

**STRATEGY
RESEARCH**

CHINA'S GREEN AMBITION
March 2017

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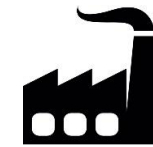
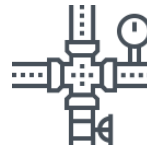
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RAYMOND FUNG

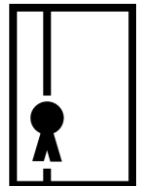
SPEAKER PROFILE

- 2015/09 – Present **CEO & CHIEF INVESTMENT OFFICER of CGNPE**
- 2012/11 – 2015/09 **CHIEF INVESTMENT OFFICER of CGNPE**
- 2009/09 – 2012/11 **HEAD OF INFRASTRUCTURE of CHINA PINGAN**
- 2007/10 – 2009/03 **HEAD OF INFRASTRUCTURE, MEMBER OF GLOBAL INFRASTRUCTURE EXECUTIVE COMMITTEE of BABCOCK & BROWN**



2000/09 – 2003/12 **EX-CEO of CONCEPTM, INVENTOR of US PATENT 20080288351 A1**

- “System and Method for Facilitating Electronic Financial Transactions Using a Mobile Telecommunication Device”, prior date of 4 Dec 2001, publication date of 20 Nov 2008
- Led engineering team to develop mobile phone APP using SIM Toolkit in C in 2001



1994/02 – 2000/09. **ACTUARIAL TRAINING with INSTITUTE OF ACTUARIES OF AUSTRALIA**

CHINA'S GREEN AMBITION

DRIVEN BY:

1

National Security

- China imported 60.6% of total oil consumed in 2015, or 6.6 million bbl/d, US\$130 billion @ average Brent Oil price in 2015, seaborne import represents over 80% of total
- China imported 32.7% of total natural consumed in 2015, or 2.1 billion mmbtu, US\$23 billion @ average LNG import price in 2015 for Japan, seaborne import represents over 35% of total

2

Environment Security

- Air Pollution
- Water Consumption and Pollution

3

Political Commitments

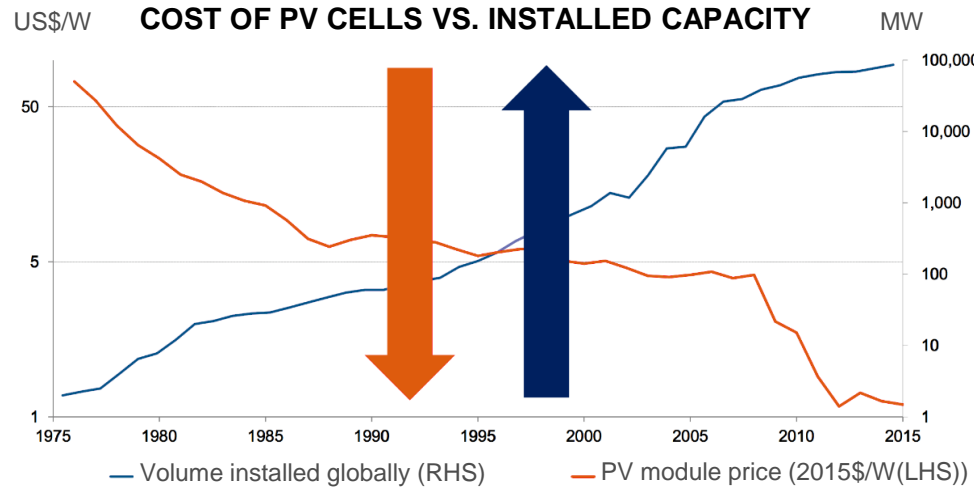
- 2020 CO₂ emission per GDP 40 – 45% lower than in 2005, 2030 CO₂ emission per GDP 40 – 45% lower than in 2020
- Fossil fuel as a percentage of primary energy production falls from 88% as at 2015 to 80% BY 2030

4

International Trade and Diplomacy

INEXHAUSTIBLE AND NON-DEPLETIBLE RESOURCE + ADVANCEMENT OF TECHNOLOGY

RAPID DECLINE OF COST OF RENEWABLE ENERGY AND SOARING INSTALLATIONS



Renewable energy is becoming ever cheaper to produce

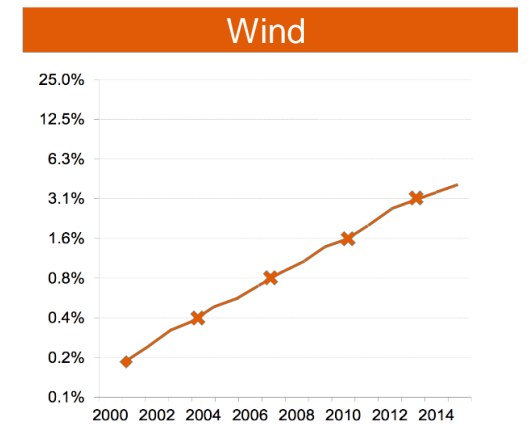
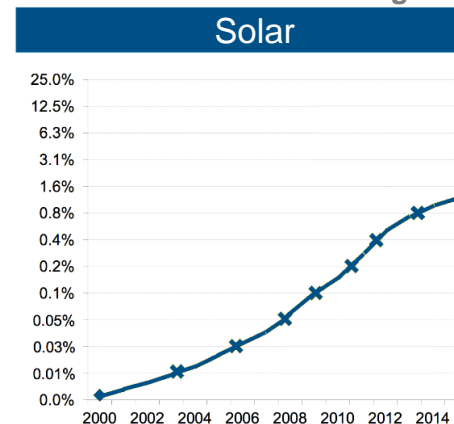
Auctions in Mexico and Morocco ended with winning bids from companies that promised to produce electricity from wind and solar at the cheapest rate, from any source, anywhere in the world

“The Stone Age came to an end not for a lack of stones and the Oil Age will end, but not for a lack of oil”





Sheikh Zaki Yamani, ex-Saudi Arabian Oil Minister

RENEWABLES' SHARE OF POWER GENERATION.

Scale is shown in doublings

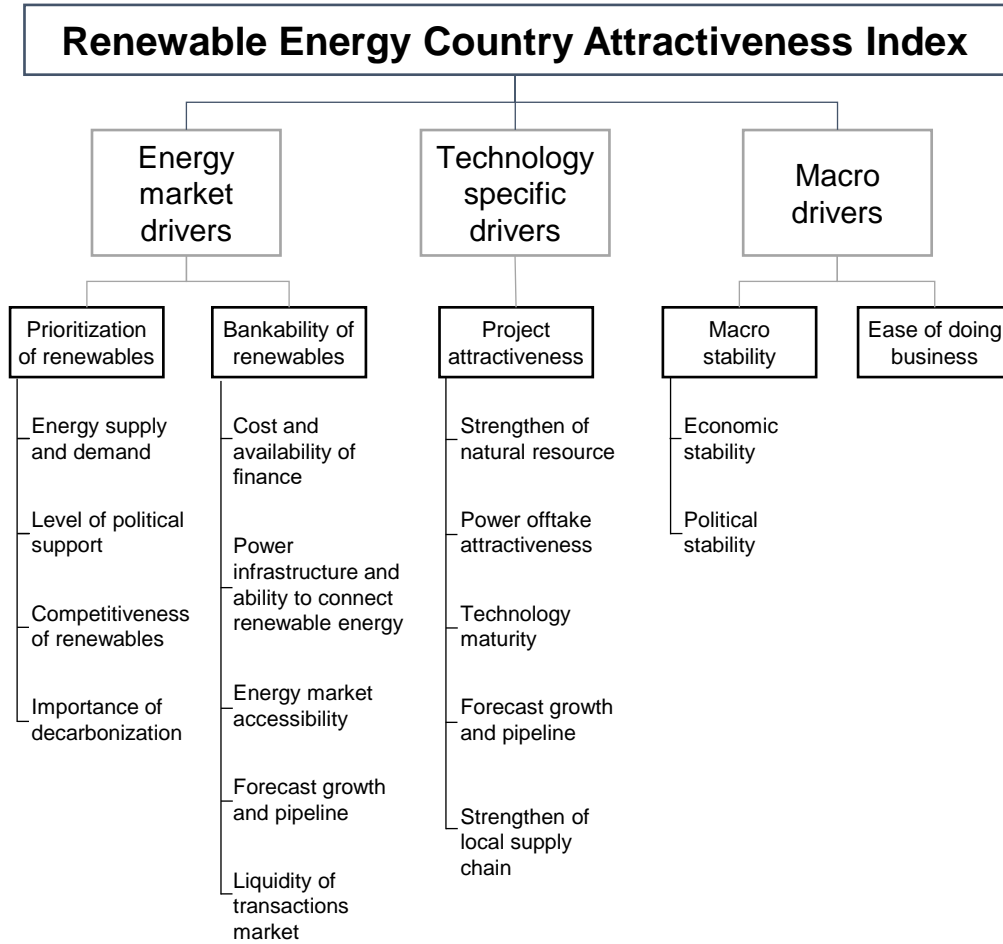


**SIGNIFICANT PROGRESS HAVE BEEN MADE
 AMBITIOUS TARGETS SURPASSED BY LARGE MARGINS**

					
2030	Likely	400 GW	150 GW	500 GW	500 GW
13th	Five-year Plan	340 GW	58 GW	250 GW	160 GW
12th	Planned	290 GW	40 GW	100 GW	21 GW
	Achieved	319 GW	26 GW	129 GW	43 GW
11th	Planned	190 GW	-	10 GW	-
	Achieved	220 GW	11 GW	31 GW	-
10th	Planned	100 GW	7.0 GW	1.2 GW	-
	Achieved	120 GW	6.9 GW	1.3 GW	-

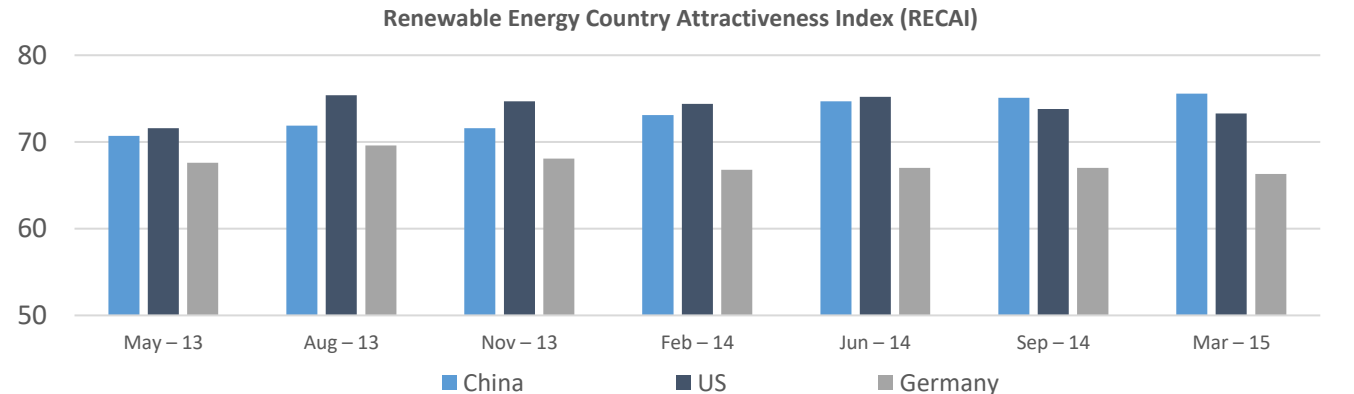
SUPPORTIVE POLITICAL AND REGULATORY ENVIRONMENT

CHINA RATED AS THE MOST ATTRACTIVE RENEWABLE ENERGY MARKET IN THE WORLD



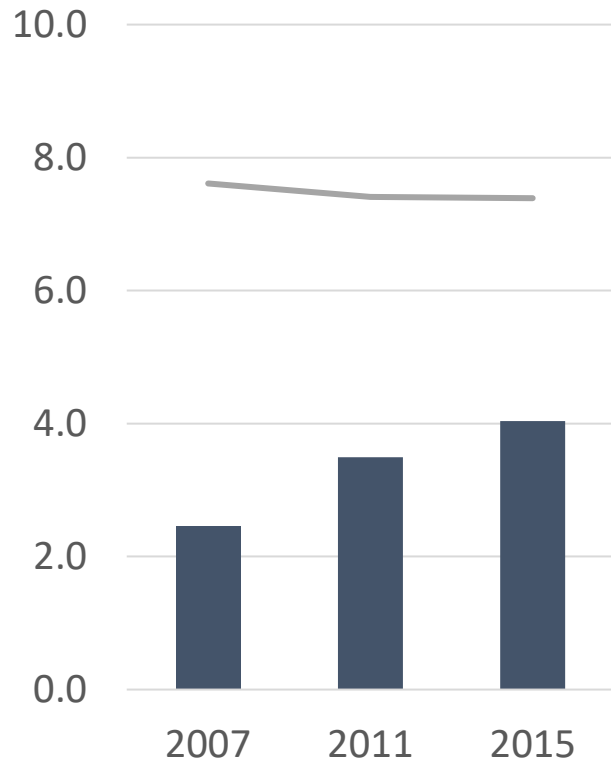
Ranking based on **RECAI** that reflects a weighted average across macro, energy market and technology-specific parameters

	1 st	2 nd	3 rd	4 th	5 th
Mar – 15	China	US	Germany	Japan	India
Sep – 14	China	US	Germany	Japan	Canada
Jun – 14	US	China	Germany	Japan	Canada
Feb – 14	US	China	Germany	Japan	UK
Nov – 13	US	China	Germany	UK	Japan
Aug – 13	US	China	Germany	UK	Japan
May – 13	US	China	Germany	Australia	UK

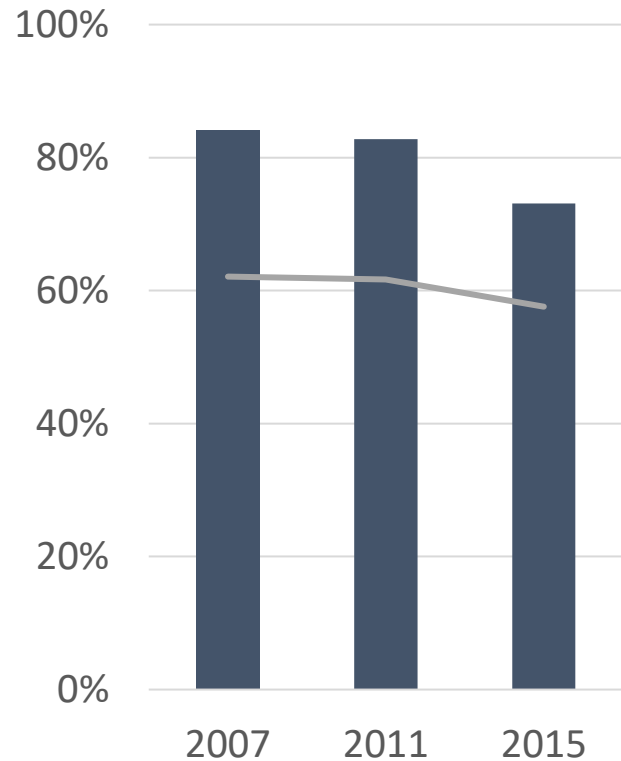


COMPARING BLACK VS. GREEN, AND GERMANY VS. CHINA THE TREND IS CLEAR: A TECTONIC SHIFT OF FUEL SOURCE IS HAPPENING

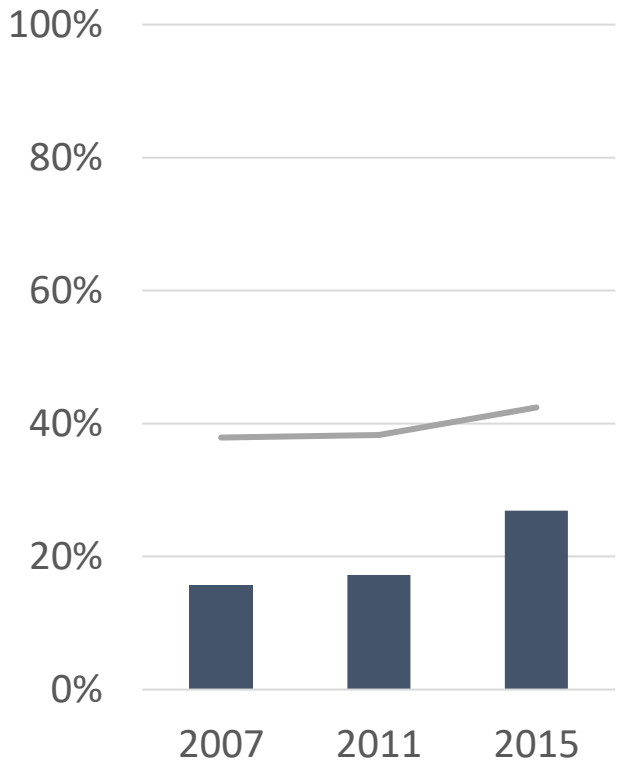
PER CAPITAL ELECTRICITY CONSUMPTION



PROPORTION OF THERMAL POWER



PROPORTION OF "GREEN" POWER



Catching up with Germany....

Lost 11% share in 8 years....

Accelerating growth....

THE PATH TOWARDS “GREEN” FUEL, MORE IMPORTANTLY, SUSTAINABILITY FEELING ITS WAY, REFINING ITS PATH, YET STEADFAST WITH ITS GOALS

KEY OBSERVATIONS: IN 10 YEARS, FROM NASCENT TO ...

- 1 REGULATORY & BUSINESS ENVIRONMENT**
 - No. 1 in Wind
 - No. 2 in Solar PV
- 2 MARKET SIZE: NO. 1**
 - 50% of world newly installed onshore windfarms
 - 26% of world newly installed Solar PV
 - 36% of world nuclear power under construction
- 3 MANUFACTURING: NO. 1**
 - 50% of world Wind Turbines
 - 70% of world Solar PV
- 4 SKILLED LABOUR: NO. 1**
 - Over 50% employed by wind, solar, hydro, biomass industries are in China
- 5 MODERN GRID: NO. 1**
 - 1000kV Ultra-High Voltage AC back-bone
 - 27 800kV Ultra-High Voltage DC interconnectors

● PHASE 1, 2006 - 2012: FINDING ITS WAY

- RE Law
- Light handed regulation
- Explosive growth
- Mis-management
- Heavy handed regulation
- Improved Grid Code

● PHASE 2, 2013 - 2020: PRODUCTIVITY GROWTH

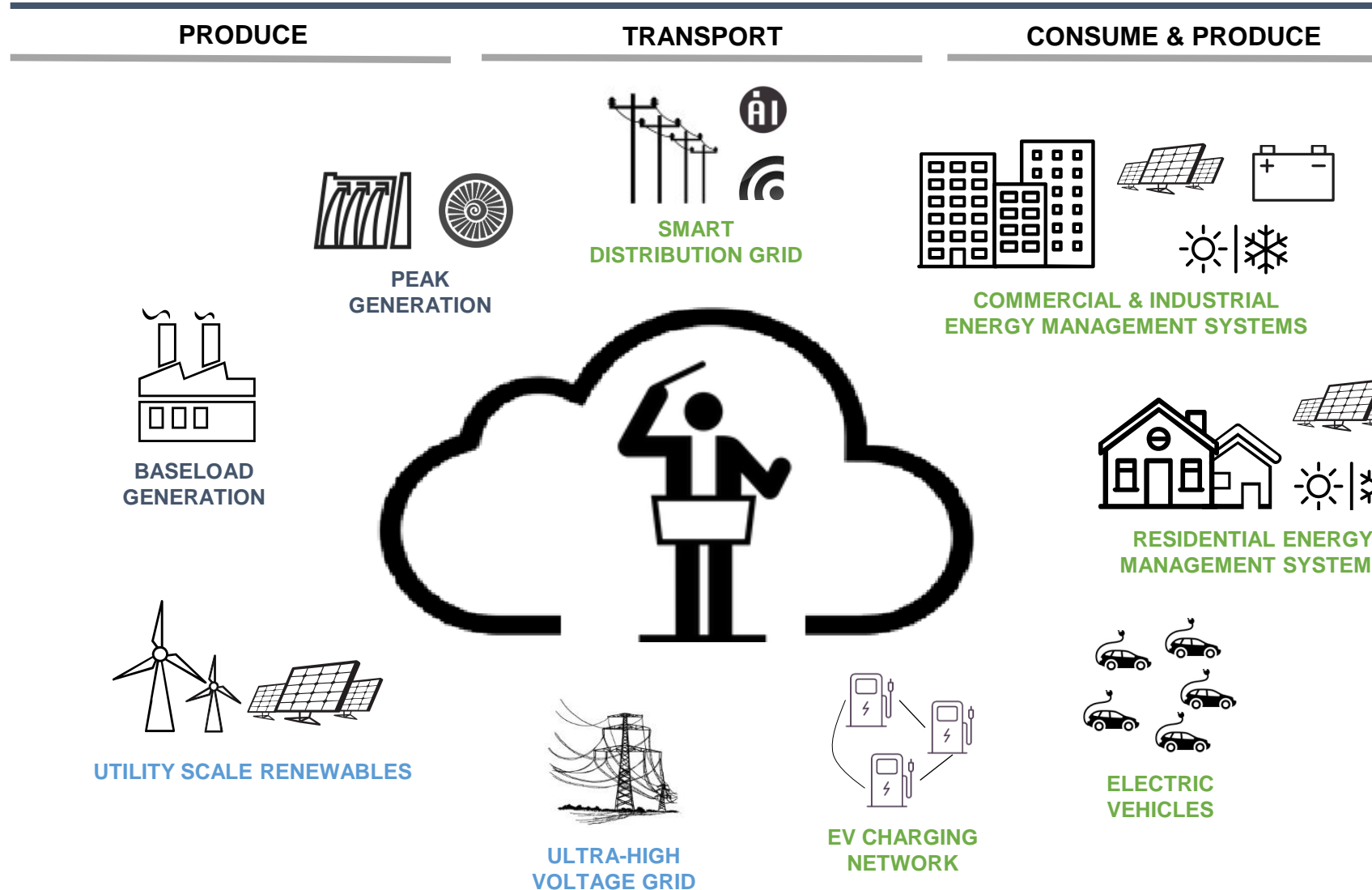
- Intensive competition drives R&D
- Increase scale
- Improving knowledge base and talent pool
- Improve dispatch
- Establish clear tariff glide path expectation
- By 2020, Wind and Solar LCOE lower by 50% and 75% against 2010

● PHASE 3, 2020 - 2030: REVOLUTION

- Demand Side: Structural reform + energy efficiency
- Supply Side: Diversify primary source of energy, enhance grid interconnectivity and capability
- Green Technology: Hardware + Software + Supply Chain + Business Model
- De-regulation: Energy Market Reform
- International Cooperation

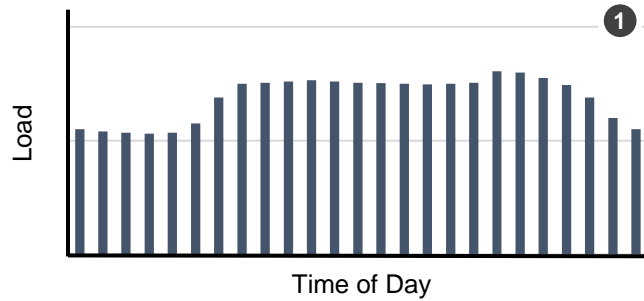
AND “GREEN AMBITION” IS A LOT MORE THAN “GREEN” FUEL TRANSFORMING HOW ENERGY IS BEING “PRODUCED, TRANSPORTED, AND CONSUMED”

“THE ENERGY ORCHESTRA”

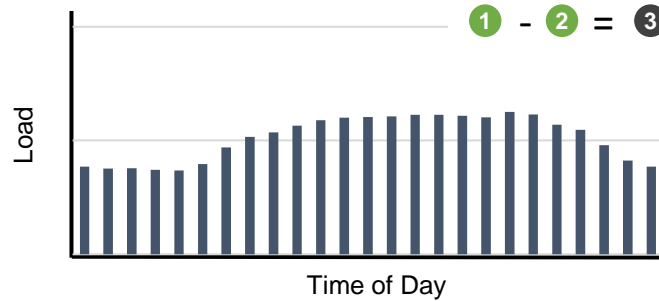


SUPPORTED BY ENERGY MARKET REVOLUTION

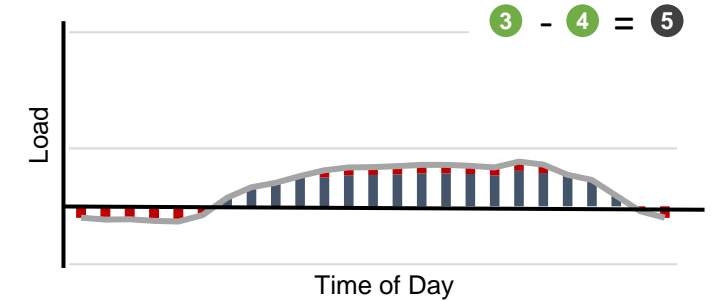
MY EXPECTATION: STACKED MARKETS, HYBRID OF PECKING ORDER + MERIT ORDER



- Dynamic stochastic forecast of each market give load curve confidence level
- Energy flow constrained by physical limitations (frequency, voltage)



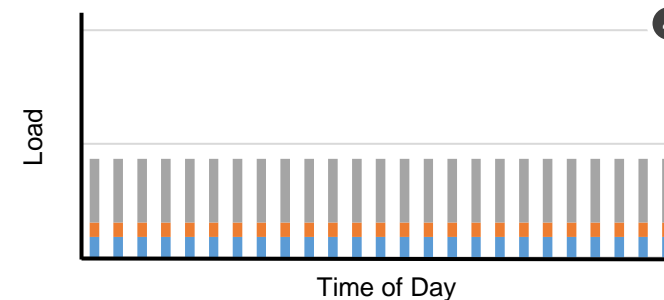
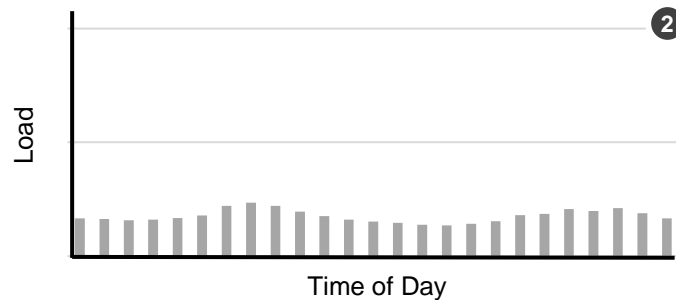
- Probability based Load Forecast
- Provide forecast to Baseload, Ancillary Service, Capacity and Energy Markets



- **DIGITALISED AND FLEXIBLE**, managed by the Energy Orchestra Cloud
- Provided by super chargers, hydro, CCGT, distributed energy management systems

- **INTERMITTENT**, managed by the Energy Orchestra Cloud
- Priority dispatch, zero Real-time Marginal Cost, zero SRMC, high Long Term Average Economic Costs

- **BASELOAD**, conventional, weekly schedule
- Zero Real-time Marginal Cost, low SRMC, low to medium Long Term Average Economic Costs

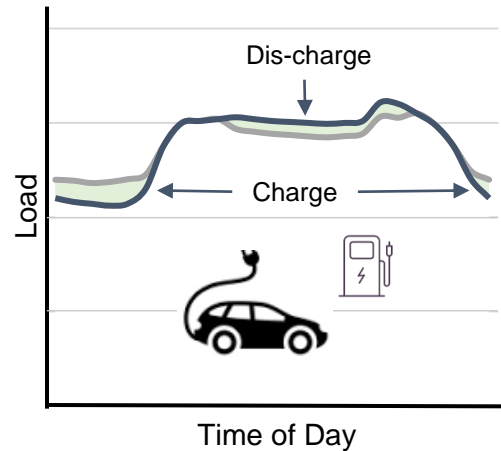


ENERGY SYSTEMS ARE TO BE “DIGITALISED”, “INTERACTIVE” AND “SHARED”

LIBERISATION: BILLIONS OF ENERGY USERS AT THE SAME TIME ARE SUPPLIERS

WHERE DOES THE REVOLUTION LEADS CHINA TO?

LOAD SHREDDING + STORAGE @ ZERO MARGINAL COSTS



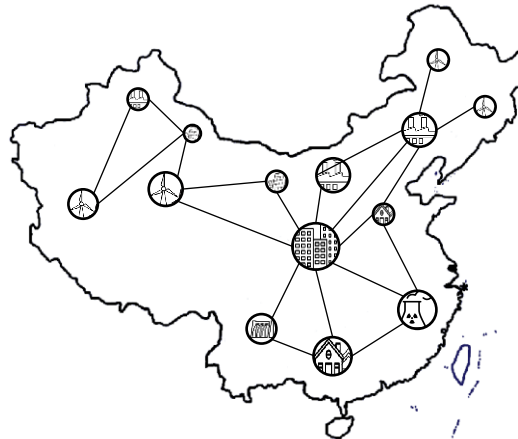
THE ENERGY ORCHESTRA

- Groups of Internet of Energy Systems conducted by system operator

CAPACITY SHARING

- Connectivity liberates value of distributed, individual energy systems such as electric cars and demand response systems
- Infinite capacity becomes available to grid at zero marginal costs

AN INTELLIGENT INTERCONNECTED GRID



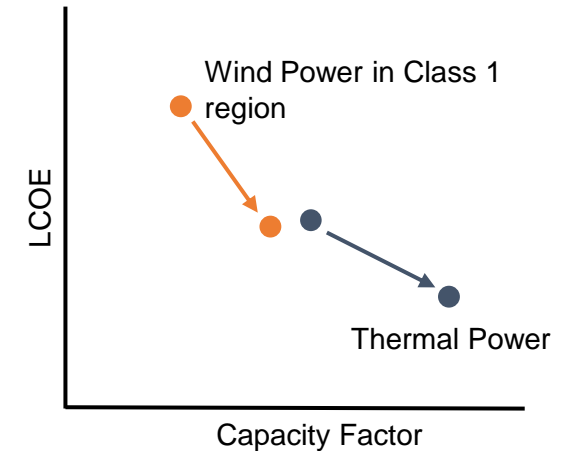
PEAKS

- Peaks will be shredded by the Energy Orchestra
- Purpose build facilities such as pump storage, OCGT will have limited economic value going forward

OFF-PEAKS

- The Energy Orchestra provides storage to grid at zero marginal costs

FULL UTILISATION OF EXISTING ASSETS



CURTAILMENT

- Integrated and well connected national grid connects fuel rich provinces to load centres and increases its capacity to accommodate based load and intermittent generation

IMPROVE EFFICIENCY

- Less investments in grid and generation assets
- 40% reduction of LCOE

THE MATHS OF ENERGY ORCHESTRA

BY 2030, "GREEN" FUEL WILL PRODUCE 57% OF ELECTRICITY IN CHINA

ELECTRICITY DEMAND BY 2030 AND OUTLOOK OF COAL + GAS POWER

SEGMENT	ELECTRICITY CONSUMED PER CAPITA 2015	ELECTRICITY CONSUMED PER CAPITA BY 2030
1 TRADITIONAL	4.0 MWh (Germany: 7.4 MWh)	5.7 MWh (78% of Germany)
2 ELECTRIC VEHICLES	-	0.43 MWh (300 million EVs)

SEGMENT	CAPACITY INSTALLED 2015	CAPACITY FACTOR 2015	CAPACITY INSTALLED BY 2030	CAPACITY FACTOR BY 2030
1 NUCLEAR POWER	26GW	73%	150GW	75%
2 HYDRO POWER	319GW	41%	400GW	40%
3 WIND POWER	130GW	20%	500GW	28%
4 SOLAR PV POWER	43GW	13%	500GW	16%
5 GAS + COAL POWER	1,056GW	48%	??GW	67%

BY 2030...

Uses 4 bn barrels less oil

Consumes 8,700 TWh electricity...

1,100 TWh from Nuclear Power

3,800 TWh from Renewable Power

Needs: 3,800 TWh from Gas + Coal Power

i.e. 550GW of Gas + Coal Power

A 48% reduction from Today

LOOKING BEYOND COAL, THERE ARE NUMEROUS DISRUPTIONS AHEAD...

8.0+ TRILLION YUAN QUESTIONS

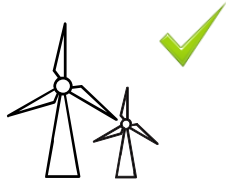
MARKET SIZE

Consumption	PASSENGER TRANSPORT	¥3.0 TN+	VEHICLES SALES: From combustion engines to electric motors
		¥1.0 TN+	FUEL CONSUMPTION: From petrol to electricity
		¥500 BN+	ELECTRIC RAIL: From hydrocarbon to electricity, from shipping coal to shipping goods
Production and Consumption	ENERGY RETAILING	¥4.0 TN+	ELECTRICITY SALES: From State Grid to new entrants
			Retail participants “ PRODUCE + CONSUME ” within the distribution grid
			UBERISATION. Connectivity and cloud technology bring new business models and opportunities
Production and Consumption	DISTRIBUTED ENERGY SYSTEMS		Each charging station is a zero marginal cost “ MICRO-PEAK + MID-MERIT ” power station
		6,000 GW	CAPACITY: Assume all 166 million vehicles in China in 2015 are to be converted into electric vehicles, assume there is one super-charger (Tesla super-charger equivalent) for every 17 electric vehicles
		12 TWh	STORAGE: Each electric vehicle has a battery of 70KWh. Assume all vehicles in China are electric vehicles, the aggregate storage is sufficient to store 8 hours of output from all capacity

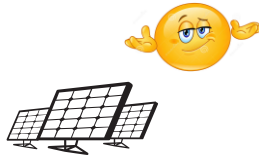
HOW DO WE PROFIT FROM THIS? (1)

GREEN FUEL

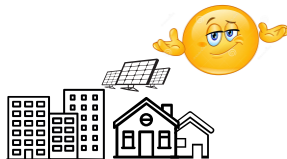
INTERMITTENT



UTILITY SCALE
WIND POWER



UTILITY SCALE
SOLAR PV
POWER

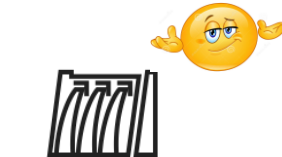


DISTRIBUTED
SOLAR PV

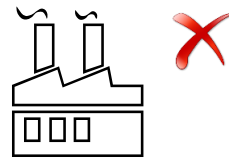
BASELOAD



NUCLEAR
POWER



HYDRO
RUN-OF-RIVER

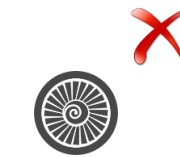


COAL FIRED
POWER

MID-MERIT & PEAKING



HYDRO
RESERVOIR



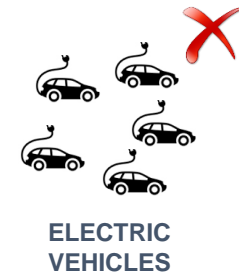
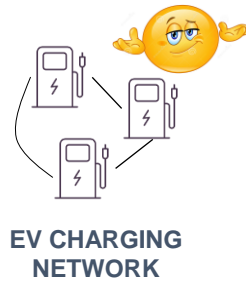
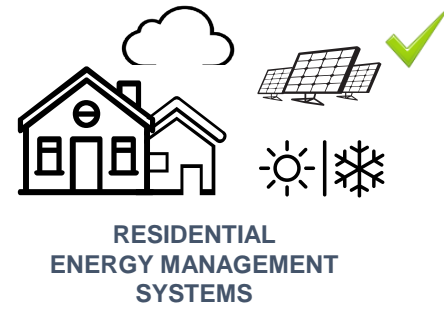
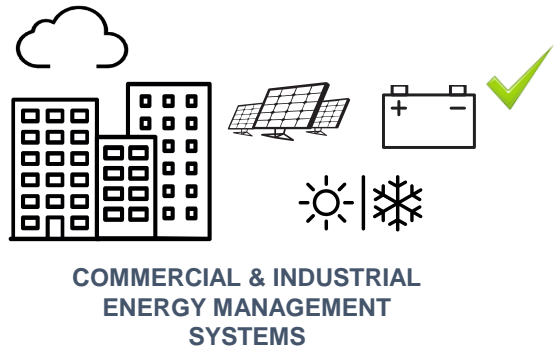
COMBINED
CYCLE GAS
TURBINE



OPEN CYCLE
GAS TURBINE

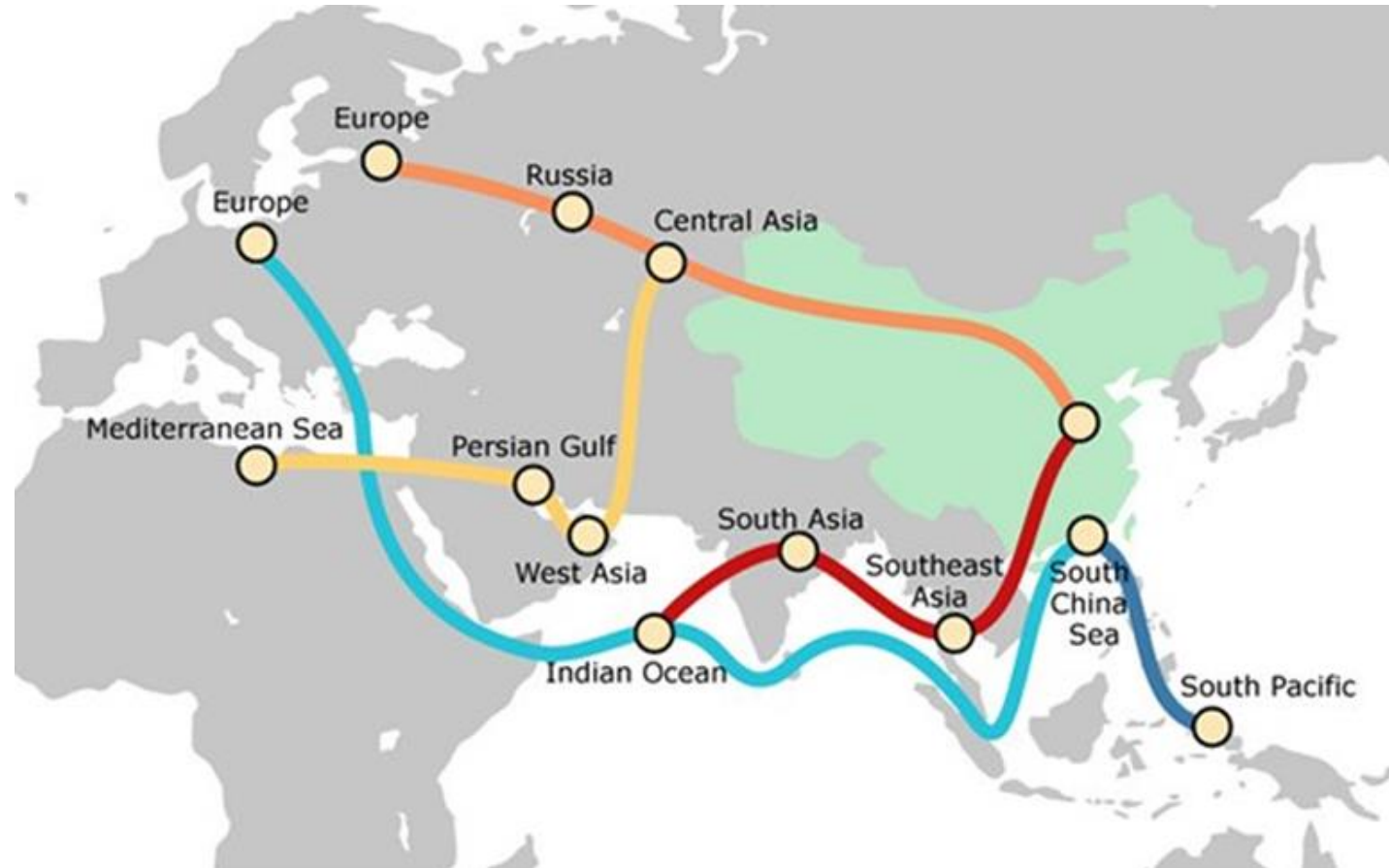
HOW DO WE PROFIT FROM THIS? (2)

CONVERTING LOW VALUE ENERGY TO HIGH VALUE ENERGY



HOW DO WE PROFIT FROM THIS? (3)

BELT AND ROAD: EXPORT OF "GREEN" ENERGY SYSTEMS



THANK YOU