Making solar the cheapest form of energy



Jon Bøhmer Founder & CEO Product designer, inventor, social entrepreneur











Memes Networks 2011





World Energy Production



Some countries must undertake massive switch from fossil Others have massive underserved demand

Solar potential of Africa







South Africa has world-class solar resources

Growth in renewables in Africa



Frost and Sullivan, 2011

Choosing Energy Sources KYOXO

	Solar	Wind	Geo	Hydro	Coal	Diesel	Nuclear
Heat	V	-	V	-	V	V	
Electricity	/		/	V	V	V	~
Deforestation	V	_	_	-	×	-	-
Climate Change	V		/	X	X	X	~
Import reliance			/	V	V	X	×
Water scarcity	V		-	X	X	/	×
Peak Oil			/	V	-	X	
Safety	V		/				×
Resource scarcity			/	×		X	_
Price uncertainty			/	V		X	_
Distributed energy			×	×	-		×
Local manufacturing			-	-	-	-	X
Cost			/		V	_	×
Total	+13	+11	+8	+2	+1	0	-2



Solar energy can be very simple

Kyoto Box - \$25





"There is nothing new under the sun" - Ecclesiastes 1:9-14



The first known mirror - made from obsidian Turkey, 8000BC





Augustine Mouchot's Solar Printing Press, Toulouse, France 1888





KYOZO

"Some day some fellow will invent a way of concentrating and storing up sunshine." Thomas Edison, 1910





Professor Ciamician Pioneer of Photochemistry

New York Lecture 1912

"On the arid lands there will spring up industrial colonies without smoke and without smokestacks; forests of glass tubes will extend over the plants and glass buildings will rise everywhere; inside of these will take place the photochemical processes that hitherto have been the guarded secret of the plants, but that will have been mastered by human industry which will know how to make them bear even more abundant fruit than nature, for nature is not in a hurry and mankind is.

And if in a distant future the supply of coal becomes completely exhausted, civilization will not be checked by that, for life and civilization will continue as long as the sun shines! If our black and nervous civilization, based on coal, shall be followed by a quieter civilization based on the utilization of solar energy, that will not be harmful to progress and to human happiness".



ΚΥΟΧΟ





Our innovation process



Kyoto Design Criteria

Low cost

- Robust
- Commodity materials
- Container transportation
- Simple in-field assembly
- No digging or leveling
- No cranes or power tools





Development Timeline A 10+ year journey

\$1.5M invested to date

\$1.0M \$5.0M

ldea and experimentation	Design 7 form factors	Prototyping Test Deployment
2000	2005	2012 2013
The second secon	e form factors explored	



Parabolic cooker with fiberoptic transport 2000





Dish concentrator with Cassegrain secondary 2006









2009 Mosaic optic with movable secondary





Heliostat / Tower



KXOXO

Large scale - 50MW Large heliostats -100m2 150m towers

Introducing Butterfly Solar Farms

ALC: N



Butterfly Heliostat

2,5m² 25kg

Low cost

KYOXO

- Made from plastic and aluminum
- Light weight, high precision tracking
- Made in existing local factories
- The complexity and size of a bicycle





Butterfly Heliostat

2,5m² 25kg

No steel, glass or concrete
Simple in-field assembly
No digging or leveling
No cranes or power tools



BM

Mirrors

Plastic substrate

KYOTO

- 3M mirror foil laminated
- Unbreakable, light weight





KyotoGear



Traditional

- Dual axis gear
- Complicated
- Not easy to mass produce



- Wheel and axle
- Plastic gears
- Triple worm gears
- 15 000:1 ratio
- Low cost motors



Heliostat Controller



Utilizing the latest advances in motion sensing
Compass, gyro
Extreme precision at low cost
Solar powered, no field wiring



Heliostat Controller

- Wireless mesh communication
- Mobile phone control
- Targeting
- GPS, time input
- Errors, status, controls





Heliostat Costs, \$/m²



Complete value chain re-engineering

Butterfly Field Layout





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25m tower (pole) with 100 heliostats = 50kW module

KTOYO

Butterfly Field Layout

	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Electr
10	0 Heliostats				HOT W
			· · · · · · · · · · · · · · · · · · ·	********	
	<u><u>+</u></u>	<u> </u>	<u>±</u>	<u> </u>	

1MW field 7 acres

The Butterfly Receiver



38.5% efficiency



KYOXO

Array of high-efficiency CPV solar cells with water cooling (Co-Gen)

The Butterfly Receiver

KYOX0



Array of high-efficiency CPV solar cells with water cooling (Co-Gen)



Scissor Mast



Efficiency vs temperature



Efficiency (%)

Heat for important tasks:







 Co-generate electricity, drinking water and salt

KYOXO

- Grains, vegetables, fruits, meat, fish
 Extend shelf life to 3 years
- Reduce size/weight by up to 90%
- 50% of crops rot and are not consumed

- Freezers for slaughterhouses
- Cooling of milk for dairy farms

Desalination using waste heat **KYOXO**



Memstill plastic modules



Cooling using waste heat





Ammonia absorption

Slaughterhouses, dairy production



Energy storage



MW-size grid batteries Zinc-Air or Sodium-Ion



Low costs Off-grid comparison, US cents per kWh



Butterfly





South Africa



Currently over 20 companies and institutions involved







Butterfly is 100% manufactured in South Africa and can employ unskilled labour to achieve unprecedented scale





South Africa Research Partner



UNIVERSITEIT STELLENBOSCH UNIVERSITY



SOLAR THERMAL ENERGY RESEARCH GROUP



Testing, performance evaluation, CSP Cycle

Free is the Sun

Kyoto Energy Ltd, Box 234, Thika, Kenya Phone: +254 725 834 494

email jon@kyoto-energy.com