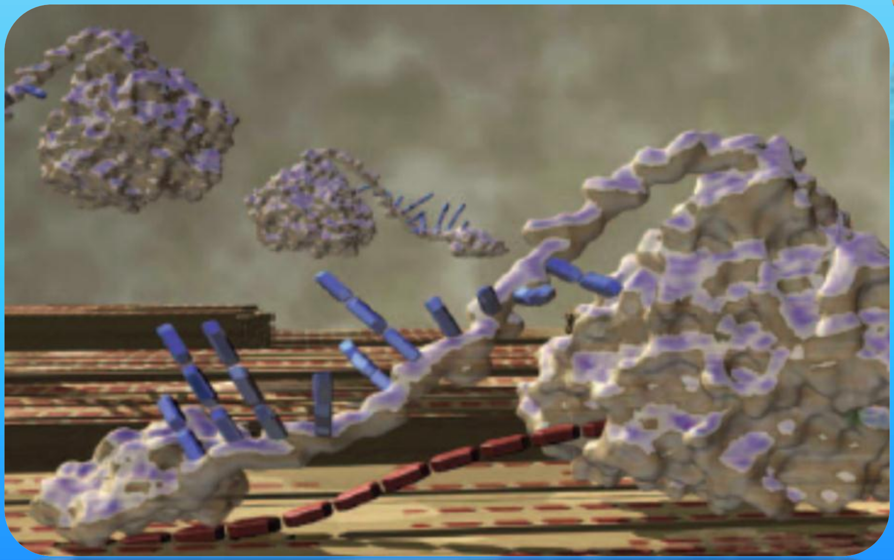
1. Glucose → Glucose-6-P (hexokinase) -1 ATP
2. G-6-P → Fructose-6-P (phosphogluco isomerase)
3. F-6-P → F-1,6 bis-P (phosphofructo kinase) -2 ATP
4. F-1,6bis-P → Di hydroxi accetone-P and G-3-P (aldolase)
5. DHAP → glyceraldehyde 3-phosphate (isomerase)
6. G-3-P → 1,3 di phosphoglycerate (thriosephosphate isomerase)
7. 1,3-DPG → Glycerate 3-P (phophoglycerokinase) +2 ATP
8. 3-P-G → 2-P-G (phophoglycero mutase)
9. 2-P-G → phosphoenolpyruvate (enolase)
10. PEP → pyruvate (pyruvatekinase) +2 ATP
11. Pyruvate → acetaldehyde + CO_2 (pyruvate descarboxylase)
12. Acetaldehyde → ethanol (alcohol dehydrogenase)

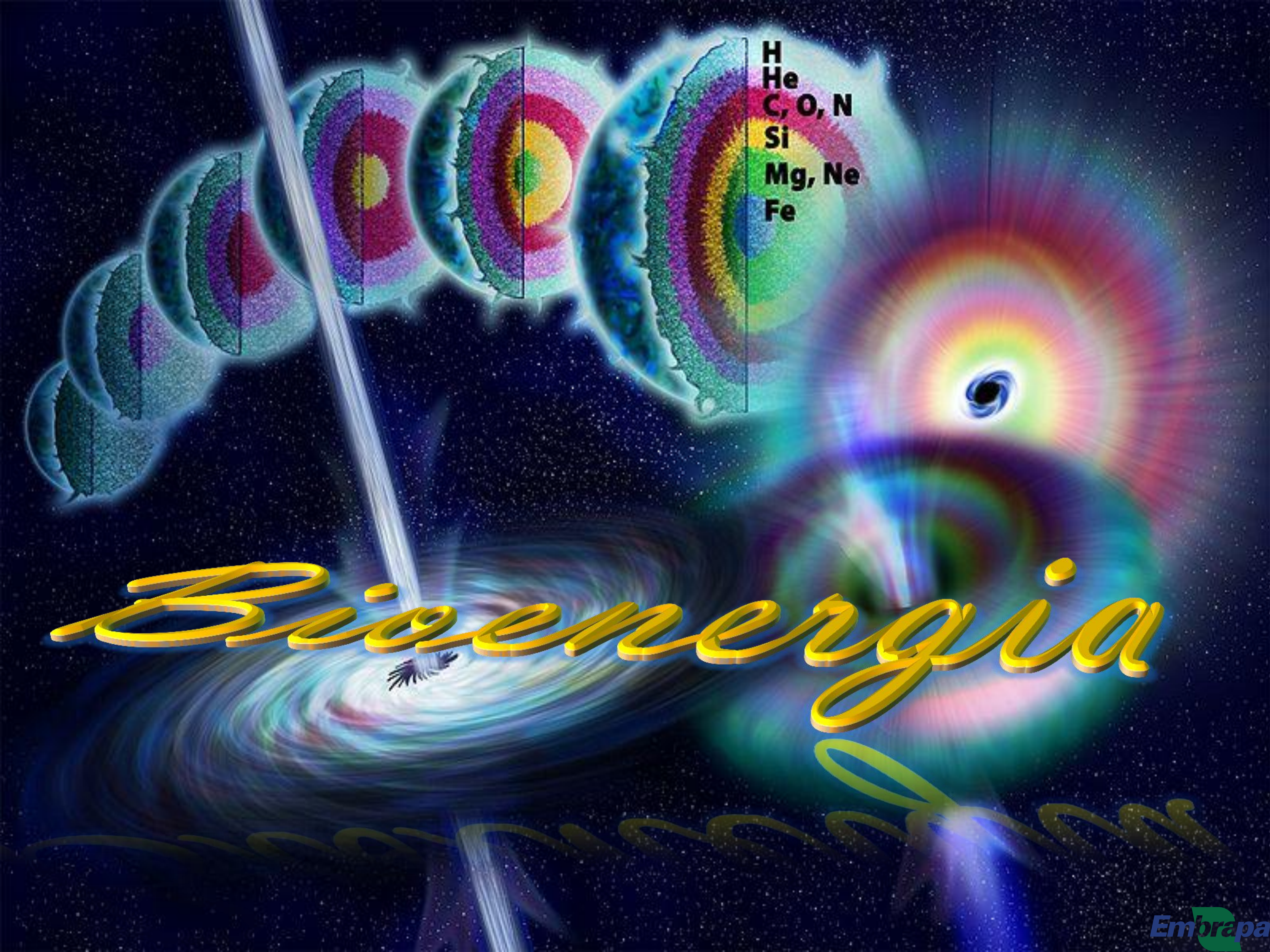


Ethanol & CO_2 get diffused through the cell membrane

Enzyme dynamics






H
He
C, O, N
Si
Mg, Ne
Fe
Bioenergia
Embrapa

Produção de biomassa

Perspectives of oilseed rape as a bioenergy crop

Biofuels (2010) 1(4), 621-630

M Zhang & SS Malhi

SUMMARY

Future outlook is analyzed under conventional and technology breakthrough scenarios. In conventional scenarios, expansion of oilseed, rape production is challenged by high water footprints, nitrous oxide (N_2O) gas emissions from nitrogen fertilizer application and full carbon credit accounts.

In the technology breakthrough scenario, the challenges can come from the advancement in technology of other feedstocks for biodiesel production, such as algae-based biodiesel technology

For both scenarios, the ultimate constraints for oilseed rape expansion are the availability of land and water.

KEY POINTS

• Oilseed rape as a rotational crop provides both economic and environmental benefits in agricultural crop production systems.

• Adoption of herbicide-tolerant oilseed rape brings benefits and concerns in production and environment - impact of the escaped gene on the environment and the impact of transgenic crop on soil microbial communities.

• In the conventional scenario, oilseed rape production expansion is challenged by high water footprint, N_2O emission and input cost.

• In the technology breakthrough scenario, transgenic technology will play a major role in improving resistance of oil seed rape to insects and disease and in enhancing nutrient use efficiency. The challenge may come from advanced algae-based biodiesel technology, which will be more cost-effective in comparison with oilseed rape-based biodiesel.

• The upper threshold for such expansion is the availability of land and water for crop production, because these resources are finite. It is very likely that these upper thresholds will be reached within the next 10-15 years.

The untapped potential of sweet sorghum as a bioenergy feedstock

Biofuels (2010), 1(4), 563-573.

Danielle Bellmer, Ray Huhnke, Rob Whiteley & Chad Godsey

SUMMARY

As world energy demand increases, alternative sources of renewable energy are required. Sweet sorghum has great potential as an alternative bioenergy feedstock. It is a highly productive and versatile crop that can be cultivated in temperate climates. However, the freshly pressed juice is not stable, and must be processed immediately, making it difficult to operate a large plant to a short harvest season.

The relatively low technology conversion process for sweet sorghum lends itself to rural, decentralized processing, and it is this scenario that should be further pursued in order to fully utilize its potential. This article will discuss critical issues and various processing options for production of ethanol from sweet sorghum.

KEY POINTS

• Sweet sorghum is a potential bioenergy feedstock characterized by high yield potential and drought tolerance.

• Its high productivity and versatility make sweet sorghum a desirable feed stock, especially in parts of the world where environmental constraints limit the growth of other feed stocks.

• An advantage to producing ethanol from sweet sorghum is the fact that directly fermentable sugars are simply pressed from the stalks, much like sugarcane. The process is simple and robust, making it an ideal candidate for rural processing.

• Processing of sweet sorghum in large plantations similar to sugarcane can be realized today. Sweet sorghum could also be used as a complement to sugarcane facilities, and processed during the months when harvestable cane is not available.

Biofuels from algae: challenges and potential
Blofuels (2010) 1(5), 763-784
Michael Hannon, Javier Gimpel, MillerTran, Beth Rasala & Stephen Mayfield

Algae biofuels may provide a viable alternative to fossil fuels; however, this technology must overcome a number of hurdles before it can compete in the fuel market and be broadly deployed.

These challenges include strain identification and improvement, both in terms of oil, productivity and crop protection, nutrient and resource allocation and use, and the production of co products to improve the economics of the entire system.

Although, there is much excitement about the potential of algae biofuels, much work is still required in the field. In this article, we attempt to elucidate the major challenges to economic algal biofuels at scale, and improve the focus of the scientific community to address these challenges and move algal biofuels from promise to reality.

KEY POINTS

- Algae have the potential to produce high amounts of oil-rich biomass using non arable land, are diverse organisms, and are a rich research frontier.

- Water and nutrients, especially sulfur, nitrogen, phosphorus and iron, are limiting growth or not currently acquired through sustainable methods.

- Efficiency in harvesting and production can improve algae economics.

- Algae monocultures are susceptible to abiotic and biotic factors that can cause populations to plummet.

- Even significant improvements in algae productivity may not be enough to make algae-based oil competitive. Value-adding improvements are required to bring algae biofuels into competition with petroleum.

- Engineering of algae is a developing field that has been successful in *Chlamydomonas reinhardtii* and a number of other species.

- Algae produce a number of higher value natural co-products that have high market value. Species may be identified that have both high lipids, as well as high-value secondary metabolites that can add value to the overall system.

Recent developments in microalgae for biodiesel production

Biofuels (2010) 1(4), 631-643

Haiying Tang, Steven O Salley & KY Simon Ng

SUMMARY

Biodiesel is a renewable and environmentally friendly alternative fuel, which is comprised of mono-alkyl esters of long chain fatty acids derived from renewable resources.

However, biodiesel production is dependent on available feed stocks and the growth. of biodiesel as a petroleum diesel substitute is limited by the expensive cost of feedstock. Microalgae are among the most promising of nonfood based biomass fuel feedstock alternatives.

Algal biofuels production is challenged by limited oil content, growth rate and economical cultivation and'-extraction- techniques.

This article summarizes the current state of research related to potential algal stains, cultivation conditions, biomass production rates and technologies for extraction of algal oil and production of biodiesel.

KEY POINTS

• Many algal strains have high lipid productivity and maybe suitable feed stocks for biodiesel production. Different microalgae species exhibit different biomass productivity, lipid content and lipid productivity, even for the same species under different cultivation conditions.

• There its great variation in fatty acid composition among algae strains, often with a higher proportion of unsaturated FA over saturated FA.

• Cultivation conditions such as light, temperature, nutrient source, pH and oxygen may have varied influence on algal growth, oil content and FA composition for biodiesel production.

• Nitrogen starvation is the most effective method to increase the lipid content in algae.

• Open ponds are the least expensive, but are more readily contaminated, have low productivity, high harvesting costs and a large degree of water loss.

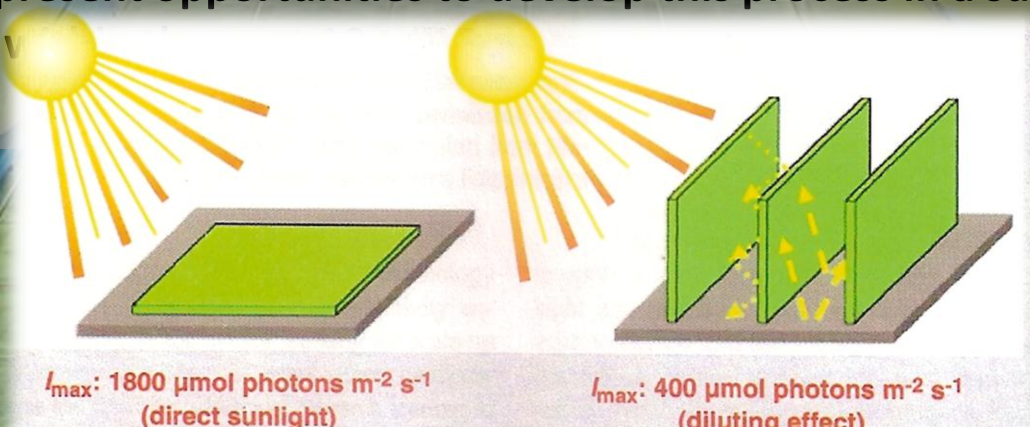
• Photobioreactors (PBR) can reduce the chances of contamination, allow precise environmental control and can operate as a continuous process. However, PBRs have a higher capital cost than open pond systems and may have higher operating and temperature control costs.

An Outlook on Microalgal Biofuels
Science 329:796-798
Rene H. Wijffels and Maria Barbosa

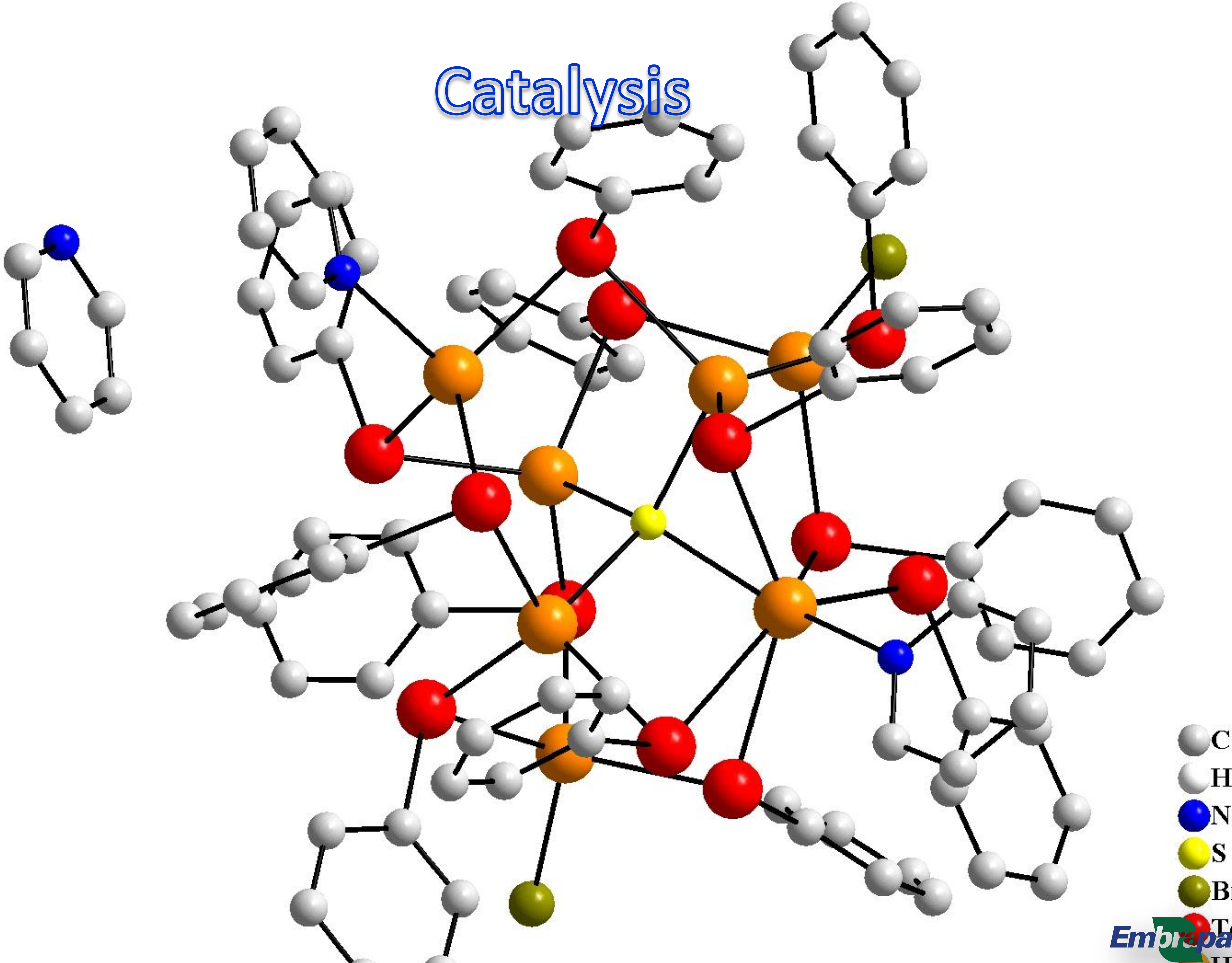
SUMMARY

Microalgae are considered one of the most promising feed stocks for biofuels. The productivity of these photosynthetic microorganisms in converting carbon dioxide into carbon-rich lipids, only a step or two away from biodiesel, greatly exceeds that of agricultural oleaginous crops, without competing for arable land. Worldwide, research and demonstration programs are being carried out to develop the technology needed to expand algal lipid production from a craft to a major industrial process.

Although microalgae are not yet produced at large scale for bulk applications, recent advances-particularly in the methods of systems biology, genetic engineering, and biorefining-present opportunities to develop this process in a sustainable and economical way



Catalysis



Keeping intermediates on the track: towards tailored metabolons for bioelectrocatalysis
Biofuels (2010) 1(5), 677-680.
Evaluation of: Moeblenbrock MJ, Toby TK, Waheed A, Minteer SD: Metabolon catalyzed pyruvate air biofuel cell.
J. Am. Chem. Soc. 132, 6288-6289.(2010).

SUMMARY

Enzymatic fuel cells suffer from a severe limitation: they convert only a fraction of the substrate's chemical energy into electricity. The reason for this limitation lies in the specificity of single enzymes, which are not able to completely oxidize complex organic substrates such as glucose. Enzyme cascade electrodes may help to overcome this limitation; however, they are only a starting point.

In their communication, Moehlenbrock et al. have proposed the use of metabolon structures - biomimetically linked multienzyme complexes - as anode catalysts. Depending on their further development, metabolon-based biofuel cells may be able to overcome today's biofuel cell limitations and close the gaps between the current technologies of enzymatic and microbial fuel cells.

Challenges and perspectives for catalysis in production of diesel from biomass

Biofuels (2011) 2(4), 465-483

A T Madsen, H Sondergaard, R Fehrmann & A Riisager

SUMMARY

Of the proposed methods for diesel production from biomass, the esterification and transesterification of plant oils or waste fats with methanol is the most prominent and has been applied industrially for a decade.

Homogenous acid and base catalysis is normally used, but solid acids, solid bases, ionic liquids and lipases are being developed. Hydrodeoxygenation of vegetable oils has likewise been commercialized.

Diesel from biomass may also be produced by a) catalytic upgrading of bio-oils from flash pyrolysis; b) aqueous-phase reforming of carbohydrates via consecutive reduction-condensation reactions; or c) gasification of biomass to syngas, and FT synthesis.

KEY POINTS

• All biomass can be gasified into synthesis gas and 'reconstructed' as hydrocarbons via Fischer-Tropsch synthesis (FT).

• Active heterogeneous catalysts are required for a) ease of purification; b) process economy; c) lowering environmental impact; d)designing efficient continuous flow systems.

• Noble metal catalysts are selective and consume less hydrogen but deactivate fast.

• Acidic or basic catalysts yield a mix of hydrocarbons via cracking, but they are easy to regenerate.

• Side reactions and deactivation behavior must be understood and avoided with most catalysts, especially when using unsaturated fatty feedstock.

• Net hydrogen consumption must be lowered, by steam reforming of the feedstock. The production of aromatics must be lowered.

• Aqueous-phase reforming is a two-phase process for reforming water-soluble carbohydrates into hydrocarbons.

Microrganisms

Engineering bacterial processes for cellulosic ethanol production

Biofuels (2010) 1(5), 729-743

Pavan Kumar, Reddy Kambam & Michael A Henson

SUMMARY

Bioethanol produced from agricultural feed stocks is renewable in nature and reduces the problem of GHG emissions associated with petroleum derived gasoline.

While most current processes for production of bioethanol are dependent on microbial fermentation of food feedstocks (e.g., corn and sugarcane), second-generation technology based on the fermentation of nonfood feedstocks (e.g., corn stover and switch grass) is under development.

Successful commercialization of bioethanol production requires an efficient microbe rapid hydrolysis of feedstock into fermentable sugars and an optimized fermentation process. This article consolidates the current state of the art in upstream processing of cellulose for bioethanol production with bacteria. Recent advances in microbial co-cultures involving one or more bacteria for efficient production of bioethanol are also discussed. The importance of engineering bacterial processes for efficient cellulosic bioethanol production is emphasized.

KEY POINTS

Genetic engineering of plant feed stocks to produce the cellulase enzymes required for ydrolysis and minimize the severity of pretreatment is under investigation.

Improved pretreatment methods for lignocellulosic feed stocks are needed to decrease ystallinity and enhance enzyme hydrolysis rates by increasing accessibility.

Engineering of ethanologenic bacteria to efficiently ferment both pentose and hexose sugars emains a very active area of research.

More fundamental understanding of hydrolysate inhibitors on bacterial growth rates and thanol productivities is needed.

Additional research on the use of bacteria that are both cellulolytic and ethanologenic in onsolidated bioprocessing (CBP) is needed.

The design and optimization of coculture systems to advance SSF and CBP technology is a romising avenue for research.

More research is needed on the development of kinetic models that enable improved nderstanding and optimization of bioethanol production processes.

Engineering microorganisms for biofuel production

Biofuels (2011) 2(2) 153-166

Parisutham Vinuselvi, Jung Min Park, Jae Myung Lee, Kikwang Oh, Cheol-Min Ghim & Sung Kuk Lee

SUMMARY

The current challenges faced in the development of advanced biofuels from cellulosic biomass include the inefficiency of the microrganisms to hydrolyze lignocellulose, incomplete utilization of multiple sugars due to the presence of carbon-catabolite repression, lack of suitable gene-expression systems for coordinating multiple-gene expression, difficulties in optimizing a synthetic metabolic pathway and toxicity of both the substrate (lignin) and the end product (biofuel) to the recombinant microrganisms.

Despite the aforementioned hurdles, potential biofuels such as short-or long-chain alcohols, alkanes, fatty acid methyl esters and isoprenoid-based fuels have been produced by metabolically engineered hosts, but with no promising, improvement in the yield. An economically feasible advanced biofuel could be possible with the recent advances in metabolic engineering, genome engineering and synthetic biology through a genetically modified microbe or a synthetic microbe with a well-defined metabolism.

KEY POINTS

enetically engineered cellulolytic hosts should also possess tolerance to different toxic npounds present in the lignocellulosic hydrolysate.

he main difficulty in developing a recombinant cellullolytic host is the recalcitrant nature of nocellulose, which requires a cocktail of three enzymes for its complete hydrolysis.

fficient use of all sugars present in lignocellulose is required for economical fuel production.

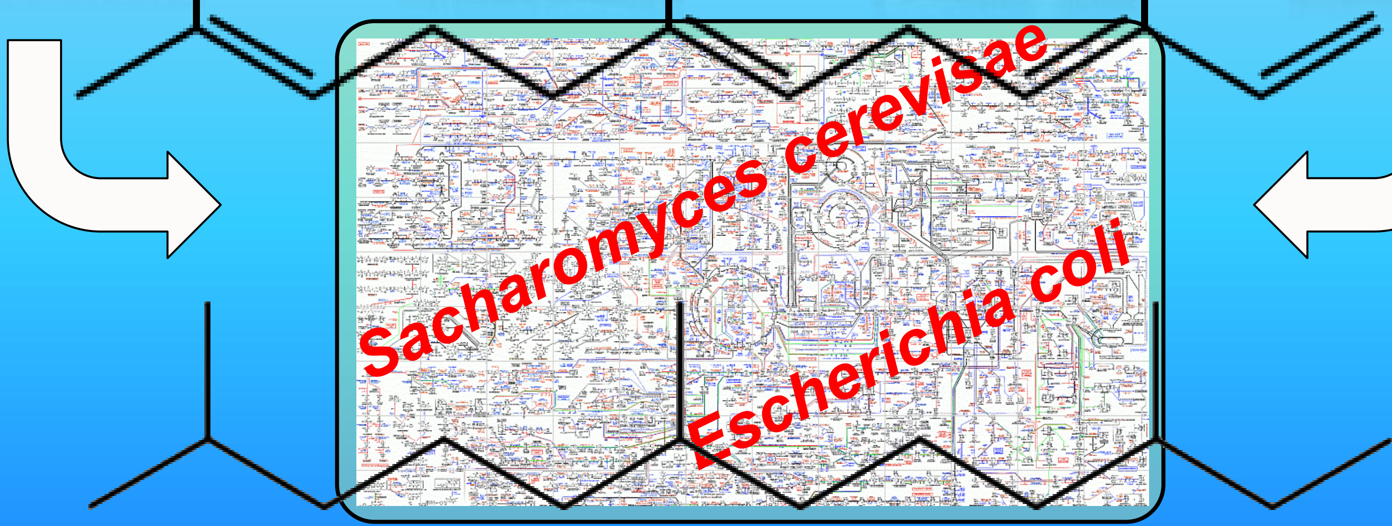
n optimized and coordinated level of gene expression, without the need for an pensive/toxic inducer, is an important requirement for industrial biofuel production.

onventional promoters have disadvantages, as requiring expensive inducers, or the need for ecialized hosts.

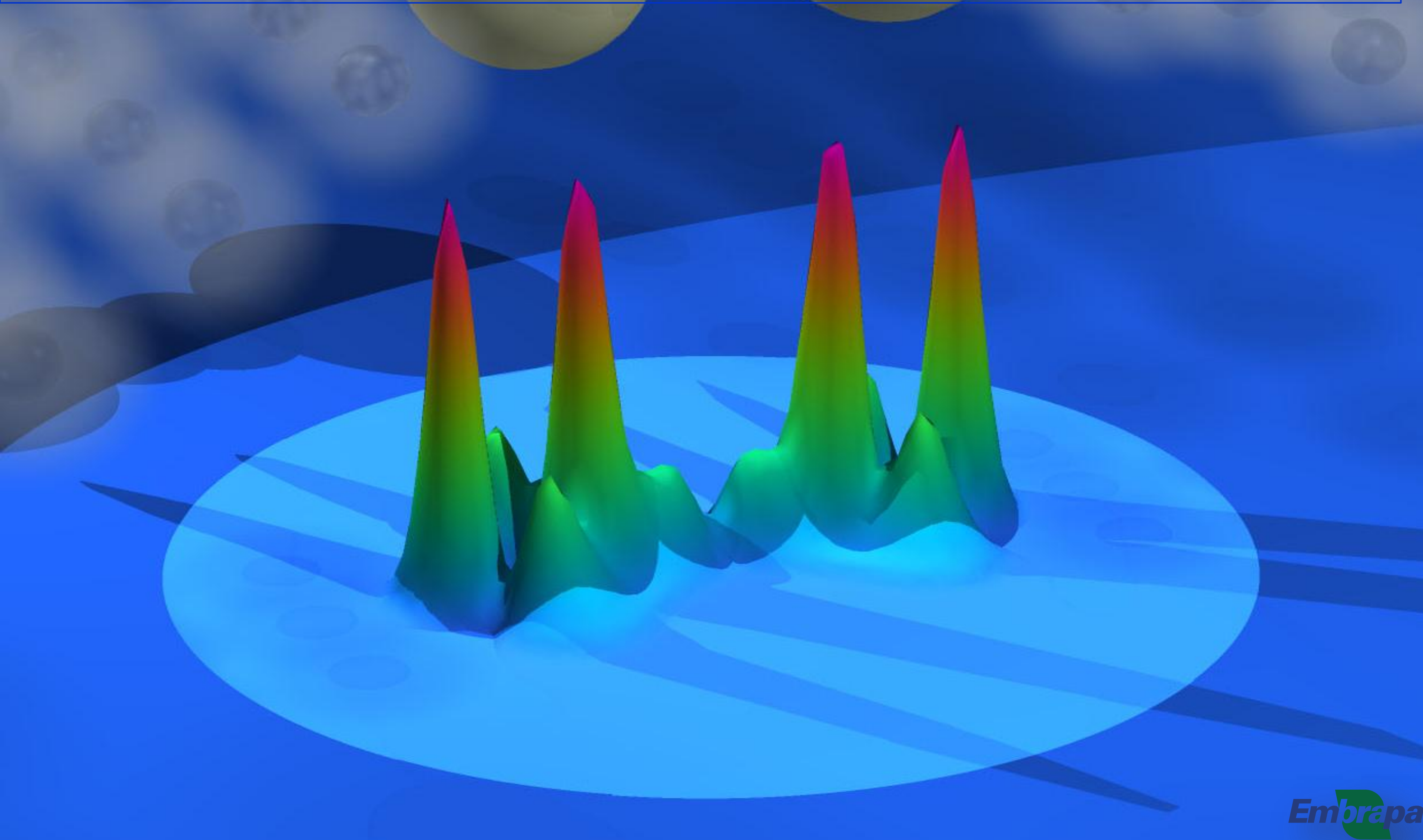
ome synthetic promoters, such as the light induced or inversion promoter system, prove emselves to be more advantageous

synthetic microbe with a minimal, well-defined metabolism, capable of performing the two jor processes in cellulosic-fuel production (expression and secretion of cellulase and oduction of biofuel), is ultimately the best option for cellulosic-fuel production

Diesel vegetal



Hydrogen



Microbial paths to renewable hydrogen production
Biofuels (2011) 2(3), 285-302
Patrick C Hallenbeck

SUMMARY

Hydrogen technologies are under intense research and development at present, to enable their future use as a fuel, in particular for the transportation sector. Whilst the engineering of hydrogen storage and use is relatively well developed, with prototype cars already on the road, a viable, sustainable means of renewable hydrogen production is lacking. A number of options for the biological production of hydrogen from abundantly available substrates, water, waste streams and, potentially, lignocellulosic materials are - available.

Thus, solar energy can either be directly converted to hydrogen in some scenarios, or fixed carbon compounds generated through conventional photosynthesis can subsequently be converted to hydrogen in others. Much is already known about the underlying biological principles, but each microbial path to hydrogen production presents technical barriers to realization on a practical scale. Here, the key limiting factors in each approach are highlighted and future perspectives for biological hydrogen production are discussed.

KEY POINTS

• Biological hydrogen production could provide a renewable-hydrogen stream, presently lacking in the development of a future hydrogen economy.

• The synthesis and molecular mechanisms of the different enzymes catalyzing hydrogen-forming reactions are now well understood, establishing a basis for the rational design of improved catalysts.

• A variety of organisms with different metabolic pathways have been shown to be capable of producing hydrogen during the breakdown of various carbohydrates.

• As a novel process, the use of microbial electrolysis cells is promising and rapidly improving, but the search is on for cheap efficient cathode materials and away to increase current densities.

• Photofermentation processes suffer from low-light conversion efficiencies, but could possibly be improved through a number of strategies, including the substitution of hydrogenase for the highly energy demanding nitrogenase enzyme.

• Efficiencies might be improved by engineering the microbes, in particular through reduction of photosynthetic antenna size.

Embrapa

Termochemistry

Production of high-value products including gasoline hydrocarbons from the thermochemical conversion of syngas

Biofuels (2011) 2(6), 677-501

Jason Street & Fei Yu

SUMMARY

This article reviews subjects dealing with the chemistry, catalytic poisoning, newer catalyst technologies and possible future solutions to increase the efficiency of creating high-value products by thermochemically converting gasified biomass (producer gas).

This article puts emphasis on bi-functional catalysts containing transition metals coupled with zeolites for renewable fuel production. High-value products such as gasoline range hydrocarbons, dimethyl ether, aldehydes, isobutane, isobutene and other olefins can be produced with gasified biomass due to the gas containing syngas (H_2 + CO).

The importance of certain process variables, such as temperature, space velocity, gas ratios, and pressure are discussed along with the importance of reactor design. The subject of the importance of the cleanliness of the producer gas, so that maximum high-value product yield can be achieved with the greatest efficiency, is also discussed.

Embrapa

KEY POINTS

- Zeolites for synthesis of gasoline-range hydrocarbon: bi-functional catalysts (no post-cracking needs) are more economic and use less energy.

- Syngas to DME – reactions take place at lower temperatures by using bi-functional catalysts

- Synthesis of isobutane & isobutane – precursors of isooctane. Hydrogenation of the CO.

- Synthesis of aldheides from syngas (oxosynthesis). Aldheides can be converted to polyvinil chloride.

- Termochemical conversion of CH_4 – Reaction of water and methane generate CO + 3 H_2

- Methane to Methanol: Possibly using solid acid catalysts or an electrochemical cell with (V_2O_5 / SnO_2) anode

Embrapa

Biomass pyrolysis for chemicals
Biofuels (2011) 2(2), 185-208
Paul de WW, Hans Reith & Erik Heeres

SUMMARY

The problems that are associated with the use of fossil fuels demand a transition to renewable sources for energy and materials. Biomass is a natural treasure for chemicals that, to date, have been made from fossil resources.

Unfortunately, the heterogeneiety and complexity of biomass still precludes exploitation of its full potential. New technologies for economical valorization of biomass are under development, but cannot yet compete with petrochemical processes.

However, rising prices of fossil resources will inevitably lead to replacement of oil refineries with biorefineries. A biorefinery uses various types of biomass feedstocks - that are processed via different technologies into heat, power and various products.

The biorefinery is self sustainable with respect to heat and power and puts no burden on the environment. Thermochemical processes such as fast pyrolysis can play an important role in biorefineries and this article presents a review of some pyrolysis-based technologies.

KEY POINTS

• Hemicellulose, cellulose and lignin react differently at various temperatures and yield a dissimilar spectra of products - can be exploited to extract value-added chemicals from biomass. The differential thermal behavior of the biomass components can be exploited via staged-thermal processing.

• Valuable chemicals can be derived from the carbohydrate fraction of biomass, like carboxylic acids such as acetic acid, in addition to furfural and levoglucosan. The lignin fraction is an interesting feedstock for production of phenolics.

• Staged degasification is a low-temperature thermochemical conversion route that generates value-added chemicals from lignocellulose in a step-wise pyrolysis approach. Higher yields and better selectivities can be obtained by further optimization of reactor conditions, application of catalysts and/or specific biomass pretreatments.

• An efficient (thermal) fractionation of biomass into a specific combination of its main constituents is a key issue in a biorefinery. Fast pyrolysis is expected to play an important role in future biorefineries, either as a central unit or as a peripheral unit to process biorefinery residues including lignin.

Gasification and synthesis gas fermentation: an alternative route to biofuel production

Biofuels (2011) 2(4), 405-419

Rachel M Slivka, Mari S Chinn & Amy M Grunden

SUMMARY

Lignocellulosic biomass has been identified among the renewable energy sources to have the highest potential to minimize dependency on dwindling supplies of fossil fuels. Conversion of this biomass to biofuels by microorganisms through direct hydrolysis and fermentation can be challenging.

Alternatively, biomass can be converted to synthesis gas (a mixture of CO, CO_2, N_2 and H_2) through gasification and transformed to fuels using microbial catalysts that can convert the CO, H_2 and CO_2 to fuels such as ethanol, butanol and hydrogen. Biomass gasification fermentation processing systems have shown promise and companies are now entering the marketplace for commercial-scale ethanol production from synthesis gas.

Isolation of new organisms capable of higher product yield, as well as functional implementation of bioreactors that enhance gas solubility for microbial fermentation, make this technology an attractive option for reducing our dependency on fossil fuels.

KEY POINTS

- Three primary reactions occur during gasification (partial oxidation, complete oxidation and water gas reaction). The gasification process results in a syngas stream with CO_2, CO, H_2, and tars at varying composition depending on biomass used, type of oxidant and reactor geometry.

- Fixed bed and fluidized bed are the two types of gasifier designs that are currently used.

- *Clostridium ljungdahlii* and *C. autoethanogenum* can convert syngas to acetate and ethanol. *C. carboxidivorons* and *Butyribacterium methylotrophicum* can convert syngas to butanol.

- Clostridia use the Wood-Ljungdahl pathway (acetyl-CoA pathway) to convert syngas to fermentation products.

- Increase ethanol yield by using nitrogen limitation, addition of reducing agents, pH shifts and addition of H_2.

Enabling cellulosic diesel with microchannel technology

Biofuels (2011) 2(3),315-324

Soumitra R Deshmukh, Anna Lee Y Tonkovich, Jeffrey S McDaniel, Lucas D Schrader, Christy D, Burton, Kai Jarosch, Anthony M Simpson, David R Kilanowski & Steve LeViness

SUMMARY

The advantages of producing transportation fuels using microchannel technology for Fischer-Tropsch (FT)-based biomass to liquids are demonstrated using the Oxford Catalyst Group's catalyst and reactor technology. Tests performed with high-activity catalysts in microchannel FT reactors across multiple scales demonstrated equivalent process performance, as determined by the metrics of CO conversion, selectivity to byproducts.

The catalyst and microchannel reactors showed excellent performance under conditions likely to be observed in a biomass to-liquids facility (e.g., low H_2:CO ratio and high dilution) and also demonstrated very good stability and excellent robustness. With these significant advantages, the microchannel FT technology is poised at the cusp of commercialization for enabling biomass derived FT fuels.

Embrapa

KEY POINTS

• Gasification followed by Fischer-Tropsch (FT) is one of the leading technologies for biofuels.

• Turn-key FT reactors are in development from several large and small technology providers. Multiple catalyst and reactor technology platforms are available.

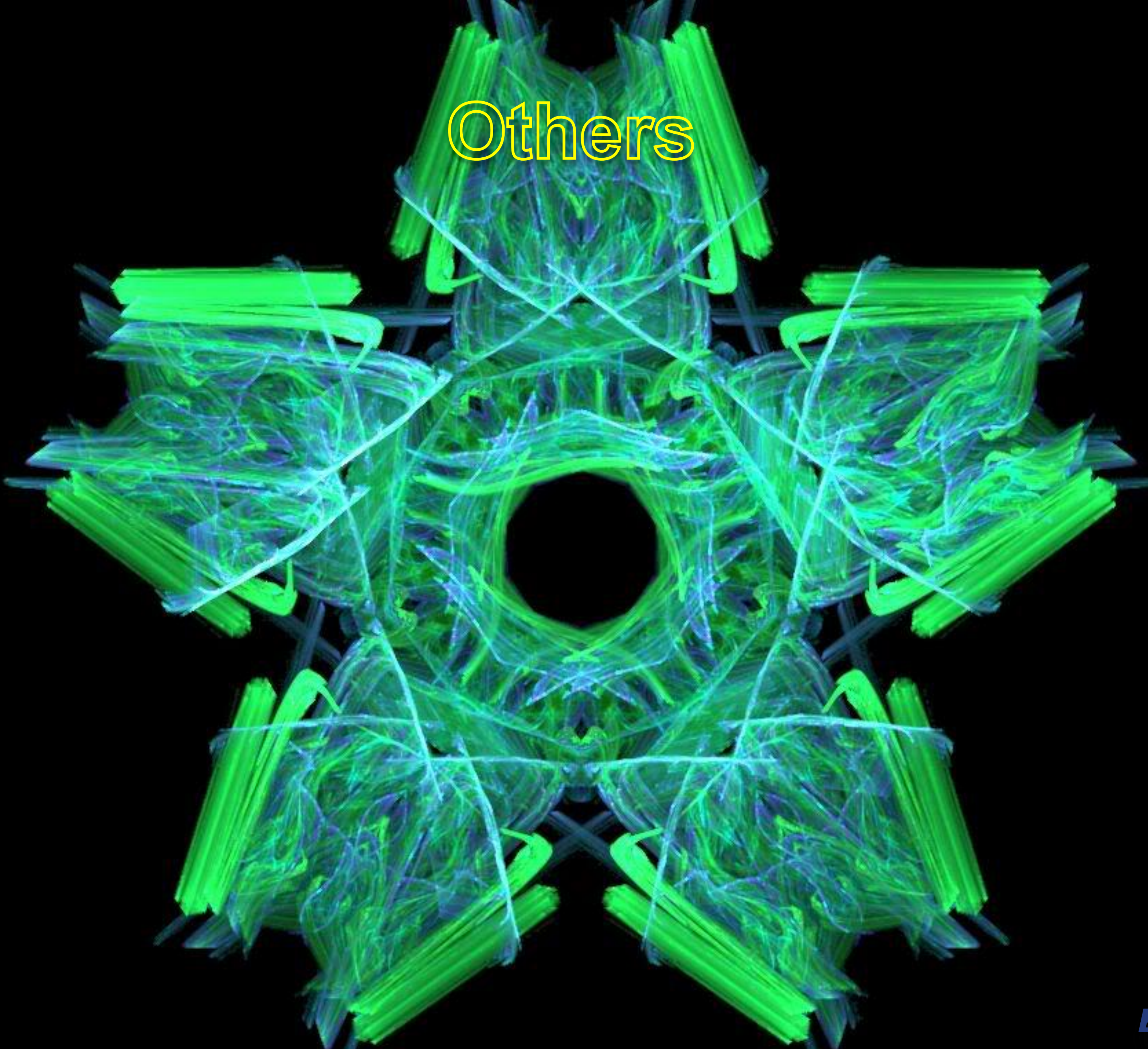
• Global development of monolithic, microchannel packed bed and microstructured FT reactors has been ongoing since the early 2000s.

• Microchannel technology allows improved temperature control, enabling near isothermal operation of the reactor, leading to reduced byproduct selectivities and lower catalyst deactivation rates.

• Microchannel technology platform drives high productivities and excellent selectivity.

• With key upcoming demonstrations, the microchannel technology-based cellulosic diesel is poised for commercialization.

Others



Artificial photosynthesis processes as a means of producing biofuels

Biofuels (2010) 1(6) 855-860

David W Wendell

SUMMARY

The transition to a sustainable and scalable energy system will require the development of new carbon neutral fuel technologies. Artificial photosynthesis seeks to meet this need by mimicking the biological energy conversion process, producing biofuels from sunlight.

While the process of photovoltaic conversion has existed for almost two centuries, the idea of artificially engineering the biological process has been a relatively recent advancement brought about by the exposed molecular workings of cellular-based energy conversion and storage.

The following report examines the benefits and limitations of the current artificial photosynthesis strategies developed for storing solar energy as biofuel

Embrapa

KEY POINTS

• Water oxidation catalysts must be integrated with photosensitizers and proton reducers to be useful as biofuel producers.

• Efficient coupled enzyme and water oxidation catalysts (WOC) must be maintained for useful biofuel production using either strategy.

• WOC artificial photosynthesis must also address hydrogen gas storage.

• Enzyme artificial photosynthesis must be able to obtain inexpensive biological components, most likely by coupling the process to conventional biomass biofuel synthesis.

• Water oxidation catalyst self-repair is essential for useful lifetimes in the harsh oxidizing environment.

Bacterial biofilms: the powerhouse of a microbial fuel cell

Biofuels (2010) 1(4), 589-604

Ashley E Franks, Nikhil Malvankar & Kelly P Nevis

SUMMARY

Research in the field of microbial fuel cells has exploded in recent years and is providing insights into the specialized biological processes that occur within these systems. Fundamental to the functioning of a microbial fuel cell is the formation of highly specialized bacterial biofilms on the electrode surface.

While many different bacterial species have been found to associate with electrodes, to date only a few have been isolated in pure culture with the ability to produce a high current density.

One such species, *Geobacter sulfurreducens*, is speculated to form an electrical conductive biofilm capable of electron transfer across a considerable distance. The mechanisms for electron transfer across such distances are only just being understood and may involve a matrix of bacterially produced nanowires and/or C-type cytochromes, but limited due to proton accumulation.

Evolutionary and genetic engineering studies are now being employed to increase power output on a per cell basis with differing degrees of success.

KEY POINTS

• Microbial fuel cell technologies are currently limited to low-power applications.

• Bacterial biofilms are essential to high current-producing biofilms.

• Bacterial produced nanowires and cytochromes are important for extracellular electron transfer.

• Electrode associated biofilms can form a conductive networks capable of long-range electron transfer but the exact mechanisms of this remain unknown.

• The entire current-producing biofilm is metabolically active but is inhibited by proton accumulation and other unknown factors.

• Strain evolution studies have seen the largest increase in power production at a microbial level.


Obrigado!