



ABENGOA

Technology, Our Leading Edge

Panel



Prof. José Domínguez Abascal

CTO, Abengoa

Hank Price

CTO, Abengoa Solar NT

Gerson Santos

EVP, Abengoa Bioenergy NT

8th Annual **Analyst and Investor Day**

April 3 & 4, 2014

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1

Technology: Abengoa's competitive advantage



2

Abengoa Research: the core of Abengoa's R&D



3

From lab to market: key success stories
Concentrated Solar Power



4

From lab to market: key success stories
Bioenergy technology



5

Key takeaways



1

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Key takeaways



R&D Allows Abengoa to Develop Competitive Advantages as Compared to its Competitors

R&D

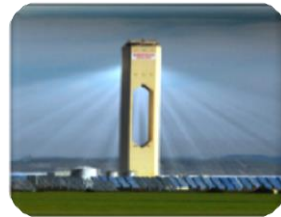
Technological leadership

Access to financing

New projects

Cooperative environment

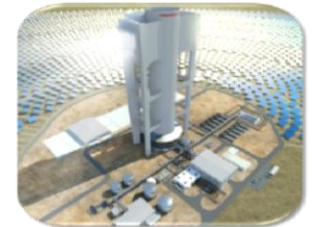
ABENGOA RESEARCH



Proven proprietary, cutting-edge technology



Financing entities motivated to fund technological projects



Winning projects with new technology. New clients, new markets



R&D Focus on Commercial Results

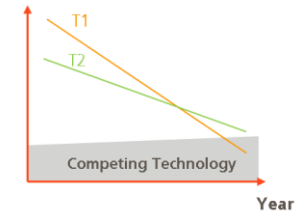
Management of the technological strategy and R&D projects is done, based on its **competitive value contribution to Abengoa**, using 3 tools:

TechValue:

Technology and R&D
Competitiveness
Value Assessment

Identify and focus R&D as a competitive advantage creator for Abengoa. A roadmap is identify for each technology

- Main Indicator :**
- LCOE (\$/kWh)
 - Water produced (\$/m³)
 - Biofuels (\$/m³)



R&D-V:

R&D Value

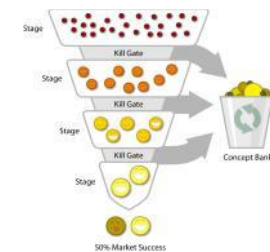
Value creation assessment R&D projects and the R&D portfolio, for current and future Abengoa's markets



S-G:

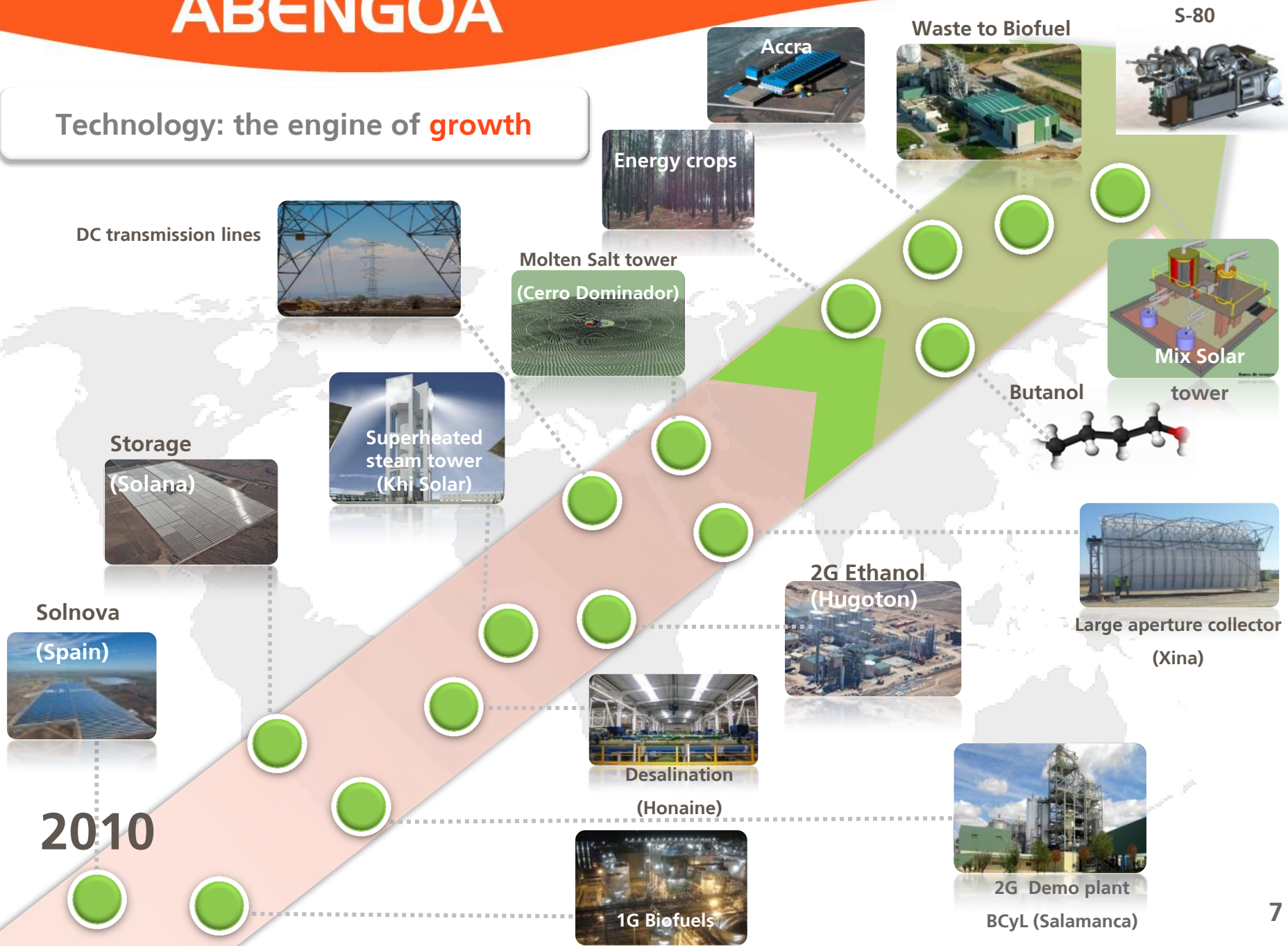
Stage-Gate

R&D projects management



ABENGOA

Technology: the engine of **growth**



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AR is the Main Technological Lever that Places Abengoa as Leader in the Energy and Environmental International Markets

✓ Produce knowledge to develop new technology

- R&D for **technologically advanced products** and **processes**
- R&D for **breakthrough products** and **processes**
- R&D to **generate new technological business** for **Abengoa**

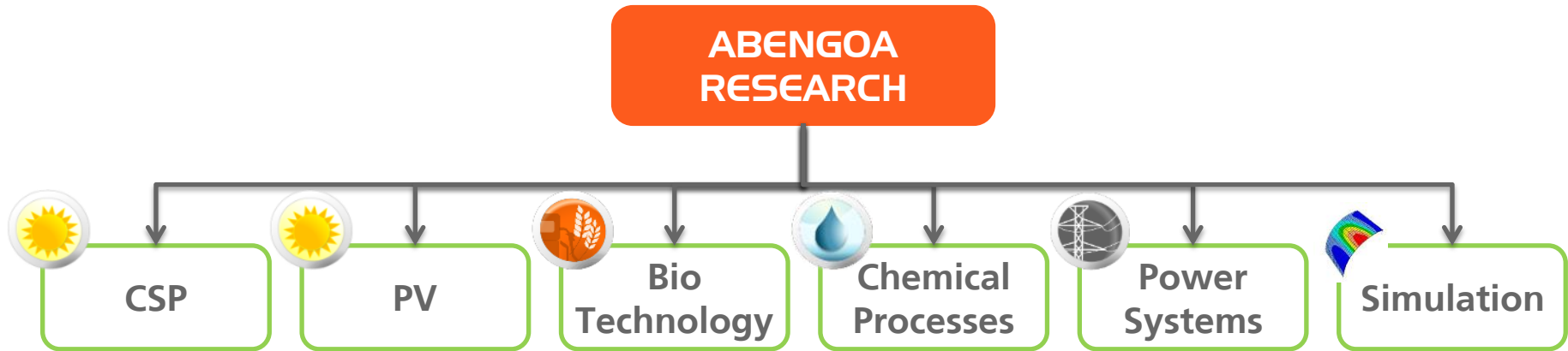
✓ Provide support for industrialization of the technologies

✓ Define the **technological strategy** aligned with business strategy

✓ Carry out **technological surveillance** and **IP management**



One R&D Structure within Abengoa with Abengoa Research Leading the Efforts to Develop New Knowledge and Technology



R&D Centers



Solucar Platform
Solar (Seville, Spain)



York pilot plant
Bioenergy (Nebraska, USA)



R&D center
Water (Seville, Spain)



Campus Palmas Altas
(Seville, Spain)



Soland R&D Center
Solar (Seville, Spain)



W2B demo plant
Bioenergy (Salamanca, Spain)



Membrane lab
Water (Bilbao, Spain)

Cutting Edge Technology in Both CSP...

CSP



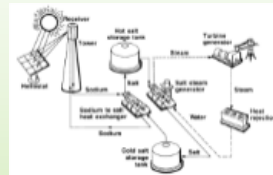
Superheated steam tower



CCP + molten salt storage



SpaceTube®



Receiver Na-K



CC + Molten Salt Tower

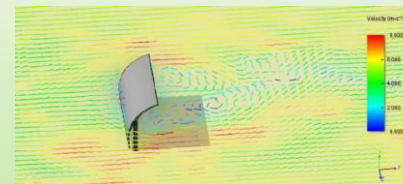


Molten Salt Tower Plus

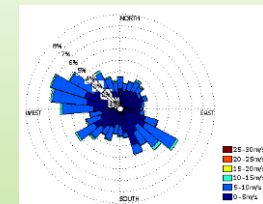
Solar fields

Optimize structures subject to wind loads

- Improve virtual wind generator
- Support in parabolic trough and heliostats wind load calculations
- Wind mitigation strategies



Instantaneous velocity vector field at vertical and horizontal cutting planes for pitch 210°



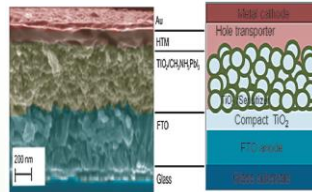
Wind directionality

...and PV

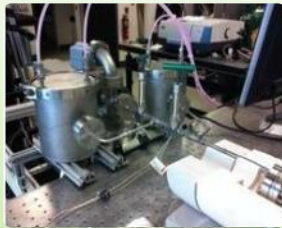
PV



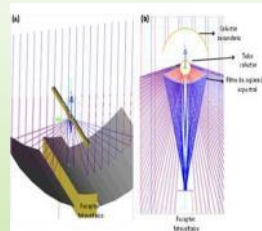
HCPV



ss_DSSC



CIGS

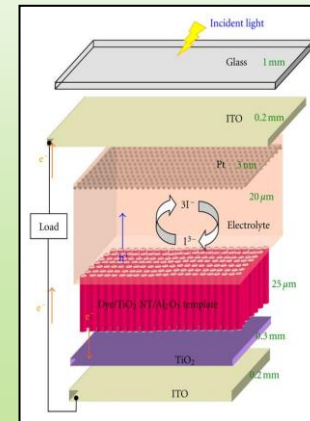


CSP + PV

New material for PV cells: Perovskite

High efficiency cells

- Reduce current costs
- Solid HTM instead current liquid
- Improvement of the deposition process



Leading the Development in Biotechnology...

Biotechnology



2G ethanol



2G Brazil



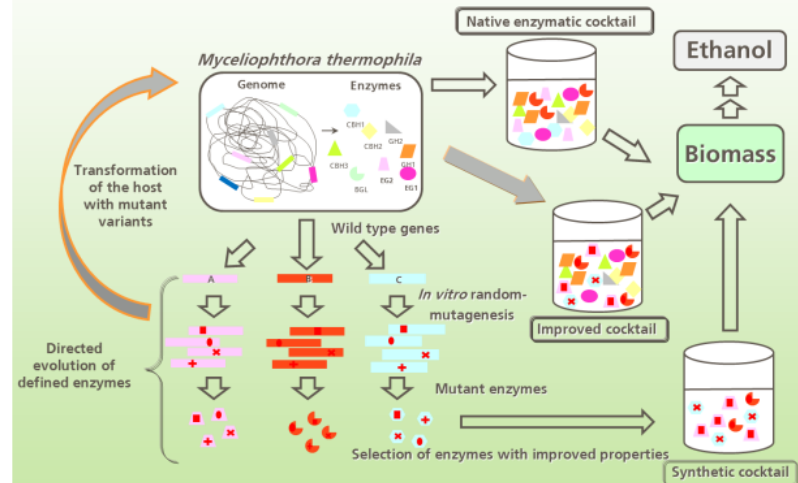
Enzymes



W2B

Myceliophthora thermophila C1

Genetic programs in enzymes

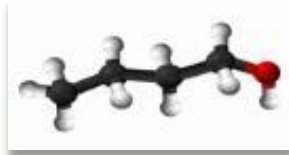


...and Physical-Chemical Processes

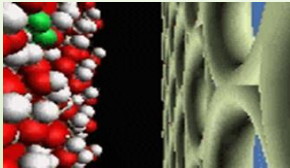
Physical-Chemical Processes



Butanol



Bioproducts



MF-UF membrane



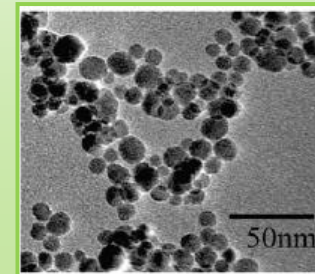
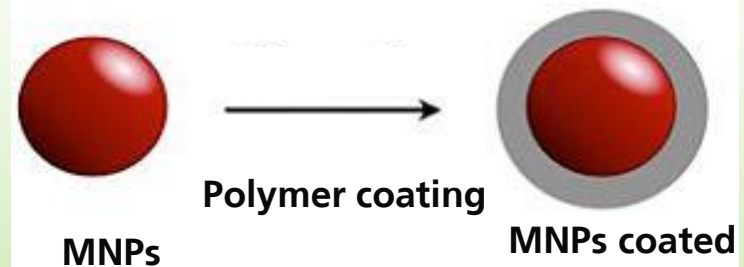
Desalination plant



S-80

Magnetic Nanoparticles for forward Osmosis

Magnetic Nanoparticles (MNPs) coated with Superhydrophilic Polymers as Draw Solute in Forward Osmosis



One Step Ahead in Power Systems...

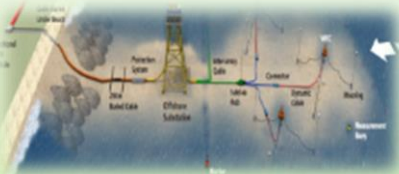
Power Systems



DC and AC transmission lines



Electricity Storage



Wave Energy Converter



VSP

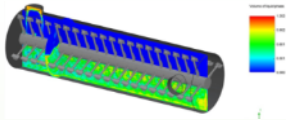
SPC for grid-friendly power plants

A controller that allows power converters to behave as an enhanced synchronous generator



...and Simulation

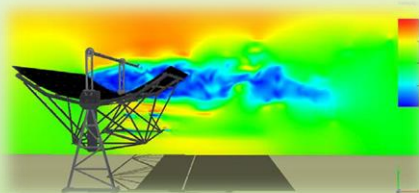
Simulation



Mixing



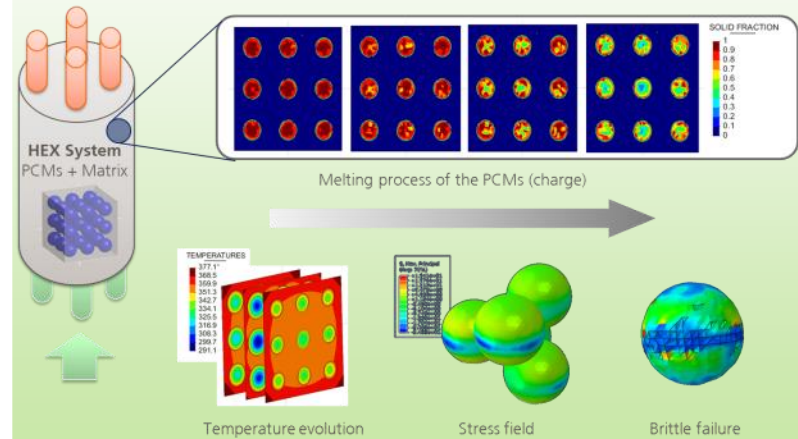
Smartcatal












Solar Field

Virtual design of structured materials

Multiscale and multiphysical characterization (e.g. encapsulated PCMs)



Abengoa's technological targets

	 Solar	 Desalination	 Water
Target	Competitive with CCGT by 2020	Decrease energy consumption to ~0.6 kWh/m ³	Development of proprietary methodology for membranes
	 2G Bioethanol	 Waste to biofuels	 Bioproducts
Target	Competitive with oil at \$100/barrel in 2-3 years	Ethanol production from MSW in commercial plants from 2016	Be competitive in the production of bioproducts from biomass in 2020
	 Hydrogen	 Energy Storage	 Energy Crops
Target	Co-generation plants based on fuel cells by 2016	Energy storage plants by 2016	Sustainable energy crops with genetic traceability in 2020.

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Abengoa Research: the core of Abengoa's R&D



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From lab to market: key success stories
Concentrated Solar Power



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Bioenergy technology



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Key takeaways



CSP is a solar technology that uses concentrated light from the sun to power a conventional power plant

- The power cycles are similar to those used with coal, natural gas or nuclear plants
- Abengoa has developed a portfolio of CSP technologies.
- Abengoa is the world leader in deployment of CSP technologies



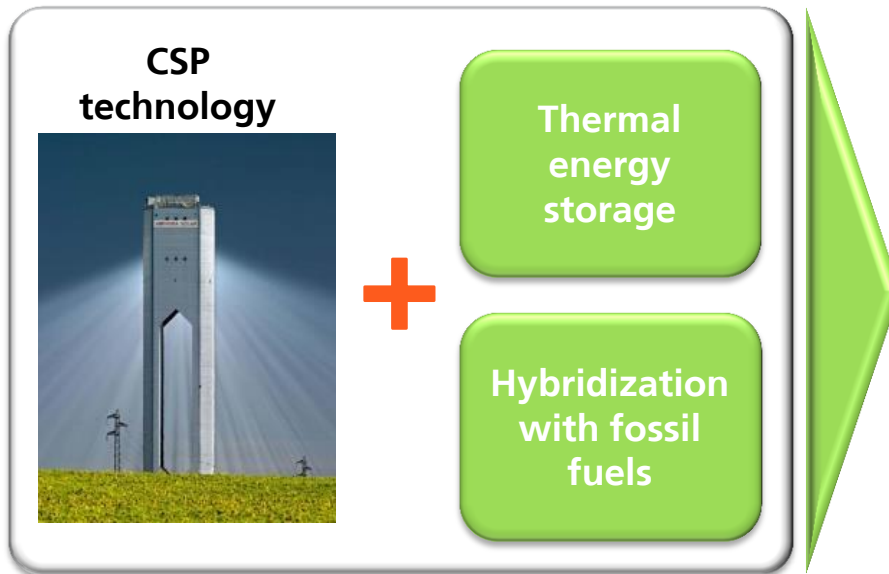
Tower: 11 MW PS10



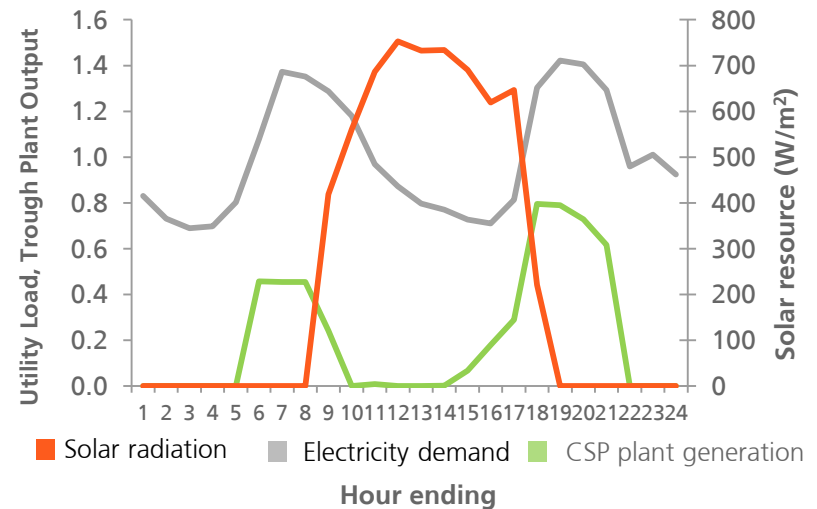
Parabolic Trough: 280 MW Solana

Why is CSP important?

- CSP can integrate thermal energy storage or be hybridized with fossil or bio fuels
- Power can be generated when needed (dispatchable)
- Allows solar plants to be designed to provide peaking or baseload power
- As renewables share in the energy mix becomes higher, CSP's dispatchability becomes more necessary and valued



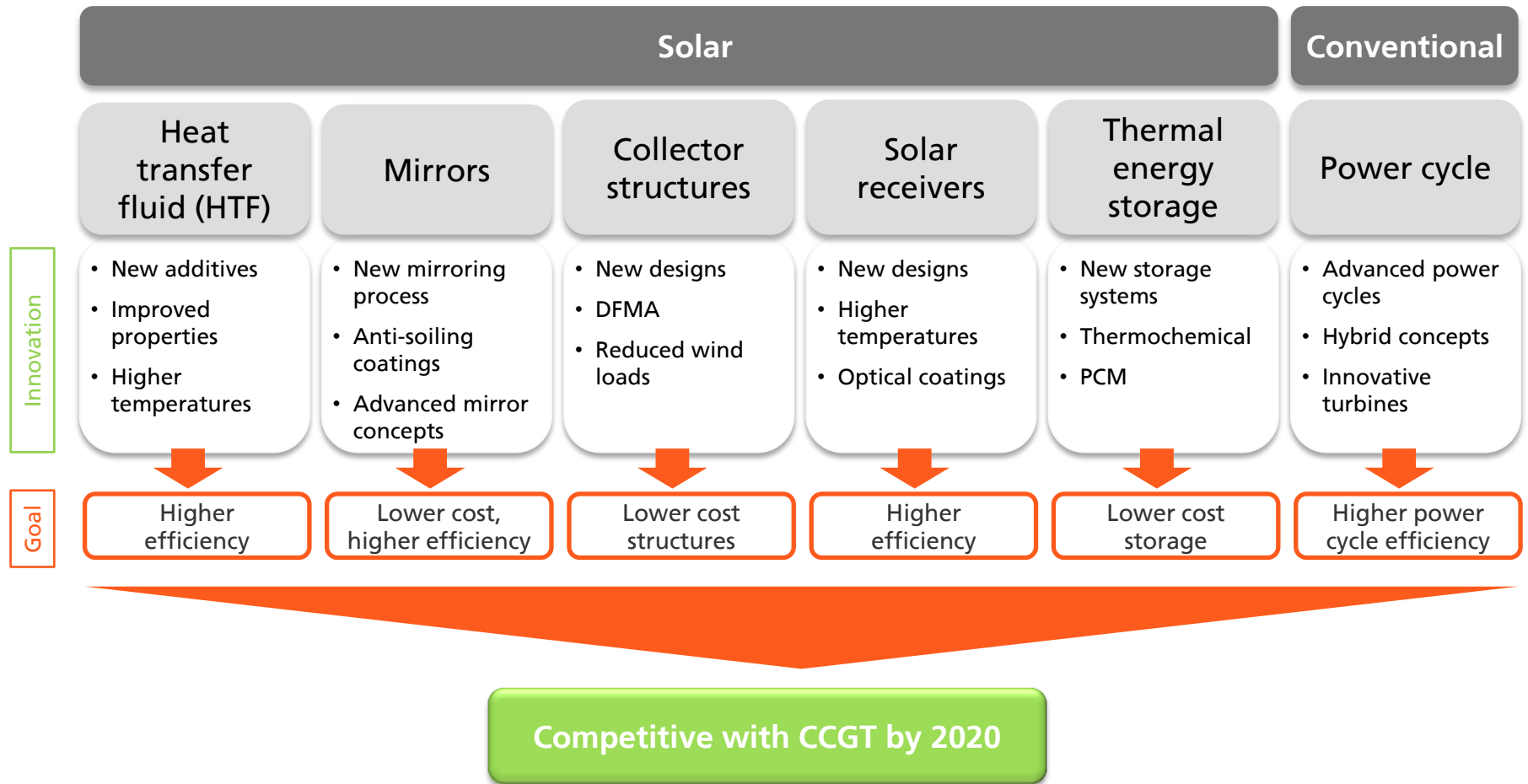
Abengoa's Solana plant in Arizona will use thermal energy storage to dispatch solar power to meet the APS winter peak.



NREL* estimates the value of dispatchability adds up to 5 cents/kWh relative to non-dispatchable energy sources

(*) NREL study "Tradeoffs and Synergies between CSP and PV at High Grid Penetration"

Technology cost reduction vectors



Other key opportunities for cost reduction include: supply chain, scale, and learning.

For Abengoa, Innovation and R&D Pilot Projects Are the Basis for Technology Competitive Advantage and the Future for CSP

R&D

- +100 in-house researchers
- R&D center in Denver, US
- R&D center in Seville, Spain
- Abengoa Research
- Collaboration with key research institutions and companies worldwide

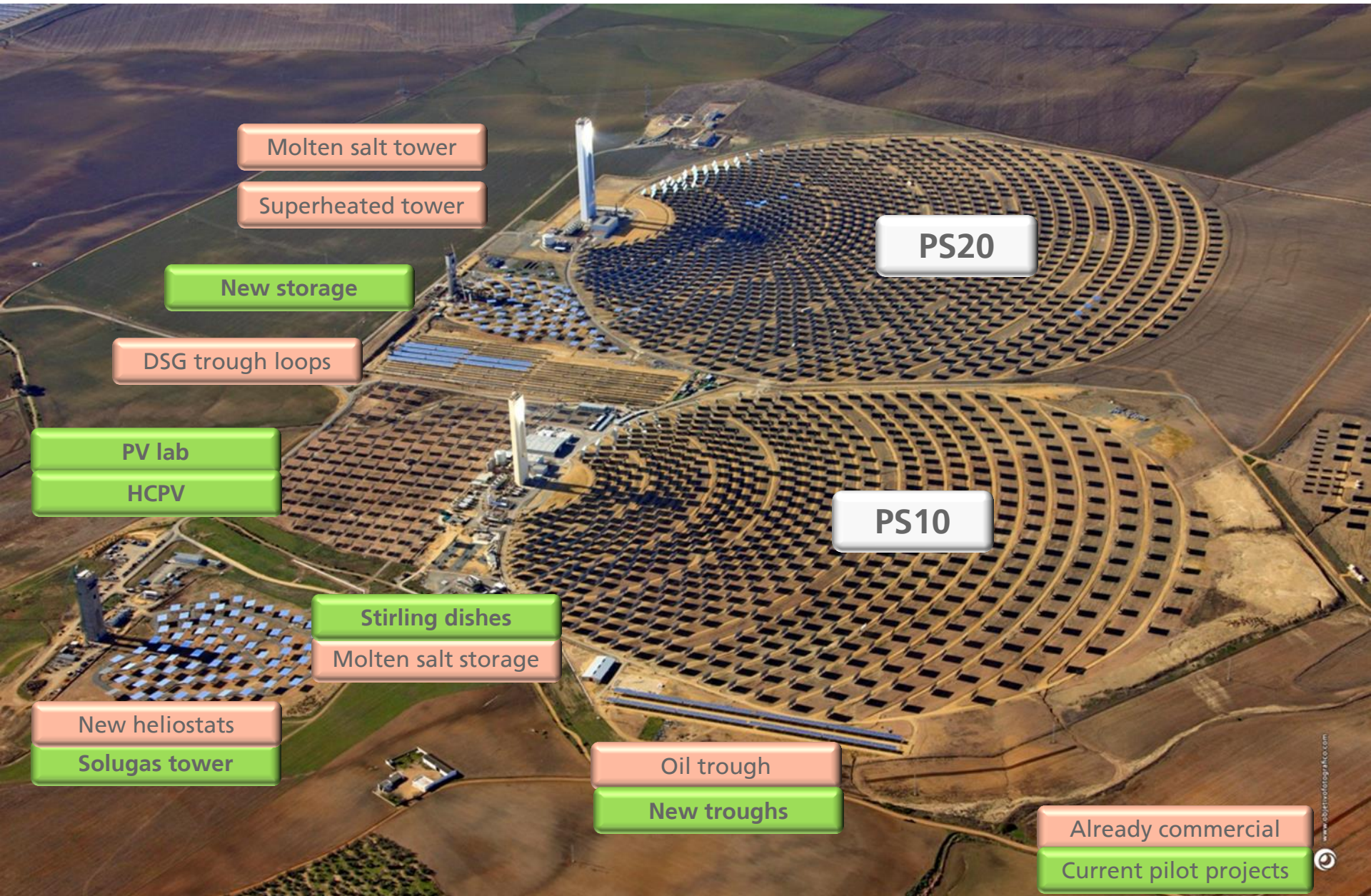


Pilot plant



Commercial project





Molten salt tower

Superheated tower

New storage

DSG trough loops

PV lab

HCPV

Stirling dishes

Molten salt storage

New heliostats

Solugas tower

Oil trough

New troughs

PS20

PS10

Already commercial

Current pilot projects



R&D

- R&D on superheated receivers and heliostats
- Technological background PS10, PS20
- Operational steam tower experience

Pilot plant

- Receiver (3MWth) at 530 °C and 90 bar
- Operation over two years
- Learning and feedback for commercial design



Eureka

Commercial projects

- South Africa awarded 50 MW project (!Khi Solar One)
- Developing engineering for larger sizes



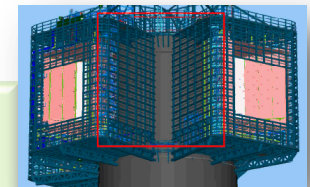
PS50 Khi



PS10

Technology:

- higher efficiencies than saturated steam PS10-PS20 towers
- improves Rankine cycle efficiencies (above 40 %)
- reduces water consumption
- includes 2 hours steam storage
- 3G heliostats can operate over distances >1.5 km



R&D

- Technological background
 - US DOE molten-salt development
- DOE Baseload FOA grant
- Leverage steam tower experience



Salt Receiver Design

Pilot plant

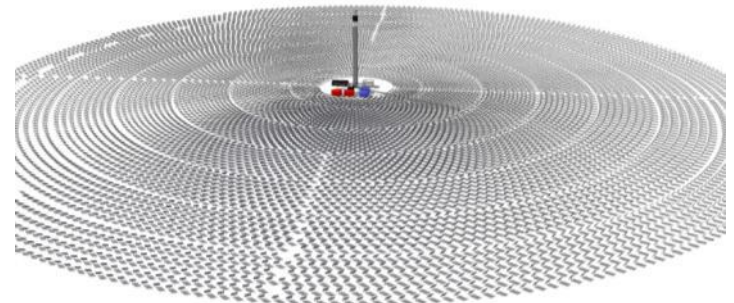
- Molten-salt receiver (5MWth) at 565 °C
- Operating over two years
- Learning and feedback for commercial design



Salt Receiver Test

Commercial projects

- Chile awarded 110 MW project w/ 17.5 hours of storage (Cerro Dominador)
- Baseload power supply for mining operations

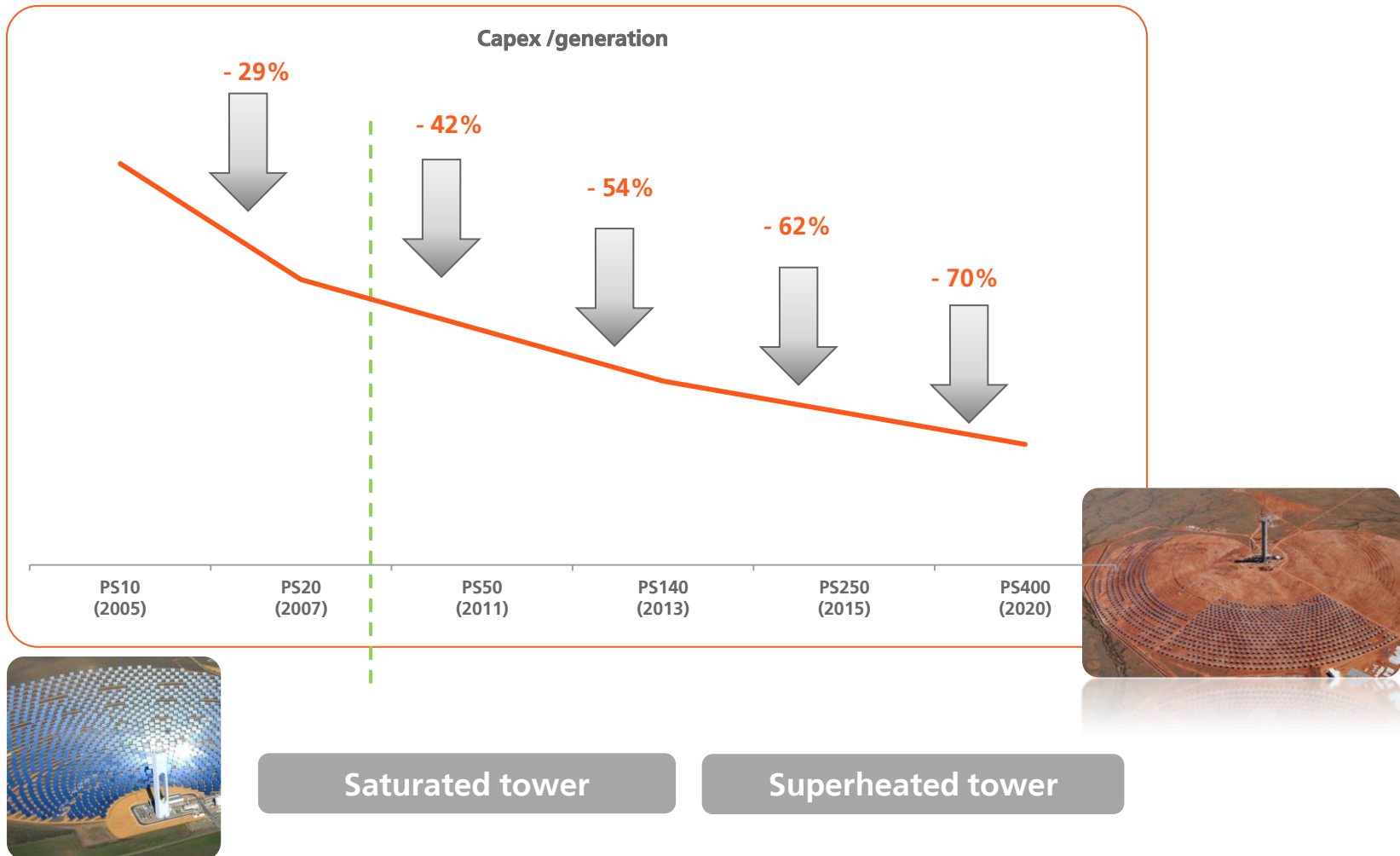


Cerro Dominador plant design

Technology:

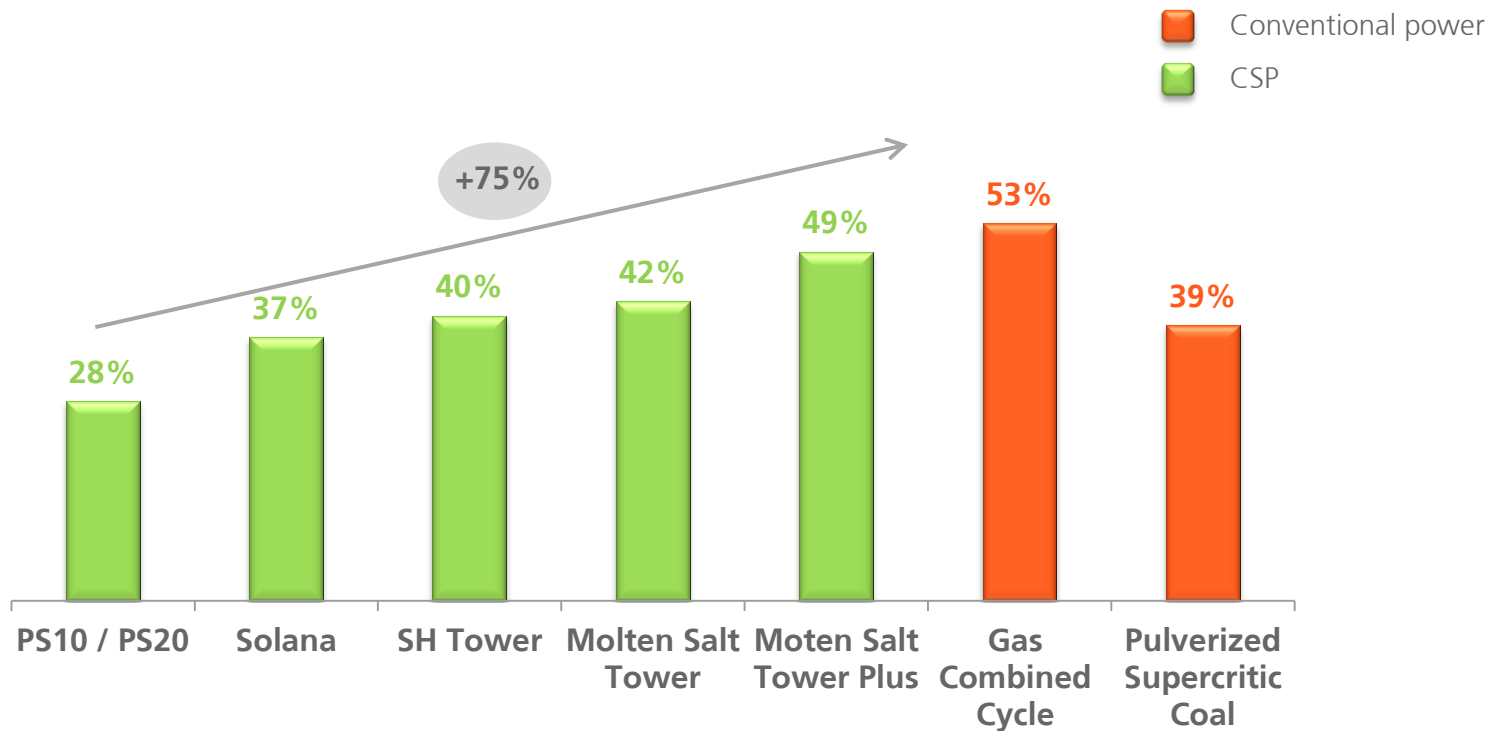
- integrates low cost, efficient thermal energy storage
- storage capacities of greater than 18 hours possible
- uses efficient dry cooled steam cycle
- allows full dispatchability of solar generation
- plants can be designed to provide baseload power

We Have Followed our Predicted Roadmap and Will Keep Reducing Costs According to it



Proven performance improvements approaching competitiveness

CSP efficiency evolution and comparison with combined cycles



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Abengoa Research: the core of Abengoa's R&D



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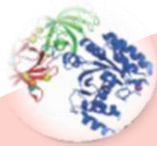
Key takeaways



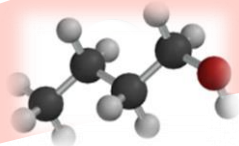
Abengoa Bioenergy Technology



2G Enzymes



W2B



Butanol



2G Brazil



2G Ethanol

Abengoa Bioenergy uses its **Technology** as an engine of growth for its **new business model**

2G: A Revolutionary Solution

Making our Technology Plan a Reality



Demo Plant Salamanca



Pilot Plant York



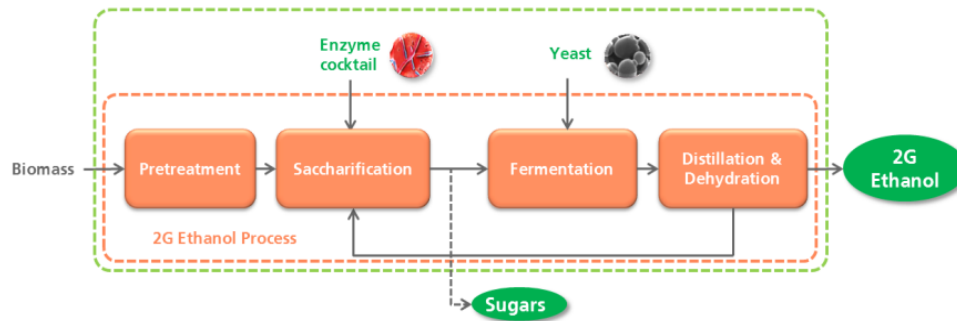
Bench scale Salamanca

Abengoa Bioenergy have demonstrated our ability to **scale-up** the 2G process

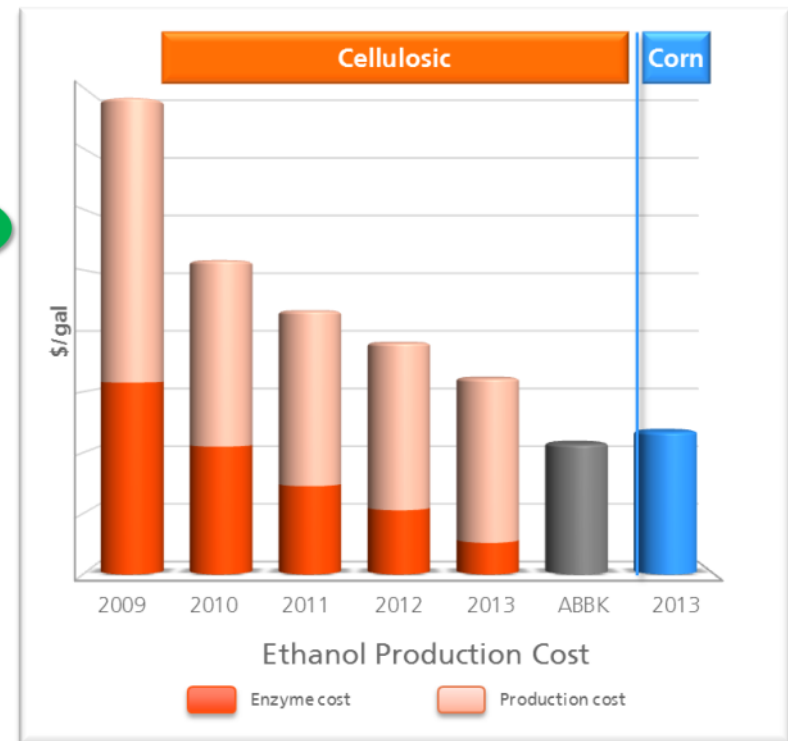
2G: A Revolutionary Solution

Making our Technology Plan a Reality

Abengoa Bioenergy provides an integrated technology package able to produce **biomass derived sugars, biofuels, and bioproducts**

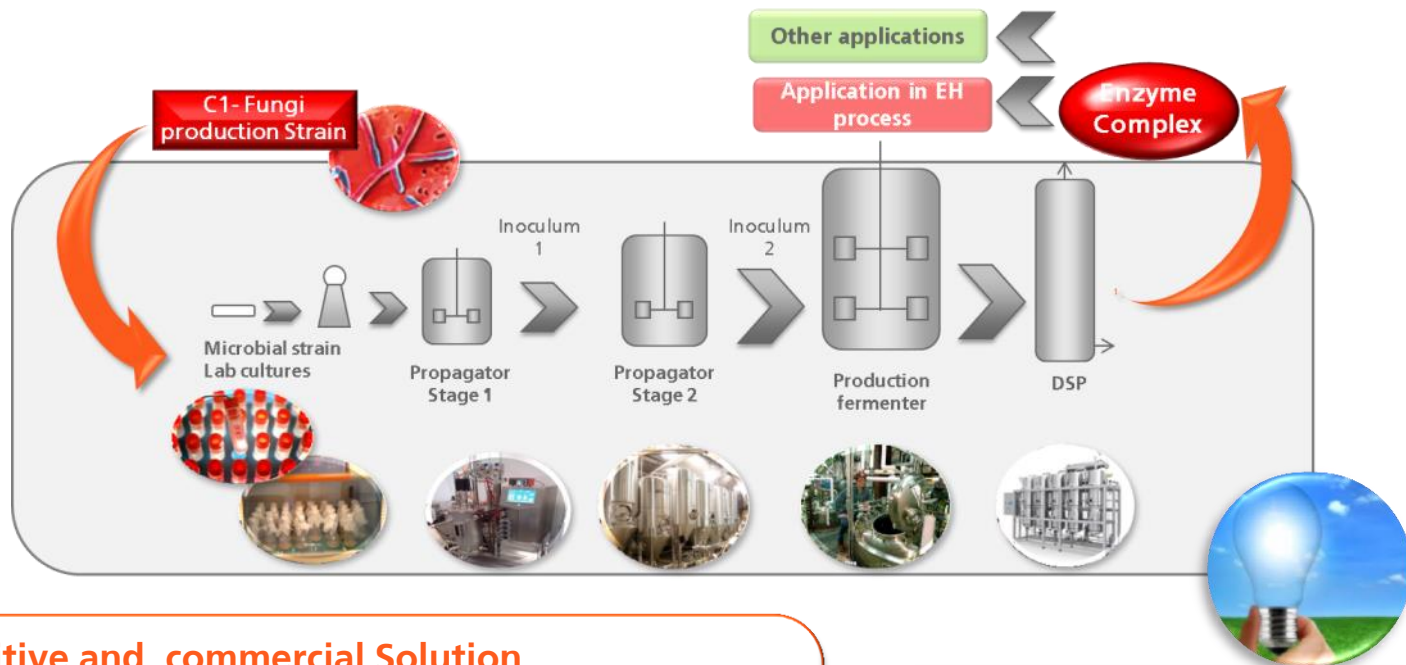


Our 2G biomass to ethanol technology is becoming **competitive** with the 1G due to our **R&D** investment



Cellulosic Enzymes a Reality

Abengoa will supply an integrated competitive 2G solution for the Hugoton Project



Competitive and commercial Solution

- ✓ We have demonstrated our production technology at 190 m3 scale
- ✓ We are supplying under commercial conditions our Hugoton plant.

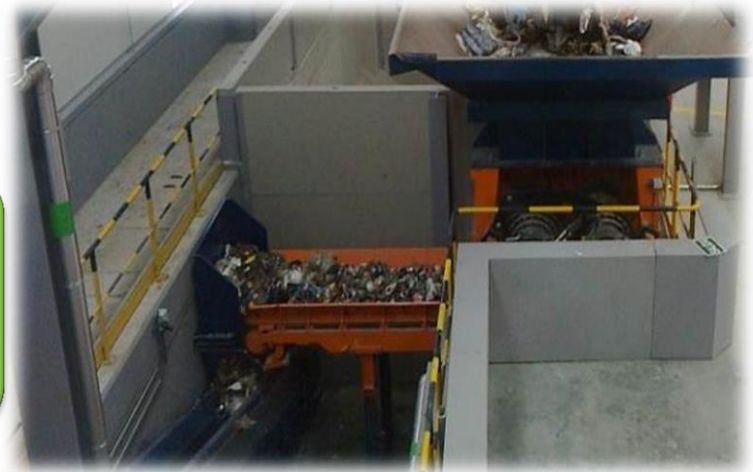
From a sole biofuels player to global biotechnology solution supplier. Product diversification through technology

Coming to Reality: Waste to Biofuel



Two birds with a stone...

A disruptive **solution** for densely populated areas, solving **waste management problems** and contributing to **energy supply security**



W2B demonstration plant **has initiated operations**; grand opening was made in **June 2013**

Coming to Brazil: A proven 2G solution

2G Ethanol is a solution to increase ethanol production capacity without increasing sugarcane plantations using & underutilize biomass resource.



Lower Capex,
lower Opex



330.800 tones of straw to be harvested (2/3)

New solution for 1G plants



Adaptation of 2G solution to 1G facilities to increase capacity at competitive cost.

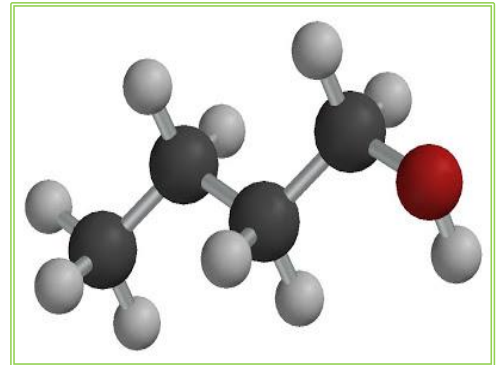
Biomass to Ethanol

Butanol a value added biobased product

Abengoa has developed an innovative technology for the production of n-biobutanol using ethanol as a feedstock

Diversification through technology

- ✓ A proven heterologous catalyst
- ✓ Demonstrated at bench, pilot, and demo scale
- ✓ A competitive biobased solution for the chemical markets



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Abengoa's Growth Driven by R&D and Technology

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Technology as a growth engine, source of competitive advantage



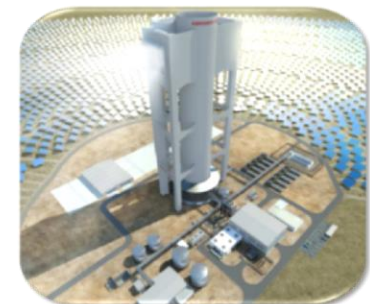
2

Efficient technology management not to lose the focus on the target: deliver attractive returns to shareholders



3

New markets opportunities and growth driven by our technology



Abengoa is a technological company with proven solutions for energy and environment: solar, biofuels, biochemical, water markets...



Thank you

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