



Waste Heat Recovery Opportunities in Cement

Market and Supplier Analysis

Intercem Conference

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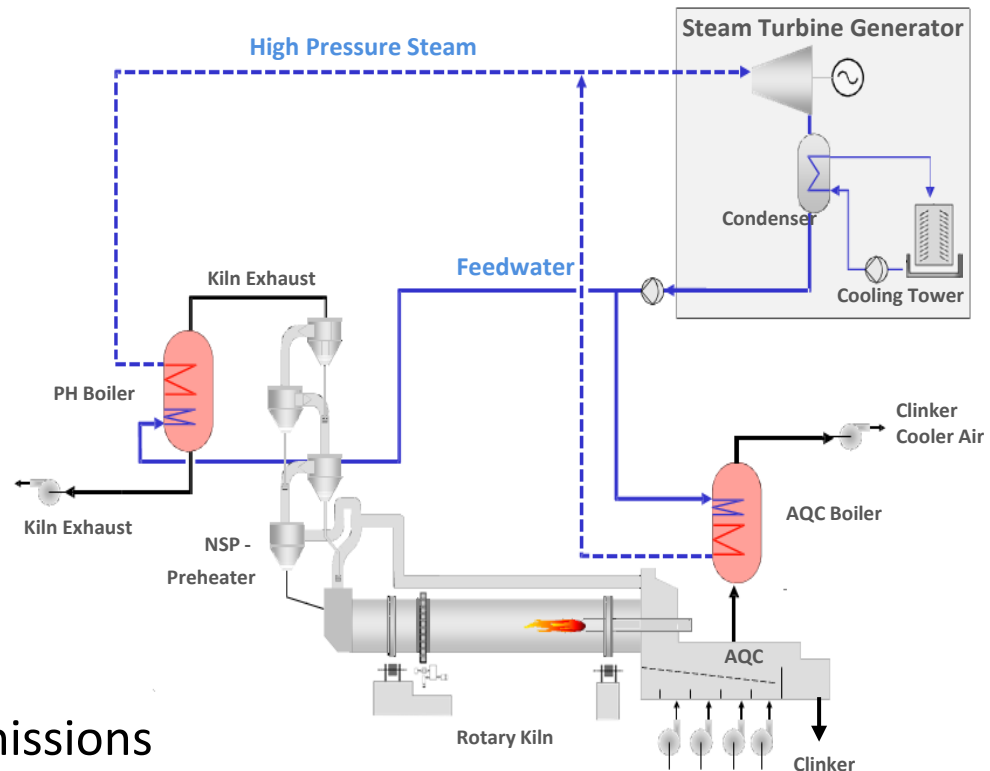
Waste Heat Recovery in Cement

- Cement production more than doubled b/w 2002 and 2012
- In Sub-Saharan Africa the sector's growth averages 8% pa
- WHR - proven technology with limited uptake, except in China
 - 739 installation in China vs. 126 installation in the rest of the world

A GREAT BUSINESS OPPORTUNITY THAT NEEDS TO BE UNLOCKED?

Waste Heat Recovery in Cement

- Potential to generate **20% to 30%** of plant power requirements (reducing purchased/captive power needs)
- Reduces operating costs
- Protects against rising electricity prices
- Enhances power reliability
- Improves competitive position
- Lowers specific energy consumption, reducing overall greenhouse gas emissions



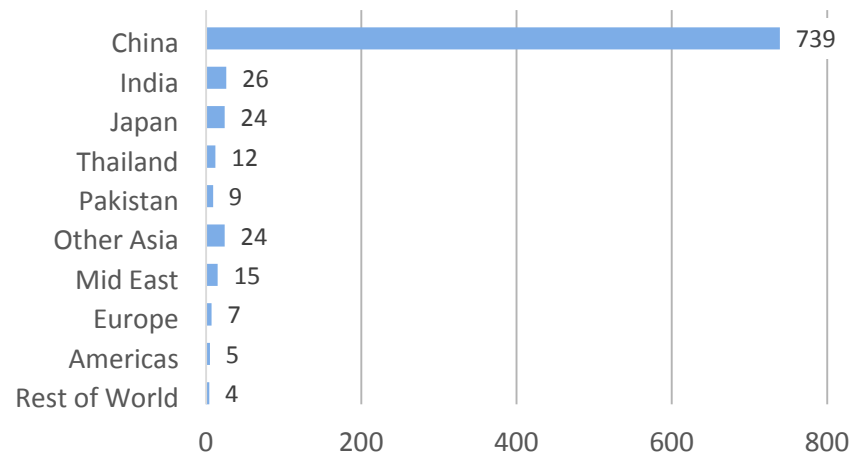
Source: Adapted from Holcim 2012

WHR Market Status

WHR is a proven technology

- Initially spear-headed by Japanese suppliers
- China is now the leader in WHR deployment and sales for cement applications

WHR Systems in Cement – Number of Units - 2012

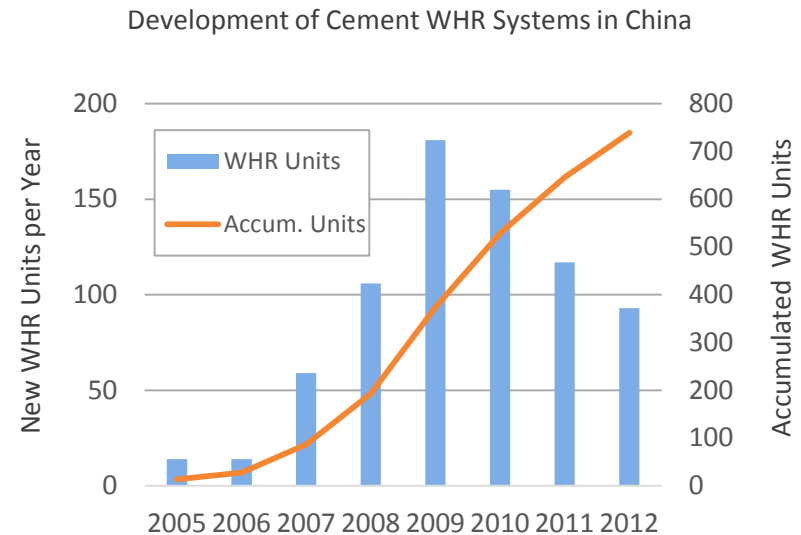


Source: OneStone Research, CemPower 2013

WHR Development in China

“Success” factors for China

- Specific laws/regulations mandating that new NSP clinker lines have WHR installed
- Much lower CAPEX
- Rising energy prices
- In some cases concern over reliability of grid-delivered electricity
- Government commitment to reduce GHG

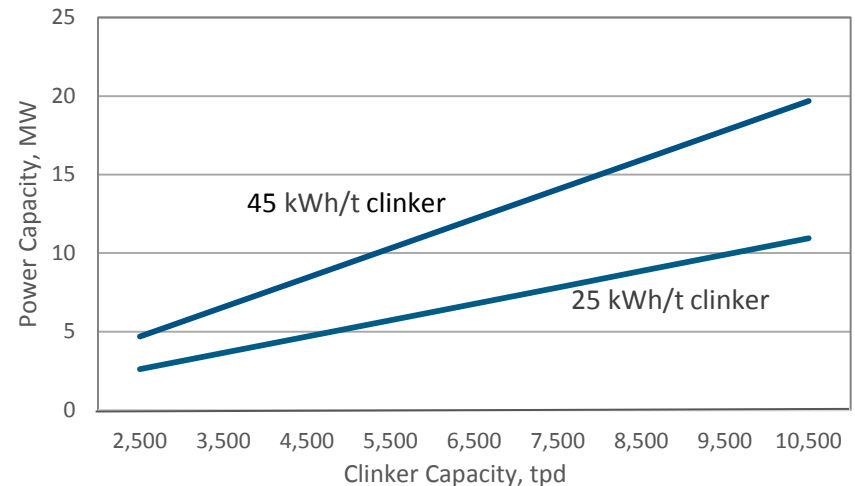


Source: OneStone Research, CemPower 2013

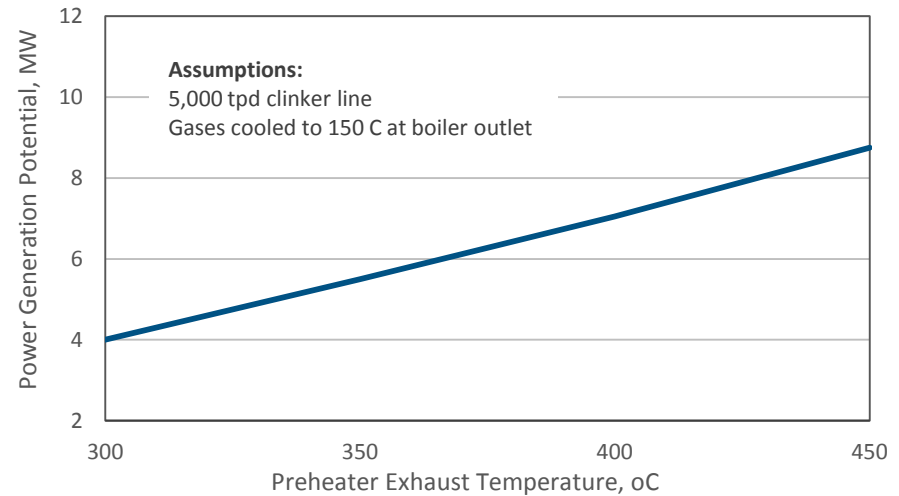
WHR Performance

- Generation efficiencies range from 15 to 25%
- Amount of available heat depends on:
 - Moisture content of raw feed
 - Number and efficiency of preheater/precalciner stages
 - Amount of excess air and infiltration
 - Configuration of clinker cooler system
- Project economics depends on net power output

WHR Generation Potential as Function of Kiln Capacity



WHR Generation Potential as Function of Exhaust Temperature

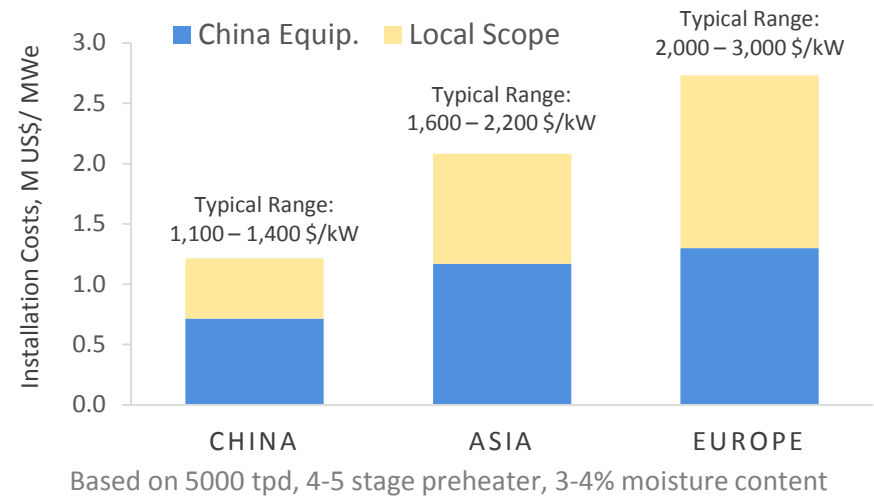
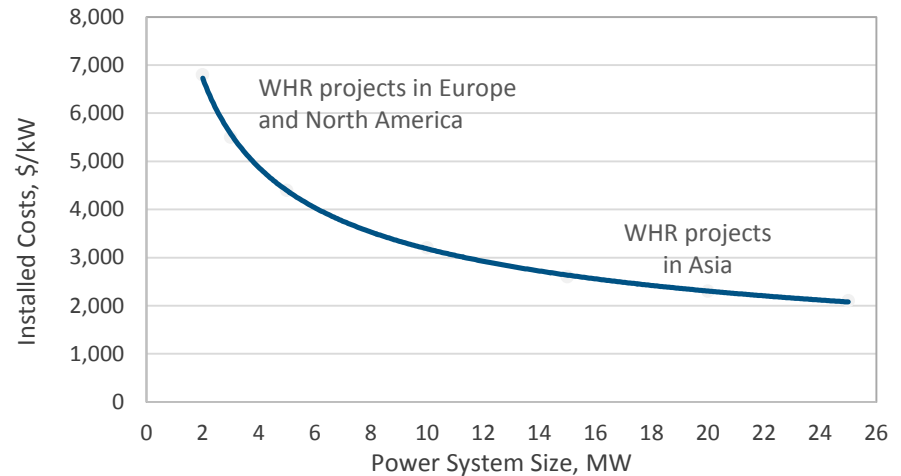


Source: OneStone Research 2013, Penta Engineering 2013

WHR Project Costs

Equipment and installation costs influenced by:

- Size
 - Steam cycle
 - Organic Rankine cycle
 - Kalina cycle
- Location
- Supplier



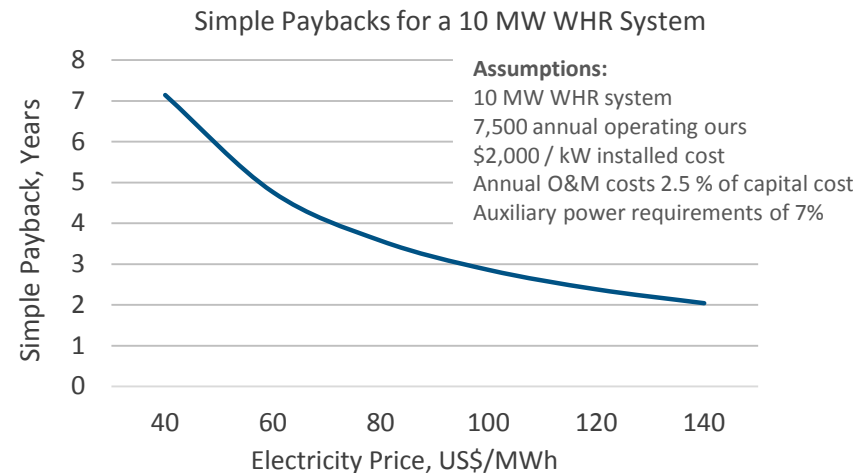
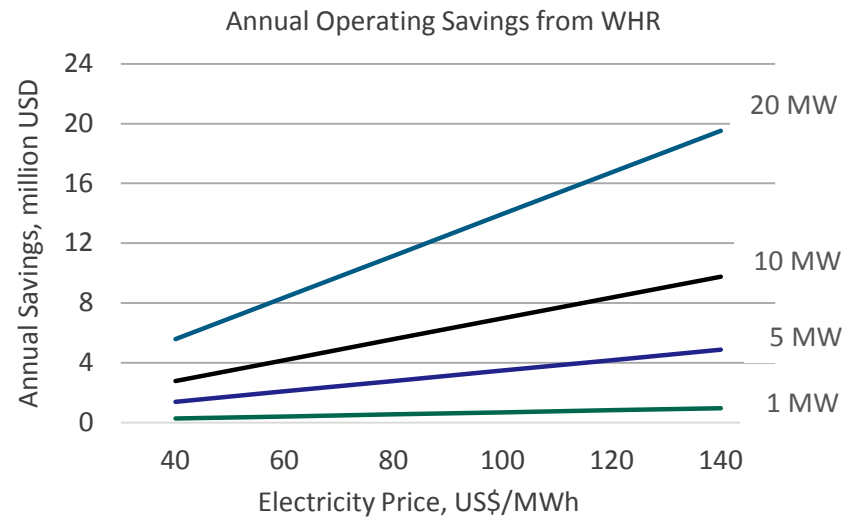
Source: Holcim 2013, OneStone Research 2013, IFC

WHR Project Economics

Economics influenced by:

- Plant size
- WHR system costs
- O&M costs (2.5% of capital costs per year for steam)
- Operating hours
- Value of displaced electricity (purchased or captive)
- Value of increased power reliability

Source: Holcim 2013, OneStone Research 2013



WHR Market Opportunity

- Evaluated potential market in eleven countries
 - Cement industry outlook
 - Power and fuel costs
 - Power reliability
- Estimated **1.6 to 2.9 GW** market; **\$5 billion** investment
 - Strong potential in Asia and Latin America
 - Opportunities in Africa and Middle East

Country WHR Market Analysis

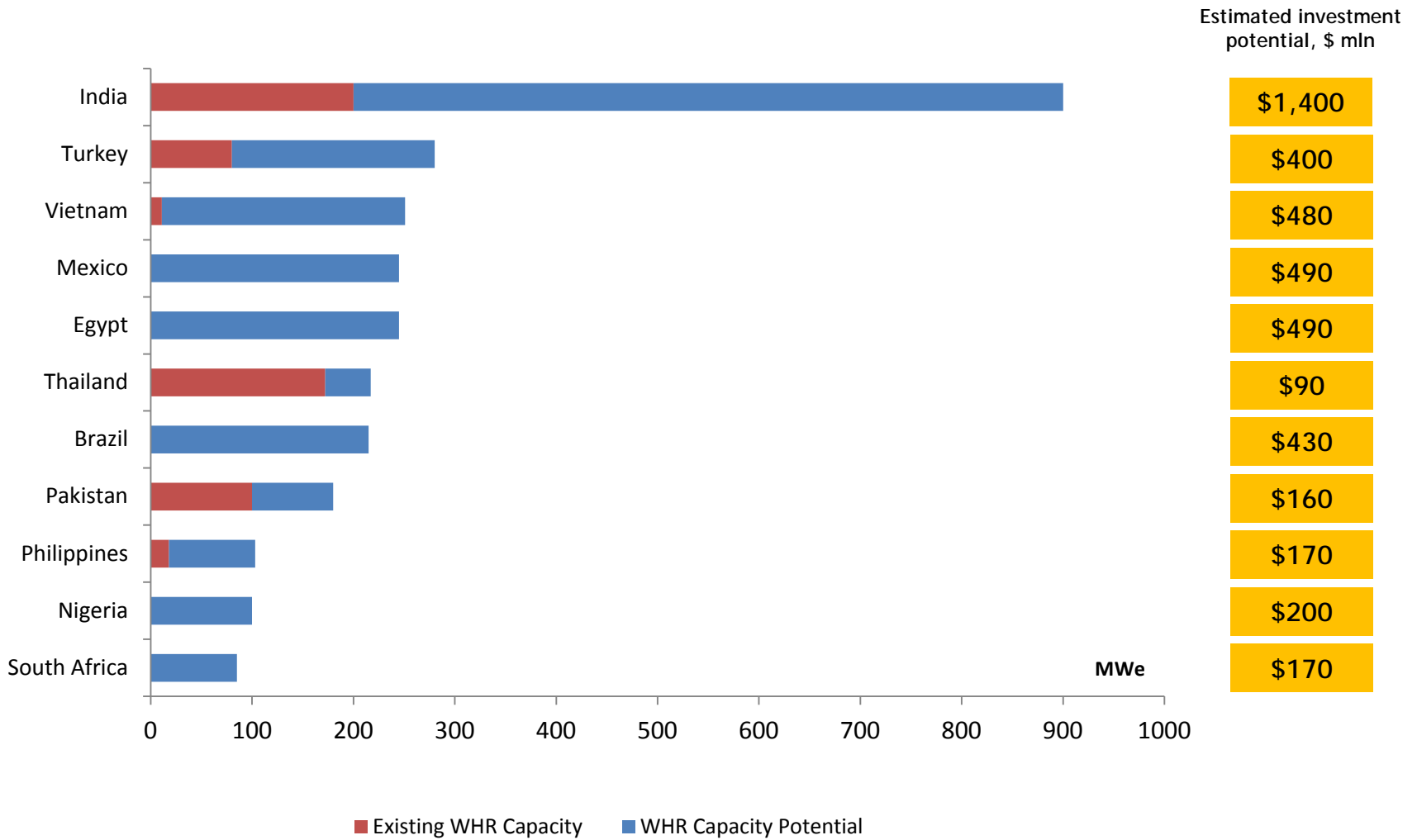
Table ES-1 – WHR Market Opportunities

Country	Remaining WHR Potential, MW	Growth in Cement Market, 2012- 2014	Concerns Over Power Reliability, Y/N	Industrial Electricity Prices, US\$/MWh	Political Stability and Absence of Violence (2012) ^a	Regulatory / Sustainability Drivers, Y/N	Existing WHR Installed Capacity
Brazil	190 - 340	4.7%	No	120 - 170	47.9	Yes	None
Egypt	175 - 300	2.6%	Yes	50 - 70	7.58	No	None
India	500 - 900	12.4%	Yes	80	11.85	Yes	>200 MW
Mexico	170 - 300	-1.7%	No	117	24.17	No	None
Nigeria	70 - 130	21.1%	Yes	50 - 100	3.32	No	None
Pakistan	50 - 100	-0.4%	Yes	130 - 170	0.95	No	>100 MW
Philippines	60 - 110	13.6%	Yes	80 - 145	14.69	No	>18 MW
South Africa	55 - 100	9.5%	Yes	80 - 150	44.08	Yes	None
Thailand	30 - 60	14.4%	No	50 - 100	12.80	No	>172 MW
Turkey	150 - 280	17.5%	Yes	100 - 150	13.27	No	>80 MW
Vietnam	165 - 310	5.8%	No	60 - 70	55.92	No	>11 MW

Note: Color coding - Green signifies a strong positive driver or factor for WHR development, yellow represents a weaker positive driver or marginal conditions for WHR development, and red represents very weak drivers or conditions that could hinder WHR market development.

^a Worldwide Governance Indicators, <http://info.worldbank.org/governance/wgi/index.aspx#reports>. For comparison, the index for USA was 68.3.

WHR Investment Potential



IFC's Project Structuring and Financing

CHUEE Project Example

- WHR 7.5 MW
- Total investment
\$7.9 m
- ROI 25.2%
- Electricity generation cost
US¢ 2/kWh
- Project is owned and operated by the cement plant

Other project financing structures:

- Direct IFC financing (debt and equity)
- Supplier financing
- Off balance sheet financing (BOOT)

