The Cement Industry Energy Dilemma

Full Cost of Policy Options for Egypt

CHEMONICS EGYPT
CONSULTANTS

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Overview

Part 1: Background on Cement and Energy Alternatives

- Understanding the Cement Energy Dilemma
- International Experience with Cement Energy
- Analyzing Cement Energy Alternatives in Egypt

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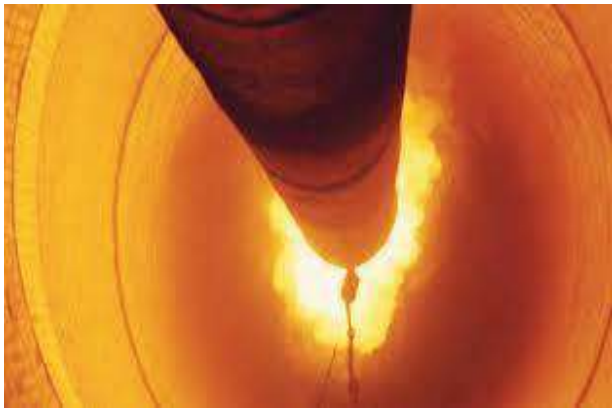
Part 1: Background on Cement and Energy Alternatives

The Cement Industry of Egypt is an important component of the national economy.

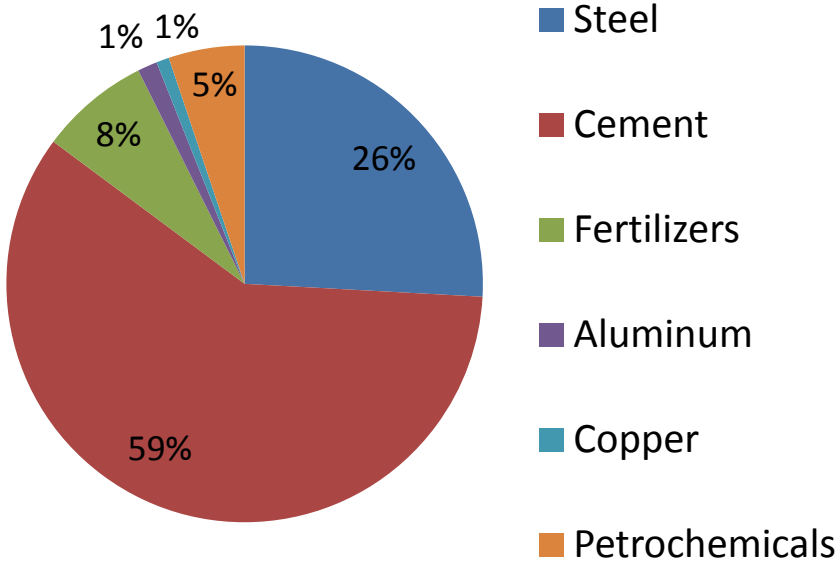
- Cement industry now accounts to around 3.7% of GDP (around EGP60 Billion).
- Local consumption vs. exports: **30.7 million tons for local consumption and 6.3 million for exports (2011).**

Cement Plant

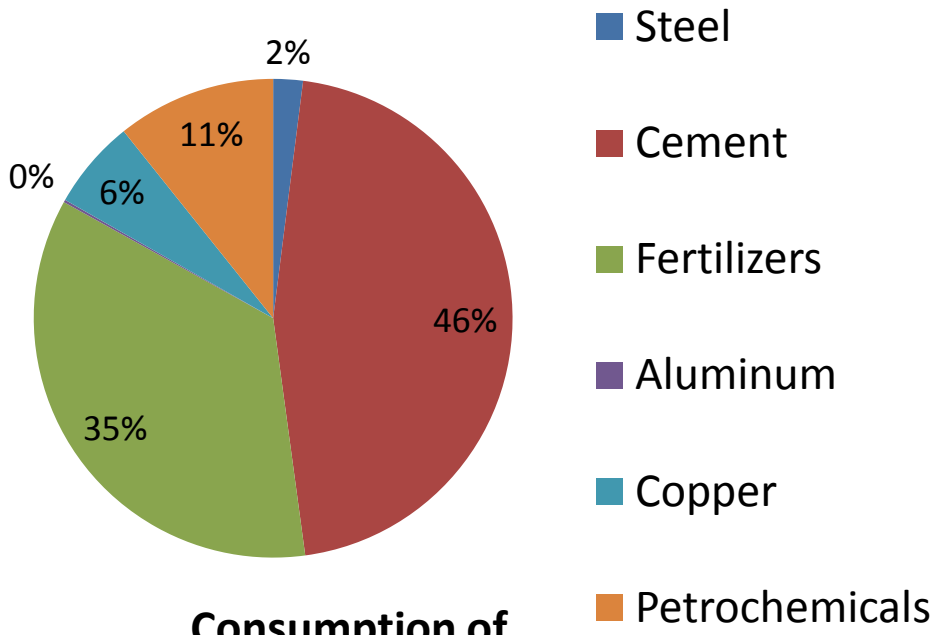


Kiln Inside

Cement industry consumes 51% of total primary energy for energy-intensive industries in Egypt, and 9% of total national primary energy.



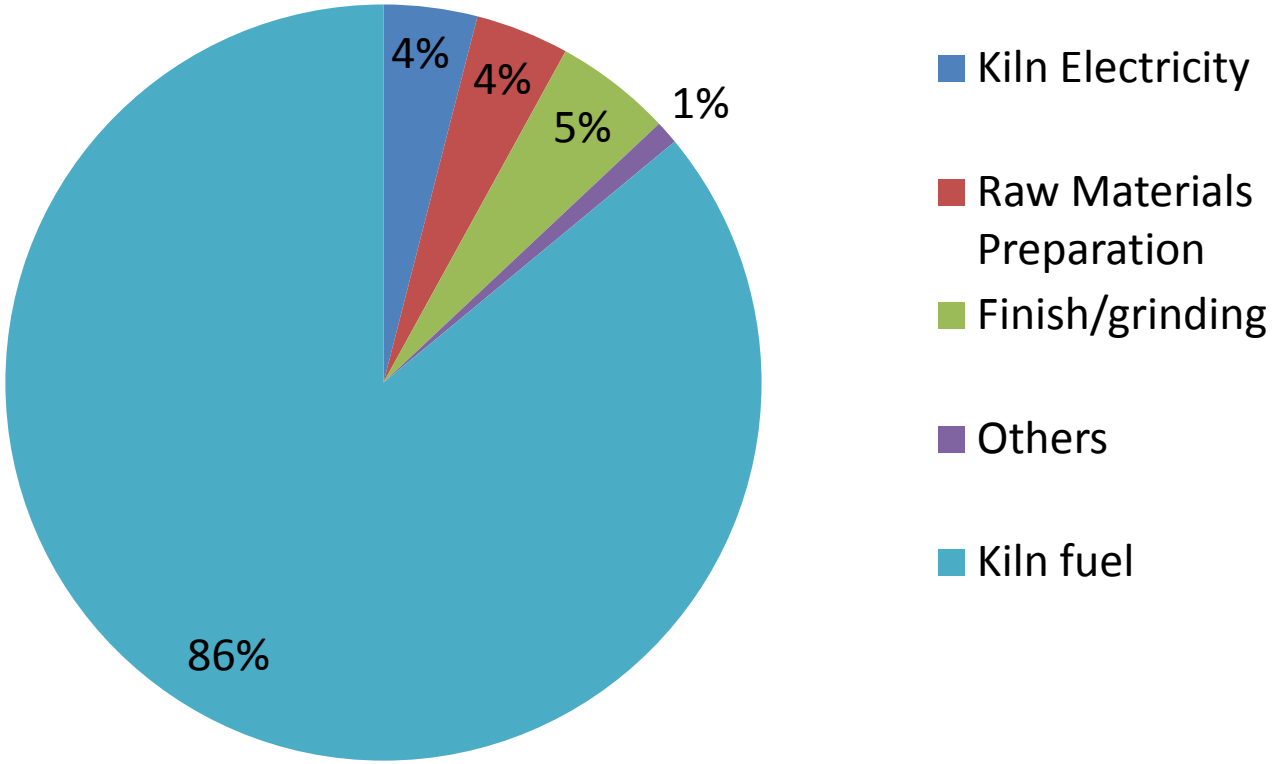
Consumption of Electricity for Intensive Industries by Sector



Consumption of Natural Gas for Intensive Industries by Sector

Chemonics Research - 2013

Most of the energy consumption occurs in the kiln, in the form of thermal energy.



Breakdown of energy consumption in cement production.

Energy consumption in the international experience accounts for **30-40% of production costs**.

N.A Madlool et al. / Renewable and Sustainable Energy Reviews 19 (2013) 18–29

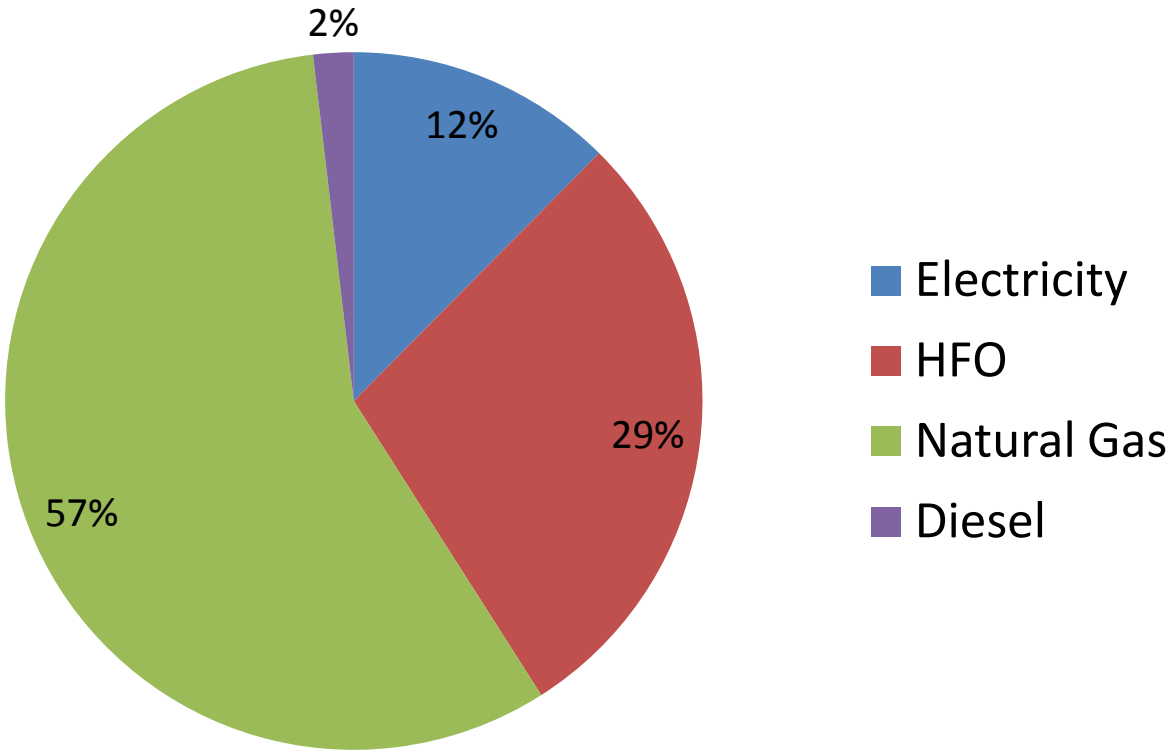
Depending on technology, cement can consume between 3 – 5.84 GJ/ton; a 40% difference.

Energy Use Area	Wet Kiln		Dry Kiln		Pre-heater Kiln	
	MJ/tonne	%	MJ/tonne	%	MJ/tonne	%
Theoretical Requirement	1,783.0	30.5	1,825.2	36.6	1,761.9	50
Exit Gas Losses	752.3	12.9	1,382.1	27.7	496.9	14
Evaporation of Moisture	2,236.7	38.3	300.7	6.0	235.3	7
Dust in Exit Gas	11.3	0.2	13.0	0.3	1.3	0
Clinker Discharge	56.7	1.0	61.2	1.2	65.8	2
Clinker Stack	189.9	3.3	590.8	11.8	614.0	18
Kiln Shell	677.3	11.6	606.7	12.1	175.1	5
Calcination of Waste Dust	40.7	0.7	18.5	0.4	6.2	0
Unaccounted Losses	88.9	1.5	192.0	3.8	173.0	5
TOTAL	5,840.8	100	4,994.6	100	3,612.5	100

The industry in Egypt is relatively modern and uses dry kiln technology. More research is required to accurately determine the current average consumption of the industry.

"Biomass Energy For Cement Production: Opportunities In Ethiopia", UNDP Report

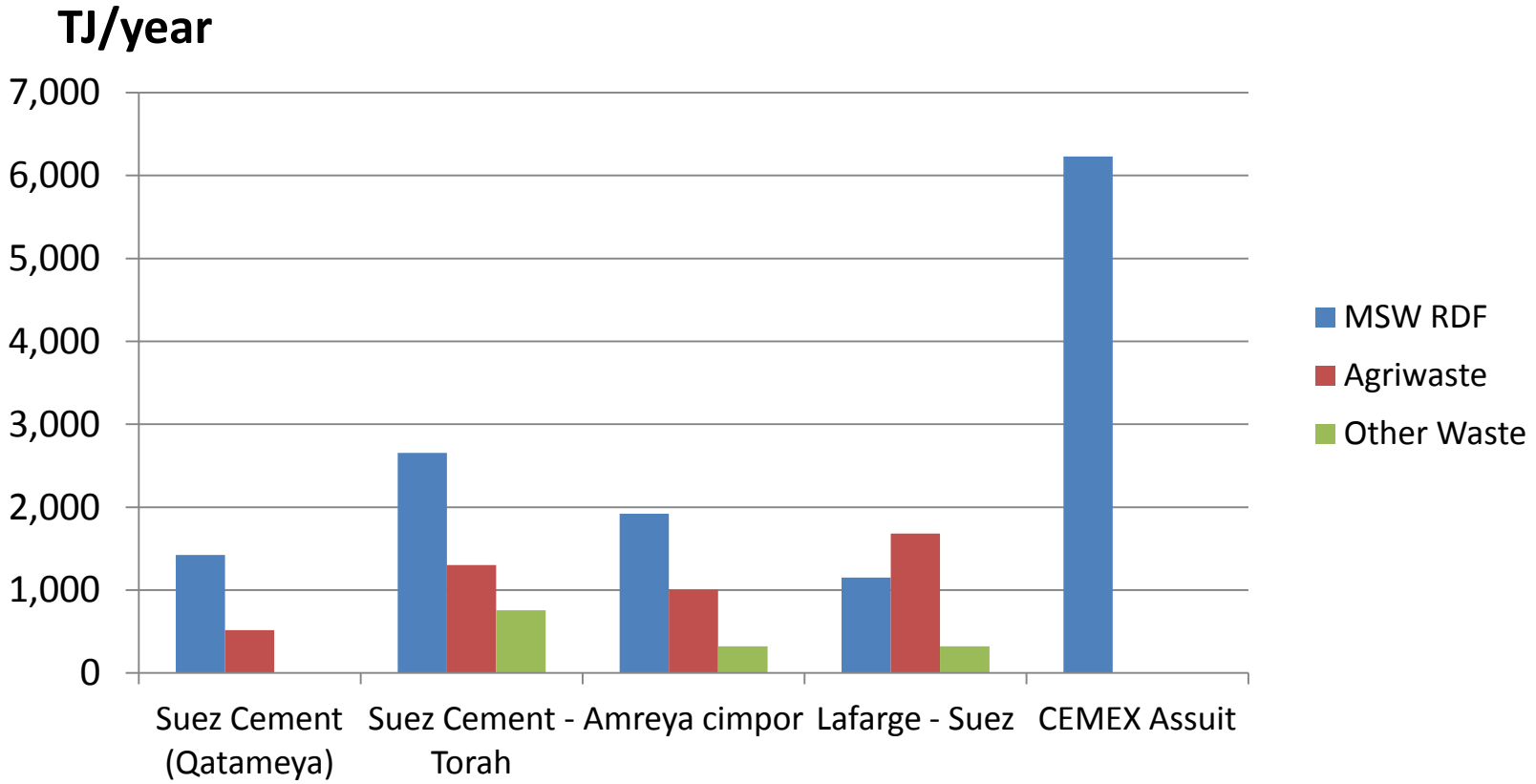
Current energy consumption breakdown by source (biomass/RDF contributions not included)



Estimated breakdown of energy sources in the cement sector in Egypt up to 2010.

Total thermal energy consumption is estimated at around 162,000 TJ/year, with a total consumption of around 185,000 TJ/year.

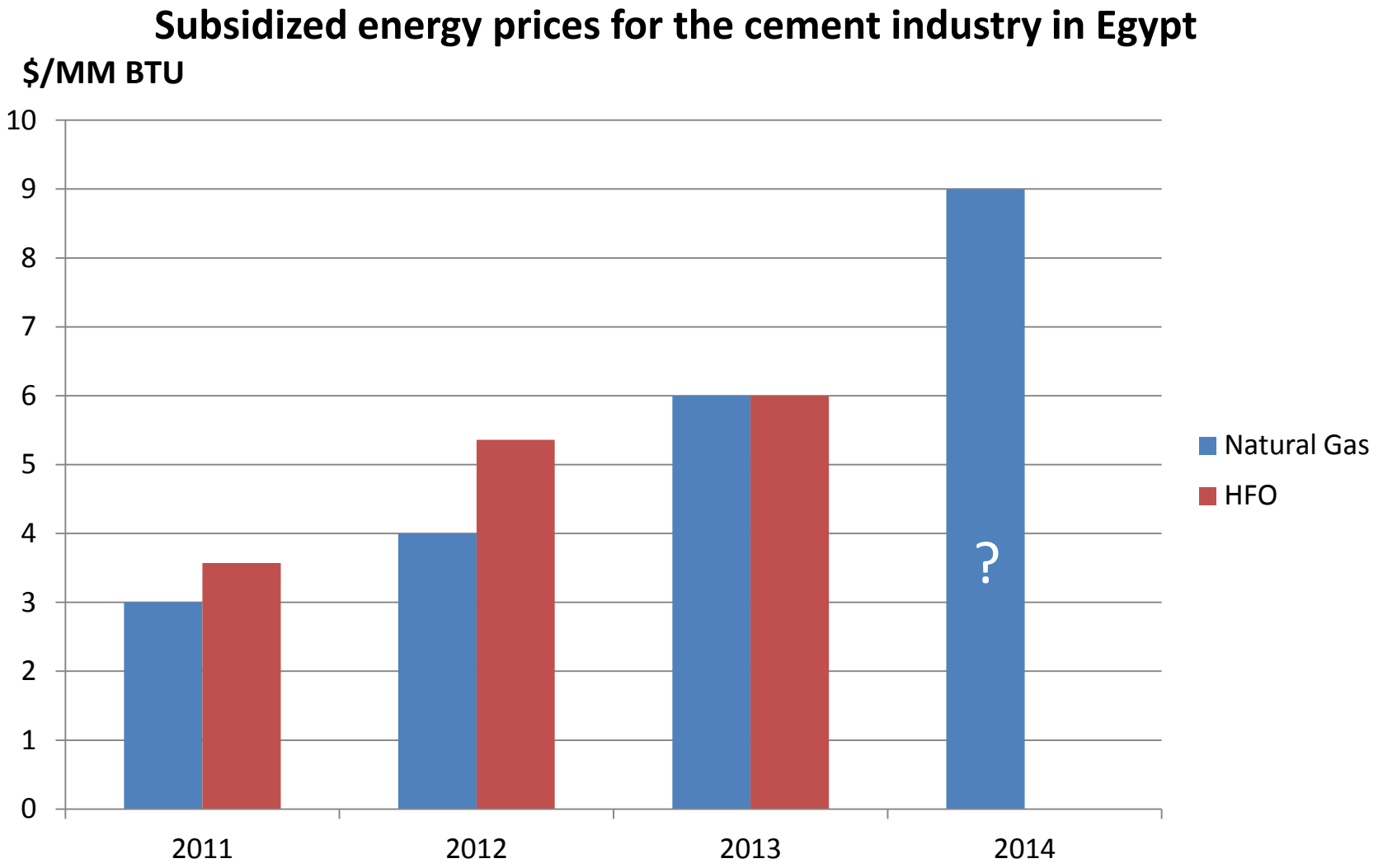
With growing expectations for the removal of energy subsidies, alternative fuels became important for the cement industry.



Substitution rates estimated to reach up to 11% of total thermal energy requirements.

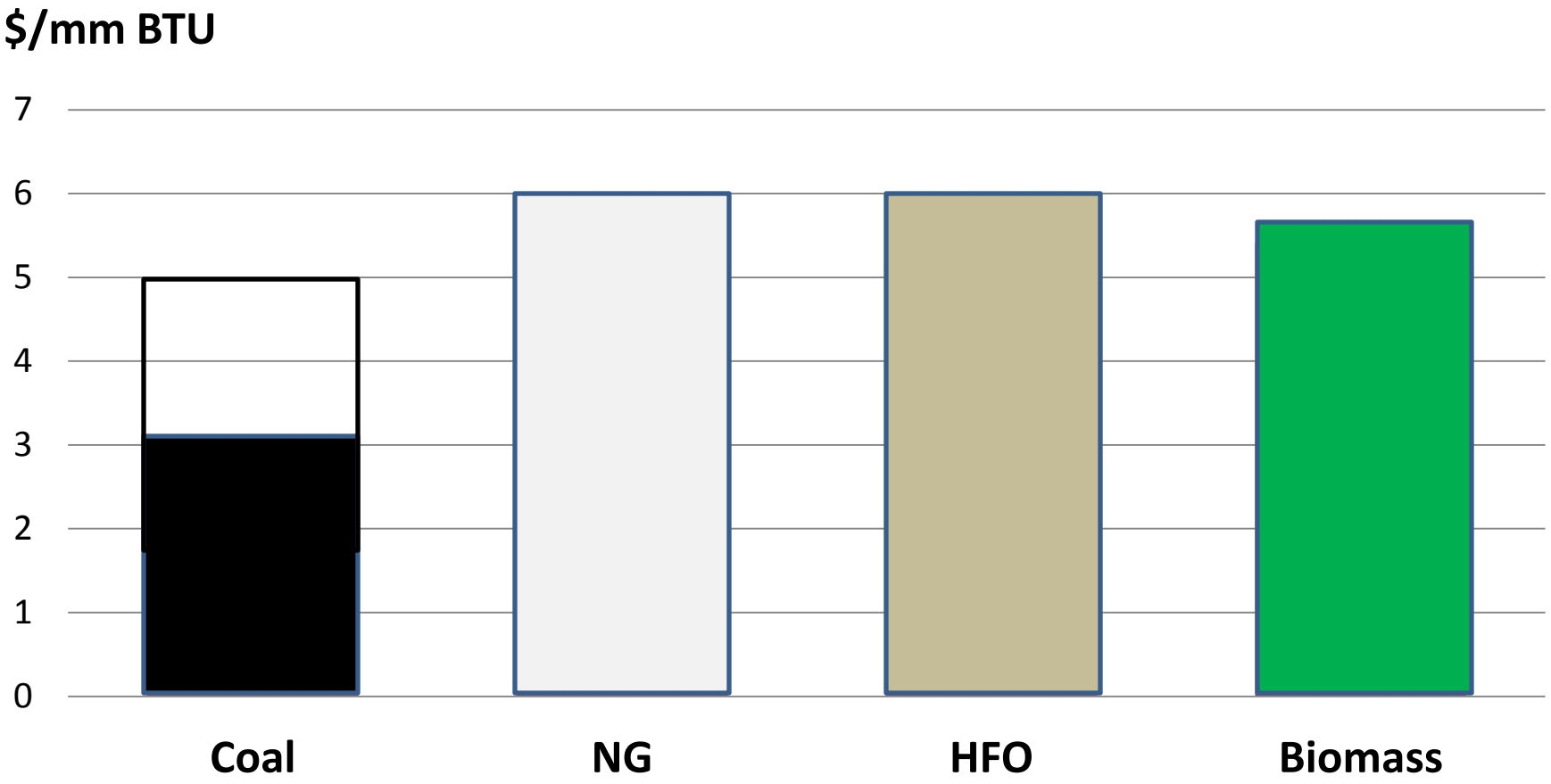
Jago P., Askar Y., "The Cement Industry In Egypt: Challenges and innovative Cleaner Production solutions", ERSCP-EMSU conference, 2010

Egypt is now at a turning point in energy subsidy policy.



Enter Coal

May 2013 Estimated Local Gate Prices of Fuels for Cement



Coal	NG	HFO	Biomass
Local unsubsidized, range for transport cost	Local unsubsidized, or international subsidized	Local subsidized	Local subsidized

Rapid move in the cement industry to switch to coal and realize energy cost savings.

«مصر للأسمنت- قنا» تتلقى 6 عروض لمناقصة إنشاء طاحونة فحم بالمصنع

20 مايو 2013 05:04 م آخر تحديث : 20 مايو 2013 05:14 م

أرسل لصديق طباعة شارك ضبط الخط

مصر للأسمنت – قنا (MCQE)

0.81 1.21% 67.94 MCQE

قال علاء عبدالحميد، مدير عام المصانع بشركة مصر للأسمنت- قنا، إن شركته طرحت كراسة الشروط الخاصة بمناقصة إنشاء طاحونة للفحم بالمصنع لاستخدامه فى الإنتاج بديلاً للمازوت خلال المرحلة المقبلة.

أضاف عبدالحميد فى تصريحات لـ«المال»، أن مصر للأسمنت- قنا تلقت 6 عروض فنية ومالية للمناقصة من شركة «إف ال سميش» الدنماركية المتخصصة فى تأسيس مصانع الأسمنت، وشركات أخرى من فرنسا وألمانيا والتشيك وشركتين صينيتين، مشيراً إلى أن الشركة سوف تبت فى هذه العروض قبل نهاية الشهر المقبل.

وأكد أن الشركة تعمل بجدية للانتهاء من إدخال الفحم للمصانع، فى ظل ارتفاع سعر توريد المازوت المستخدم حالياً ليصل إلى 1670 جنيهاً للطن، مقارنة بـ1000 جنيه منذ ثلاثة شهور، كما سيتم رفع سعر الطن إلى 2600 جنيه مع بداية العام المالى المقبل، ومن المنتظر أن يصل السعر إلى 4000 جنيه بعد إلغاء الدعم الكامل للطاقة على الصناعات كثيفة الإنتاج، وهو ما سيعمل على رفع جدوى الاعتماد على الفحم المرتبط بالأسعار العالمية.

وكشف عن تعاقد الشركة مع أحد المكاتب الاستشارية المحلية من أجل دراسة الوضع البيئى للتوسعات التى ستتبناها الشركة خلال الفترة المقبلة، ومدى تأثيره على

In addition to the above headline, some cement companies have already proceeded to convert clinker mills to coal mills, and another has started storing large amounts of coal.

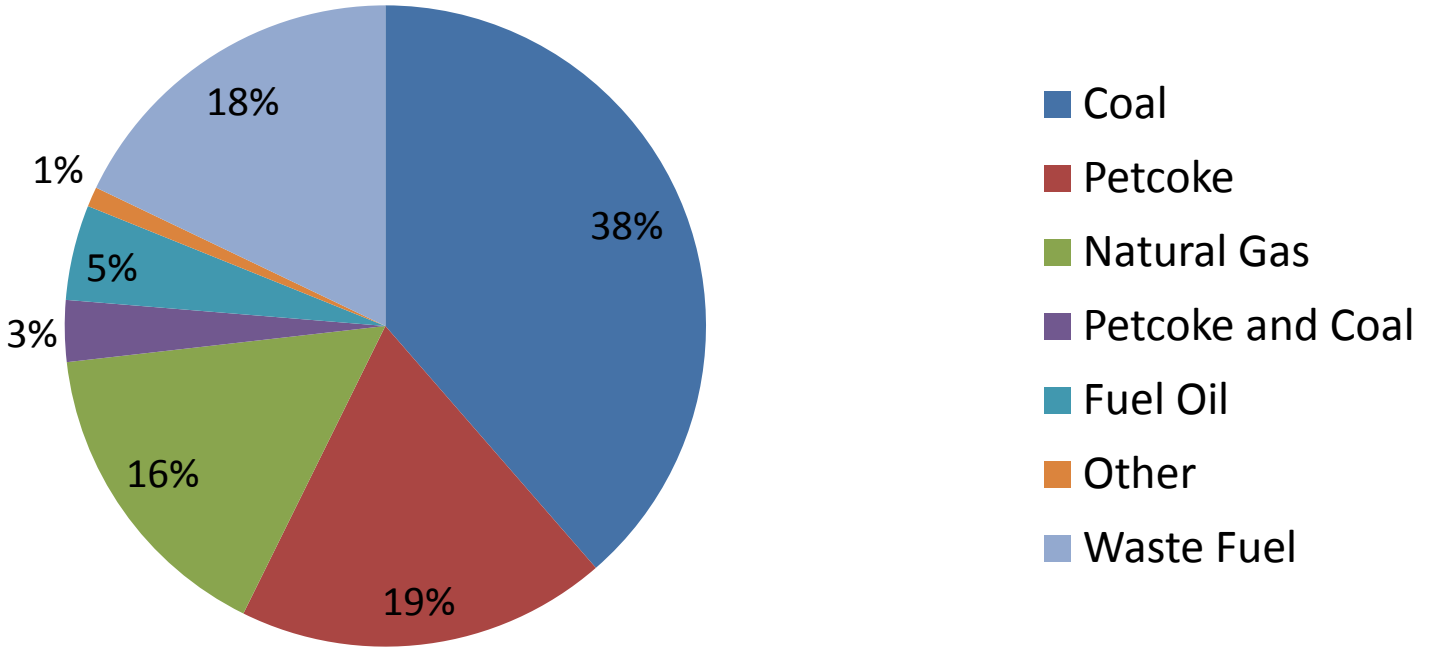
Should Egypt embrace coal as an energy source?

- A question of
  - Energy economics
  - Government deficit reduction
  - Empowering the cement industry
  - Protecting the environment and renewable energy industry
- Must answer the following questions:
  1- What are the benefits and costs of going coal, for the cement industry, the government and society at large?
  2- What are the alternatives, and how much do they cost?
  3- What is the best course of action for government intervention?

International Experience with Cement Energy Requirements

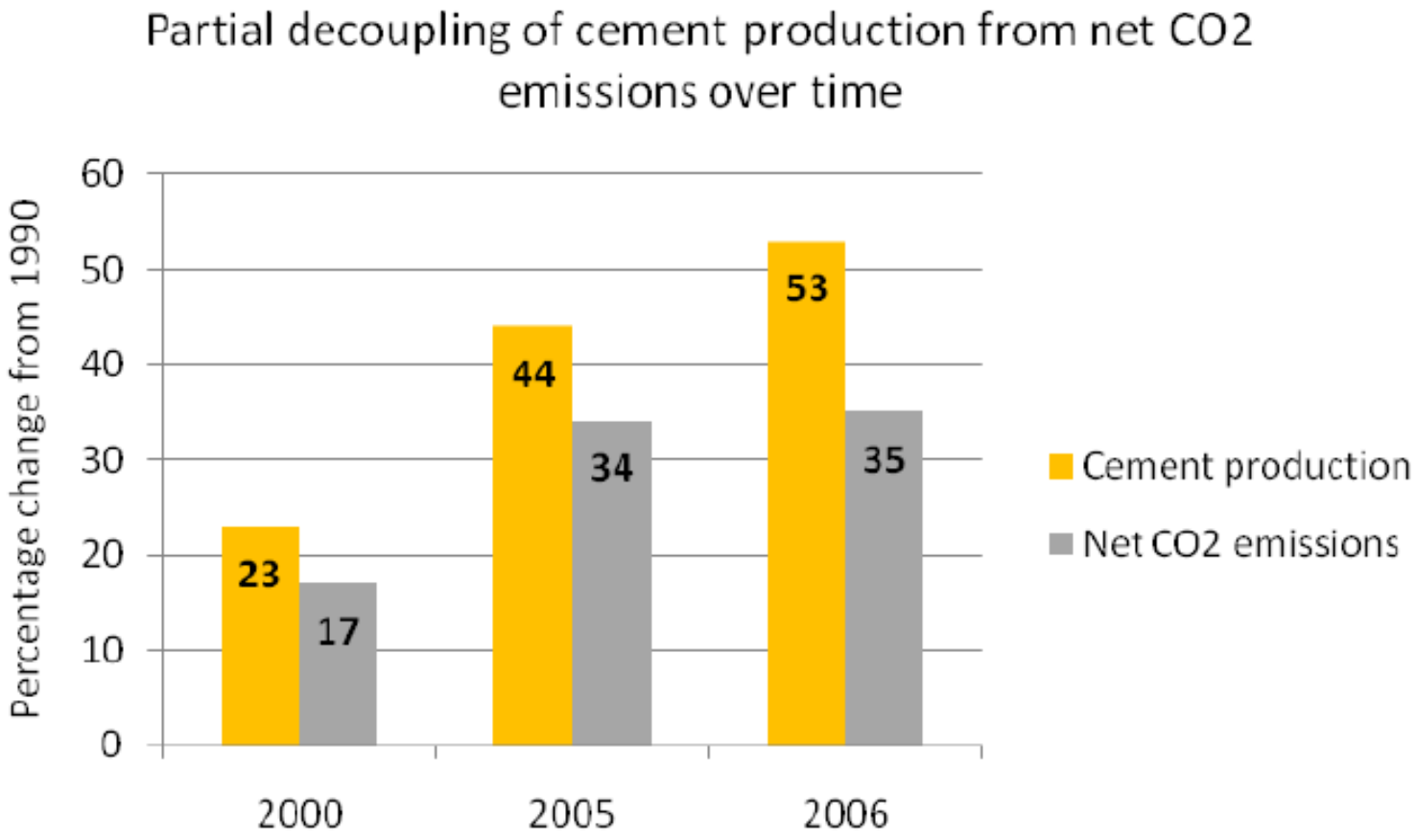
Coal is historically an important component of cement energy.

Breakdown of thermal energy consumption in the international cement industry



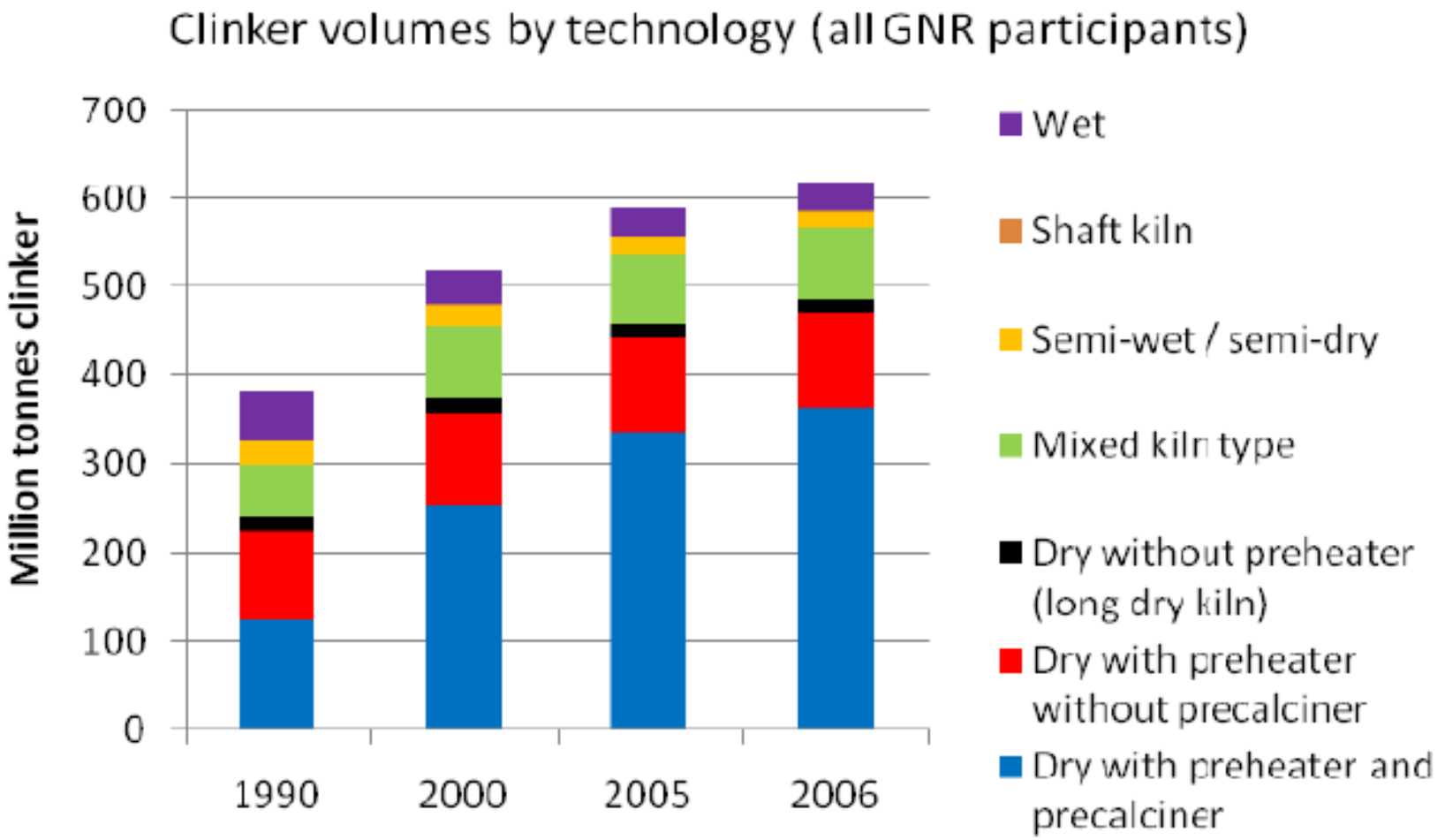
Cement Industry Energy and CO2 Performance "Getting the Numbers Right" The Cement Sustainability Initiative - World Business Council for Sustainable Development, 2006

The international trend is moving away from coupling cement to carbon dioxide generation



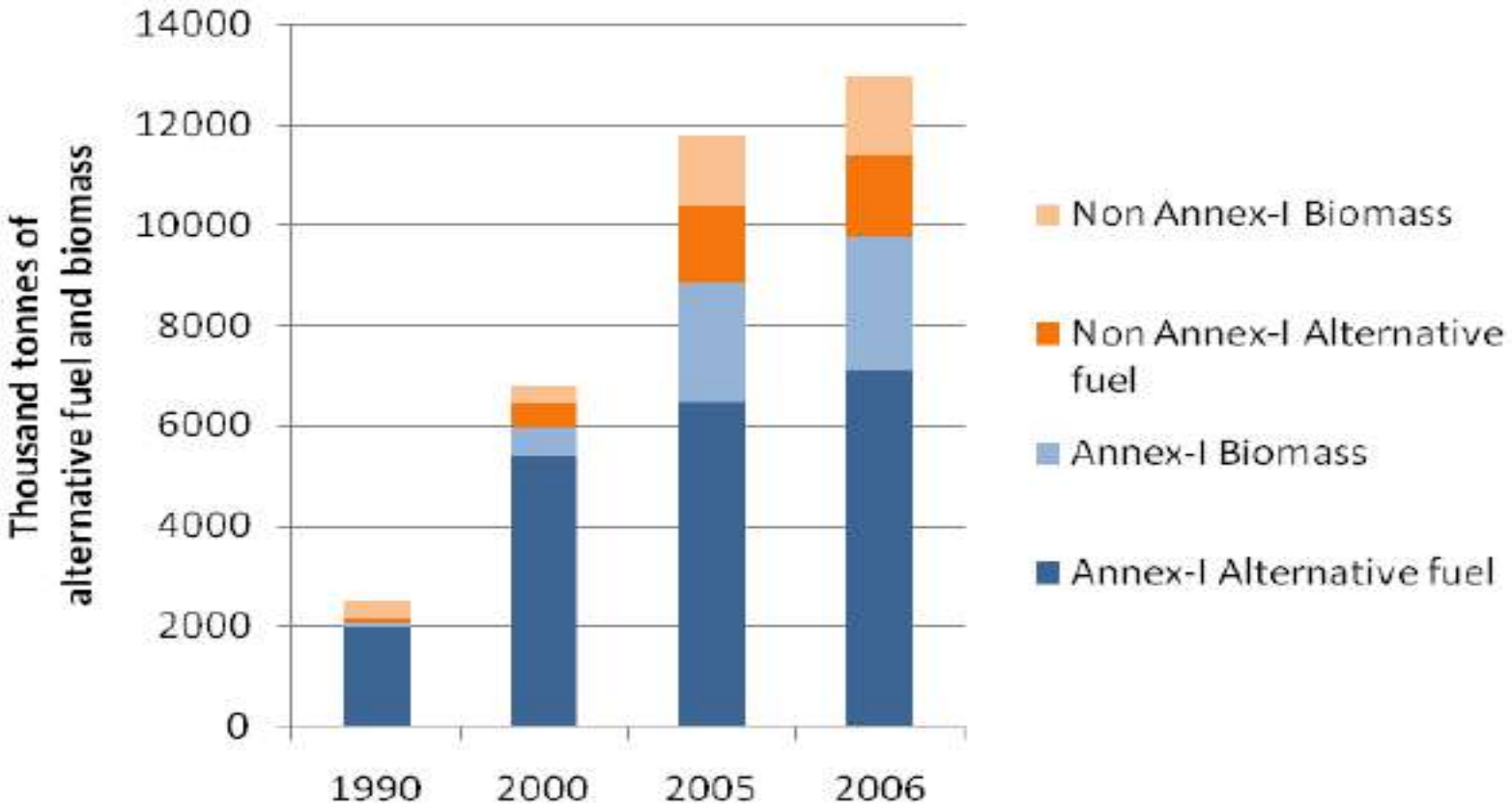
Cement Industry Energy and CO2 Performance "Getting the Numbers Right" The Cement Sustainability Initiative - World Business Council for Sustainable Development, 2006

The first carbon-reduction trend is higher energy efficiency technology



Cement Industry Energy and CO2 Performance "Getting the Numbers Right" The Cement Sustainability Initiative - World Business Council for Sustainable Development, 2006

The second carbon-reduction trend is utilizing alternative solid fuels



Annex-I and non Annex-I countries according to the Kyoto Protocol classification.

Cement Industry Energy and CO2 Performance "Getting the Numbers Right" The Cement Sustainability Initiative - World Business Council for Sustainable Development, 2006

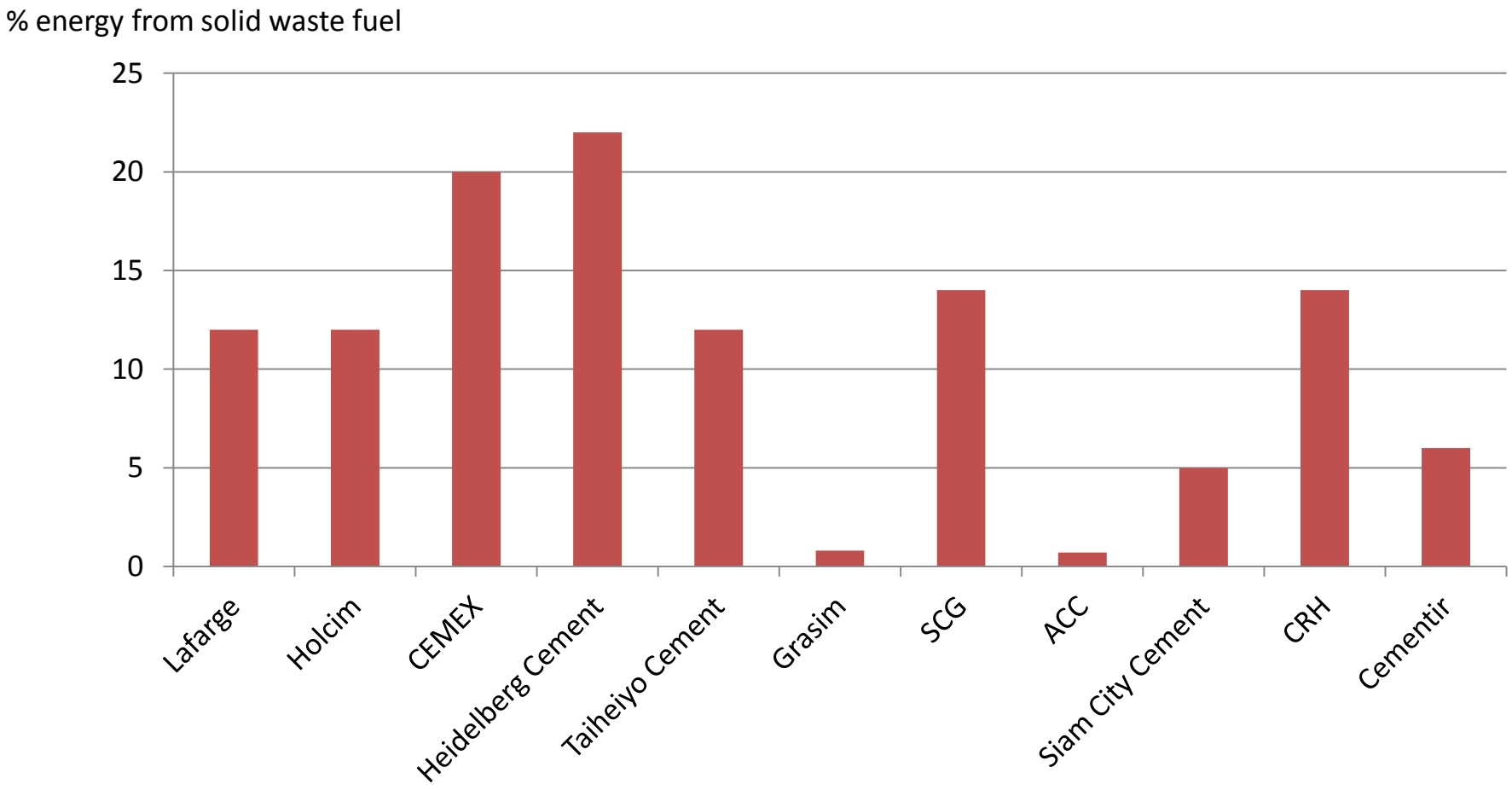
International Experience with Alternative Solid Waste Fuel

- Europe has reached substitution rates ranging from 35% to more than 70% of the total energy used.
- In Uganda, the Hima cement plant has reduced fossil fuel consumption by 30% by using coffee bean husks as an alternative fuel.
- In Malaysia, part of the coal used in the cement plants of Rawang and Kanthan has been replaced by biomass (palm kernel shells). This initiative was approved as a Clean Development Mechanism (CDM) project in April 2007.
- In Brazil, a waste management joint venture, Eco-Processa, supplies plants with substitute fuels. In some cement plants in Brazil, 42% of the fuel used comes from biomass or waste.

(Taylor *et al, 2006);* Lafarge, 2008

Cement producers globally are moving towards using more alternative solid waste fuels.

Alternative Solid Waste Fuel Energy in the International Cement Industry



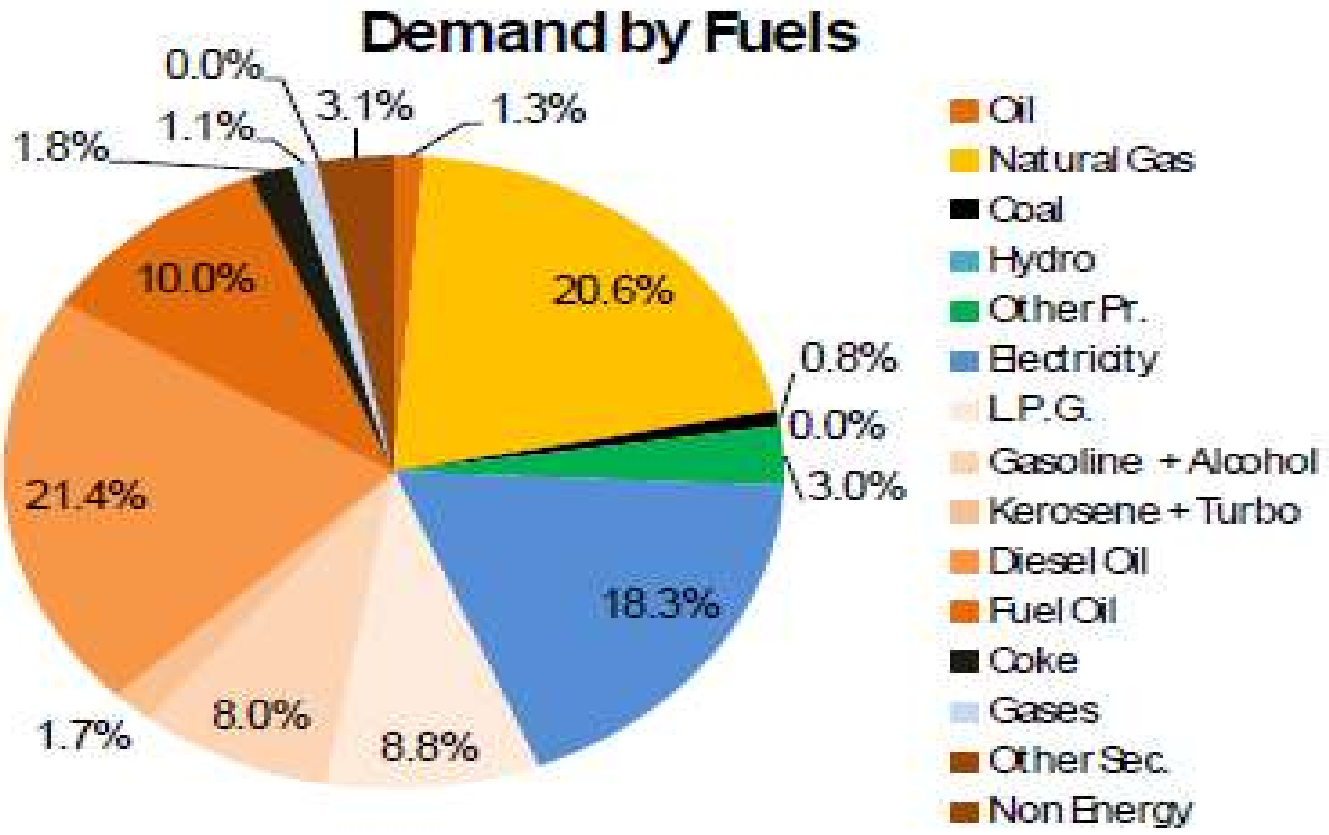
Cement Industry Energy and CO2 Performance "Getting the Numbers Right" The Cement Sustainability Initiative - World Business Council for Sustainable Development, 2006

Summary of international experience

- Coal is an important component of global cement energy, but the trend is to move away from it.
- Biomass and RDF are gaining traction globally, driven by oil prices, national policy and strategic corporate commitments.
- 20% substitution rate by biomass for fossil fuel was proven to be feasible since 2003, substitution rates greater than 50% have been achieved but requires special technology and control systems (Demirabas 2003).

Analyzing Energy Alternatives in Egypt: Coal

Coal currently accounts for only 1.8% of Egypt's total primary energy demand.



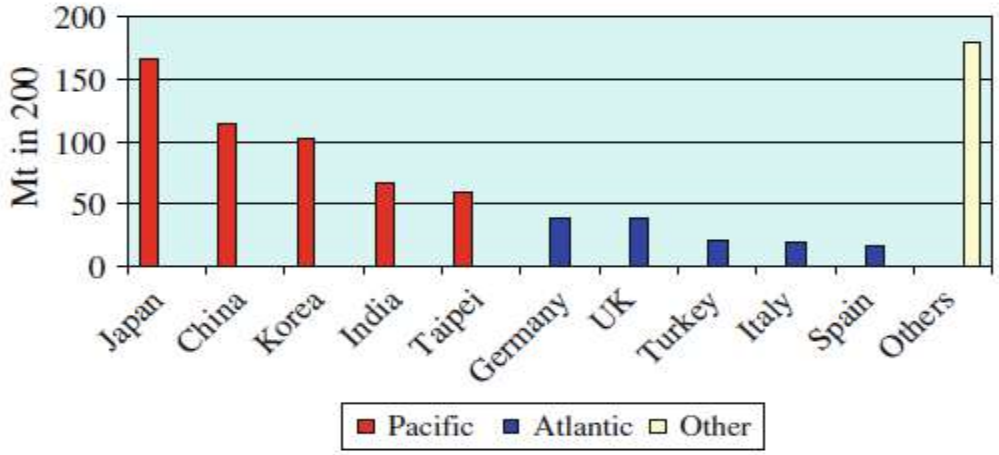
Egypt produces negligible amounts of coal, and imports effectively all its coal requirements.

"Impact of Energy Demand on Egypt's Oil and Natural Gas Reserves "- Egyptian-German Joint Committee on Renewable Energy, Energy Efficiency and Environmental Protection, 2010

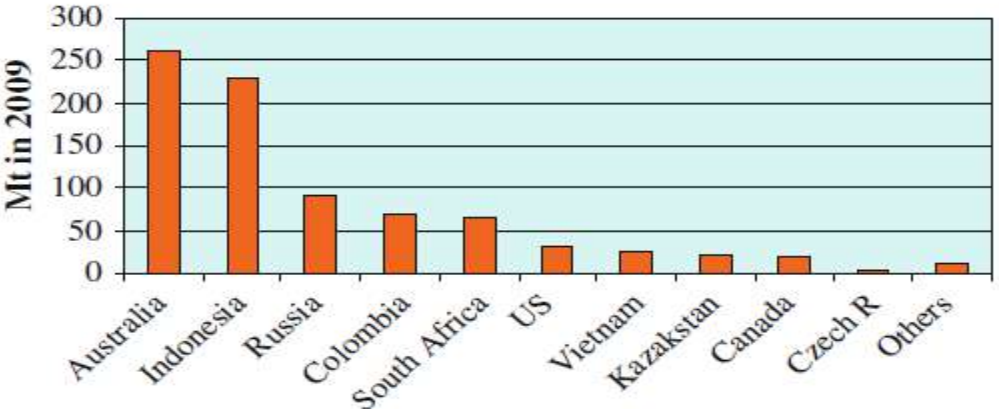
Current coal supply chain cannot support the significant amounts required.

- For example, if the cement industry substitutes 50% of its current thermal requirements (around 160,000 TJ/year), it will require around 2.9 million tonnes of (at 27 GJ/ton) coal per year.
- Expanding the current supply chain likely to utilize Nile river cargo ships, or build new facilities on the red sea.

Major Coal Importers



Major Coal Exporters



International Energy Agency, 2009

Switching to coal-firing is a significant and long-term investment.

- Cost of changing kilns to coal is hard to estimate because of lack of published data. Using coal for cement energy is widespread, but switching to coal is not a common choice.
- Switching to coal is likely to involve a replacement of the kiln burner, and a modification of the pre-calciner. In addition, equipment for coal pulverization, size control and on-site conveying will be required.
- Switching kilns to coal requires state-of-the-art technology to minimize safety risks, and is likely to be a long-term investment.
- Further research and analysis is required to survey pollution abatement technologies for coal usage in cement production, their efficiecny and their relative costs.

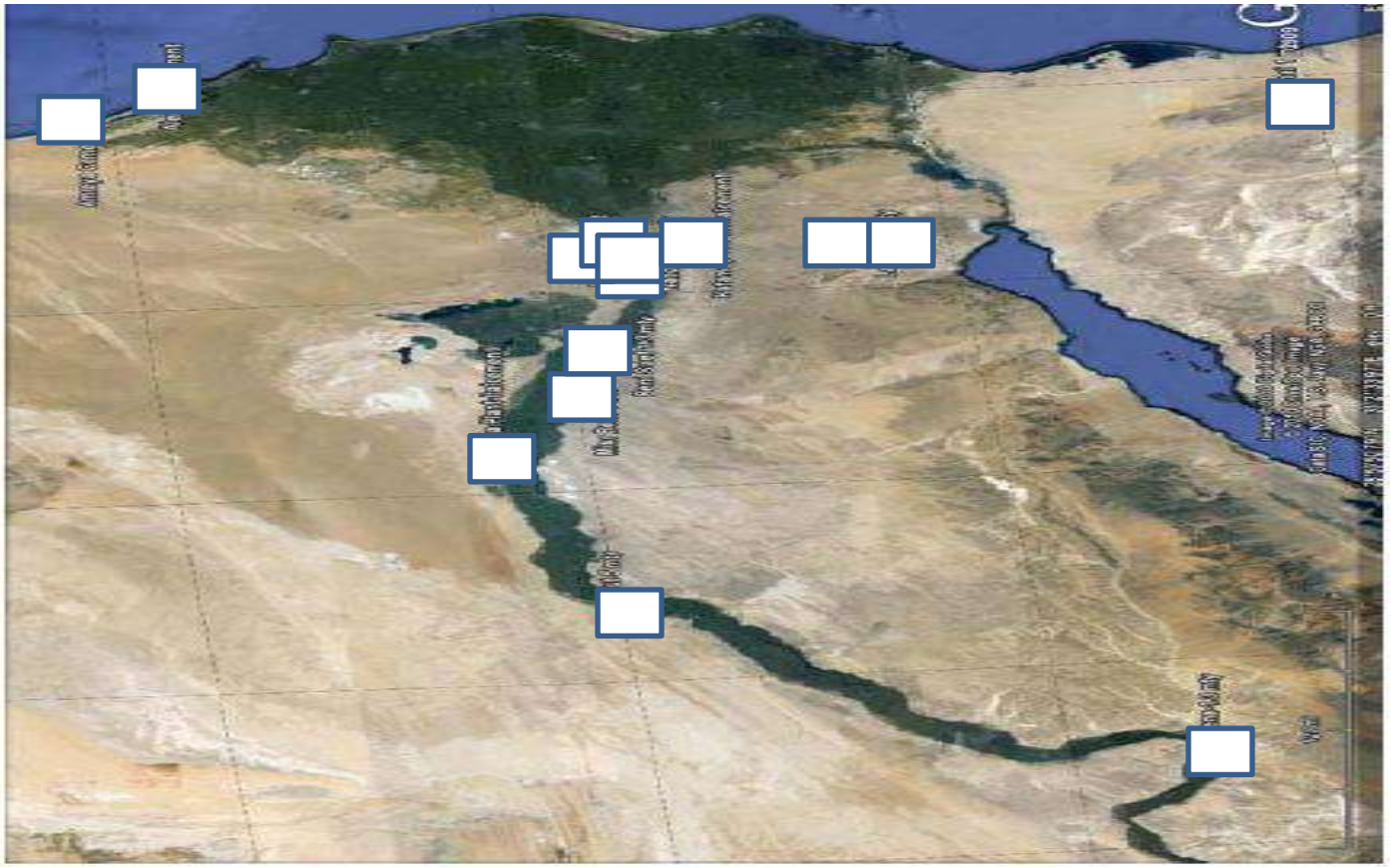
External costs of coal combustion have been well studied internationally.

- In the US, for example, a study by researchers at the Harvard Medical School found that coal power is also responsible for much of the emissions of $PM_{2.5}$ *(51%), NOx* (35%), and SO_2 (85%).
- **Public health damages** include increased mortality and morbidity due to combustion pollution; hospitalization costs resulting from increased morbidity in coal communities and higher frequency of sudden infant death syndrome in areas with high quantities of particulate pollution.
- Destruction of marine life from mercury pollution.

Epstein et. al, "**Full cost accounting for the life cycle of coal",** Annals Of The New York Academy Of Sciences, 2011

Coal externalities have not been analyzed in detail in the Egyptian context.

- Environmental and health impacts will vary according to proximity to population centers.



Epstein et. al, "**Full cost accounting for the life cycle of coal",** Annals Of The New York Academy Of Sciences, 2011

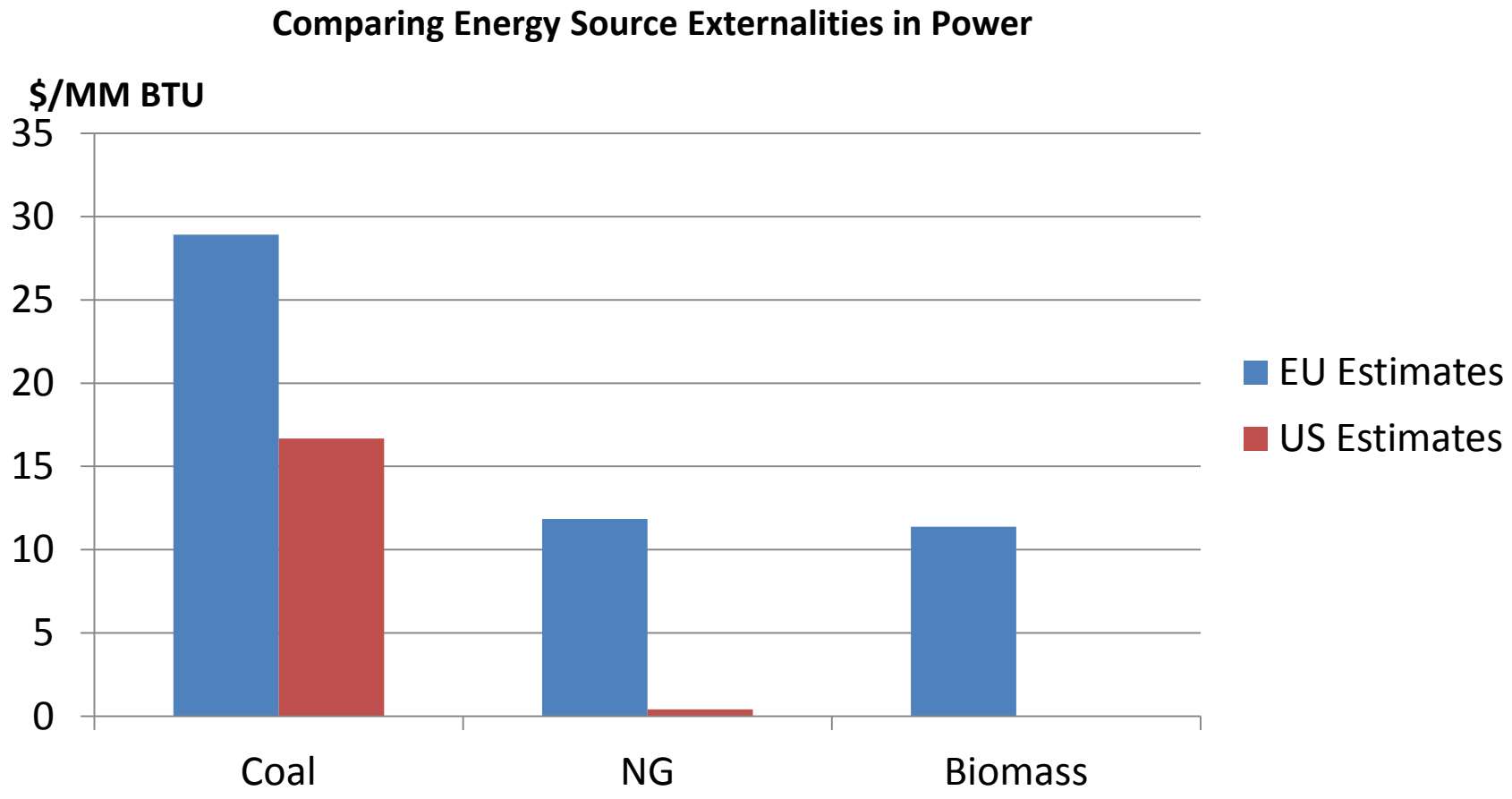
Coal externalities have a monetary value.

- International low-end estimates of environmental external costs from coal combustion only amount to:
  - Climate change: $1.16/GJ
  - Air pollution: $2.10/GJ (Harvard Medical School Study) – $8.89/GJ (American National Research Council)
  - Mercury: $0.83/GJ
- Coal externalities are dependent on proximity to population centers, and the population concentration of those centers.
- Detailed analysis is required to accurately estimate the monetary value of coal externalities in the Egyptian context.

National Research Council on behalf of the American Congress, "Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use", 2009

Epstein et. al, "**Full cost accounting for the life cycle of coal",** Annals Of The New York Academy Of Sciences, 2011

Estimates for coal externalities in international studies are significantly higher than for NG and Biomass.



National Research Council on behalf of the American Congress, "Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use", 2009

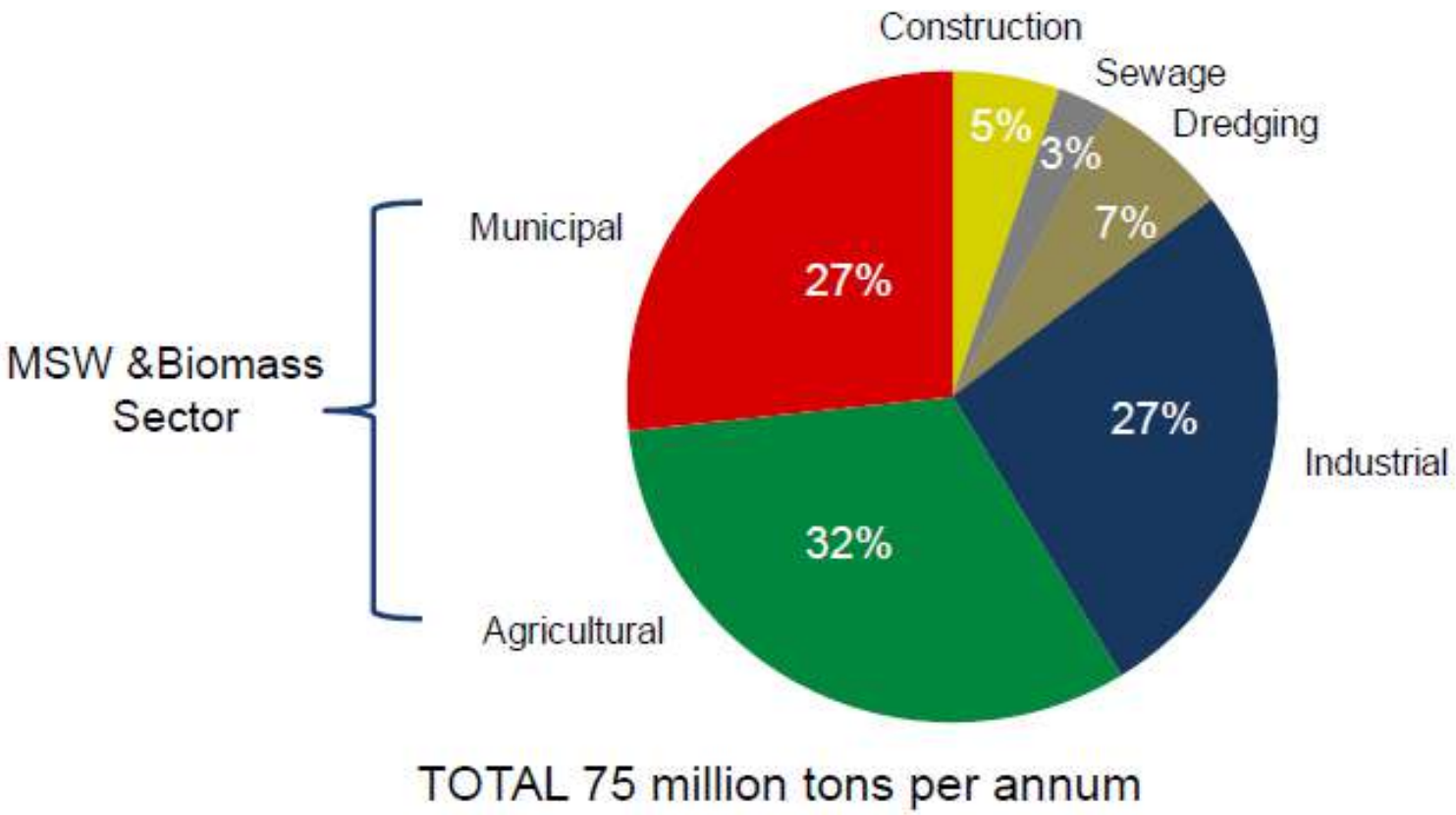
Sundqvist, T., Soderholm P., "Valuing the environmental impacts of electricity generation: a critical survey", The Journal of Enegry Literature, 2002

Coal for the cement industry might mean coal for the rest of the industrial sector, plus the energy sector.

- Using coal for power generation in Egypt can rapidly expand if unregulated to include most of the other energy-intensive industries and the power generation sector.
- Total possible expansion can reach up to 960,000 TJ, or around 29% of total primary energy in Egypt.
- Such an expansion will burn around 35 million tonnes of coal per year and cause significant health and environmental costs of water, soil and air pollution.
- A large-scale adoption of coal is also likely to limit the growing local renewable energy industry in Egypt.
- **A coal-driven economy in the 21st century is not a small decision.**

Analyzing Energy Alternatives in Egypt: Alternative Solid Waste Fuel

Egypt produces over 20 million tons/year of MSW and more than 25 – 30 million tons/year of biomass.



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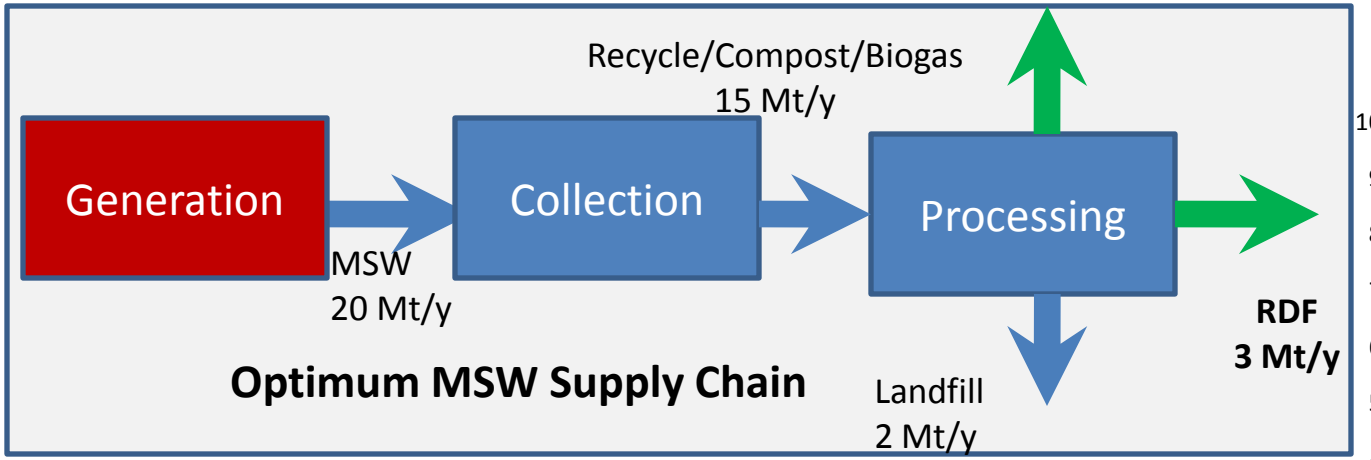
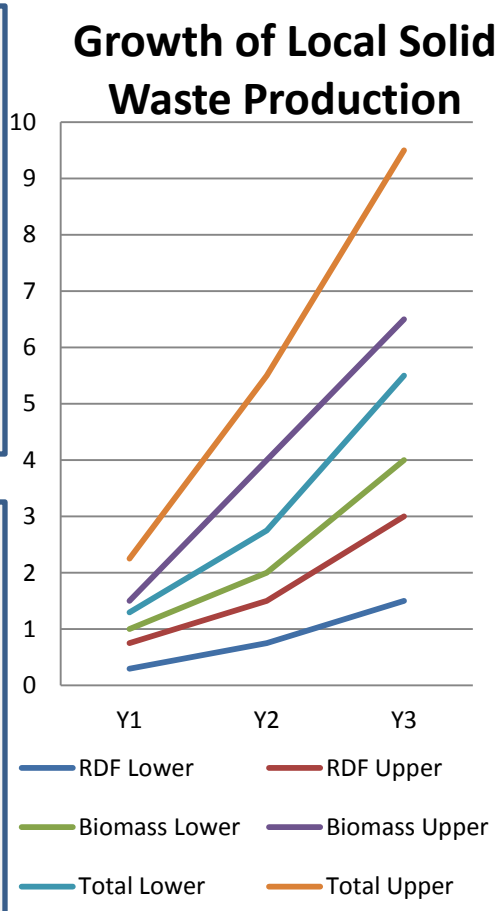
At least around 3 million tons/year of RDF and 6 million tons/year of Biomass can be available within 3 years, enough for high substitution in the cement industry.





Chemonics Research - 2013

For solid waste fuel substitution rates, controlling the properties of the fuel is critical.

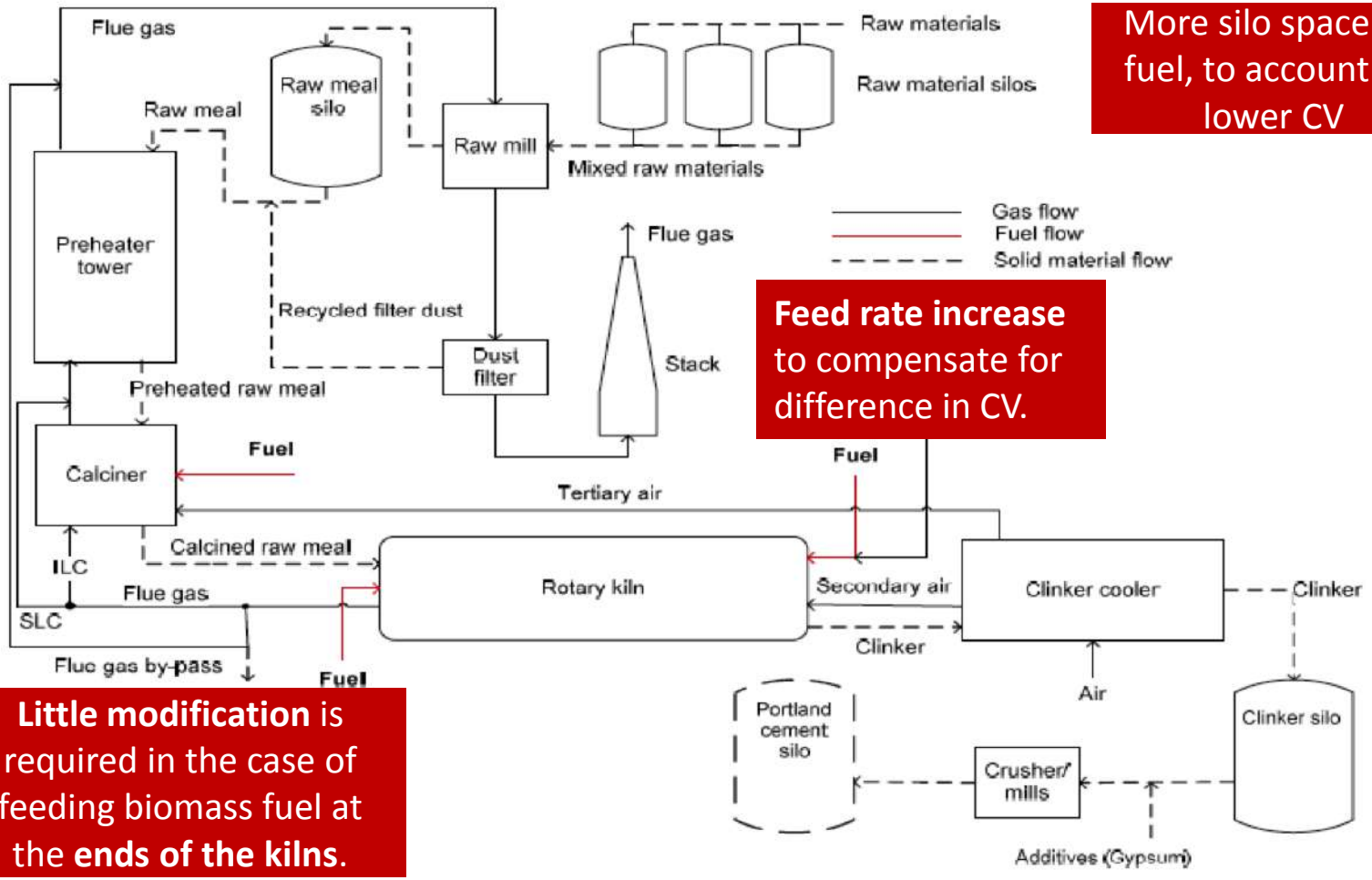
Preprocessing of solid waste fuel

- **Particle size** must be carefully **controlled** for efficient burning.
- The relatively higher moisture will result in larger heat losses, and therefore **moisture content must be controlled.**
- A major challenge, when considering direct combustion of biomass fuels in clinker kilns, is the **amount and nature of fuel ash** produced in the kilns.
- It is possible to prepare solid fuel mixes with properties optimized for firing, by preprocessing of different wastes to produce SRF.
- **The increase in levelized cost of energy over a period of 5 years in published case studies is around $1/GJ**.

RDF and biomass products in Egypt

"Biomass Energy For Cement Production: Opportunities In Ethiopia", UNDP Report

For low solid waste fuel substitution rates, some modifications to the kiln are required



More silo space for fuel, to account for lower CV

Feed rate increase to compensate for difference in CV.

Little modification is required in the case of feeding biomass fuel at the **ends of the kilns**.

"Biomass Energy For Cement Production: Opportunities In Ethiopia", UNDP Report

Full substitution with solid waste fuel is difficult with current cement technologies.

- Some fuel ash can be added to the raw meal without any problems arising.
- However, the content of the fuel ash is crucial in determining the amount that can be added to **avoid significantly affecting the chemical composition** of the final product.
- Ash and Metal composition can change product quality.

Source: Egypt new &renewable energy authority (NREA)

Solid waste fuels have many positive environmental, social and economic externalities.

- Biomass and MSW are mostly burnt in open fields in Egypt. Any form of controlled utilization will have a net positive environmental impact.
- Using biomass and RDF in energy production creates a driving force in the MSW and agri-waste collection system and increases its efficiency.
- The World Bank estimated the cost of the current MSW system failures at 0.7% of GDP, or around 11.3 billion EGP/year.
- Create real jobs in collection, processing, manufacturing and agriculture.
- Better energy security: utilizing biomass reduces reliance on for foreign currency and foreign supply.

Part 2: Comparing Government Intervention Scenarios for Egypt

List of Policy Intervention Scenarios

1- Laissez Faire: government lets market decide.

2- Cap on Coal.

3- Coal Externalities Tax.

4- Carbon Tax.

5- Cement Industry Expert Perspective.

6- No Coal, Natural Gas Subsidy.

7- No Coal and No Subsidy.

Methodology for comparing policy intervention scenarios.

- Policy intervention sets fuel prices and limitations on coal.
- A fuel mix is assumed in each scenario based on the expected response by the cement industry to the relative fuel prices.
- Baseline scenario costs for the Ministry of Finance and the cement industry are calculated based on the current fuel mix and prices.
- The cost to the cement industry is calculated based on the new fuel prices, and compared to the baseline cost to find the net gain/los. The cost of fuel switching was not included.
- The cost to the Egyptian Ministry of Finance is calculated based on as the difference between global and subsidized prices of fuels, and compared to the baseline cost to find the net gain/loss
- Calculate social cost based on estimates outlined external costs of coal.

Methodology steps for comparing policy intervention scenarios.

1. Baseline scenario estimates.
2. Set new fuel prices based on policy intervention.
3. Set fuel mix based on prices and policy.
4. Calculate new cost to government.
5. Calculate net cost/gains to government relative to baseline.
6. Calculate new cost to cement industry.
7. Calculate net cost/gains to cement industry relative to baseline.
8. Calculate external costs of coal.

Baseline Scenario Costs

- Current energy breakdown estimates

Natural Gas	HFO	Coal	Solid Waste
58%	29%	0%	13%

- Current local-basis fuel price estimates

Natural Gas	HFO	Coal	Solid Waste
$6/MM BTU	$6/MM BTU	$4.8/MM BTU	$5.4/MM BTU

- Current global-basis fuel price estimates

Natural Gas	HFO	Coal	Solid Waste
$9/MM BTU	$12/MM BTU	$4.8/MM BTU	$5.4/MM BTU

Metrics

- Price to consumer (how much cement industry will pay).
- Price to government (deficit reductions and taxes).
- Price to society (economic multiplier and externalities).

Model Limitations

1. External costs of coal require detailed extensive research to develop a reliable estimate.
   For the purposes of this model, lower-bound values from international studies were used. Those numbers underestimate the impact in Egypt due to the higher population density and the relatively higher baseline of pollution and public health hazards.
2. Positive economic multipliers and positive externalities of utilizing biomass and MSW RDF were not included, and are likely to be significant.
3. The direct investment costs for switching from one type of fuel to another were not included.
4. The indirect investment costs to develop a supply chain for large scale consumption of coal were not included.

Scenario 1: Laissez Faire (Let the market decide)

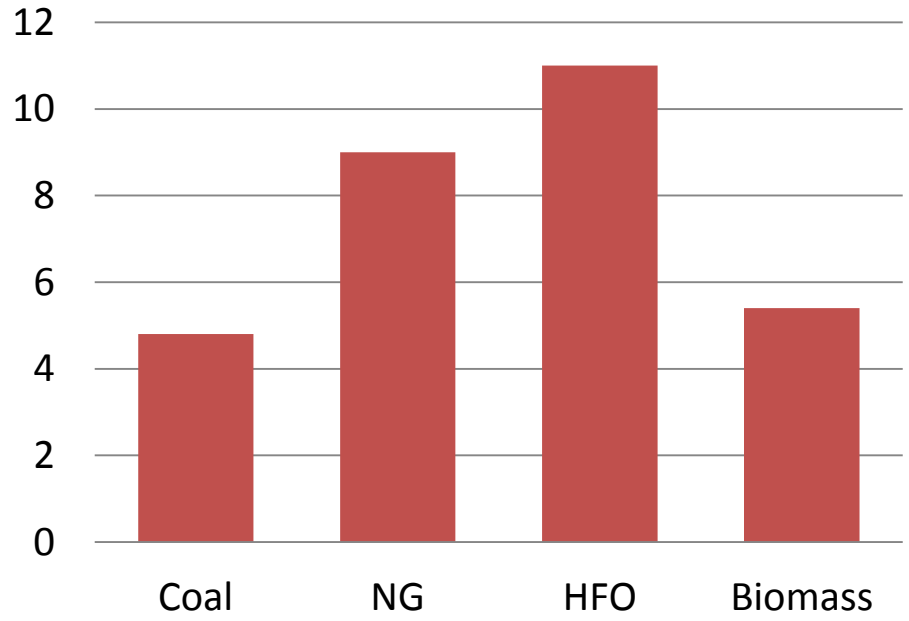
Assumptions

1- Government eliminates all subsidy and policy is neutral towards coal.

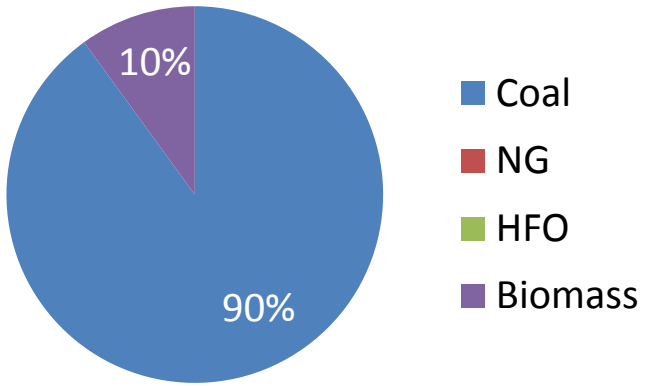
2- Industry switches all natural gas and HFO to coal, maintains investments in biomass.

Scenario 1 Energy Prices

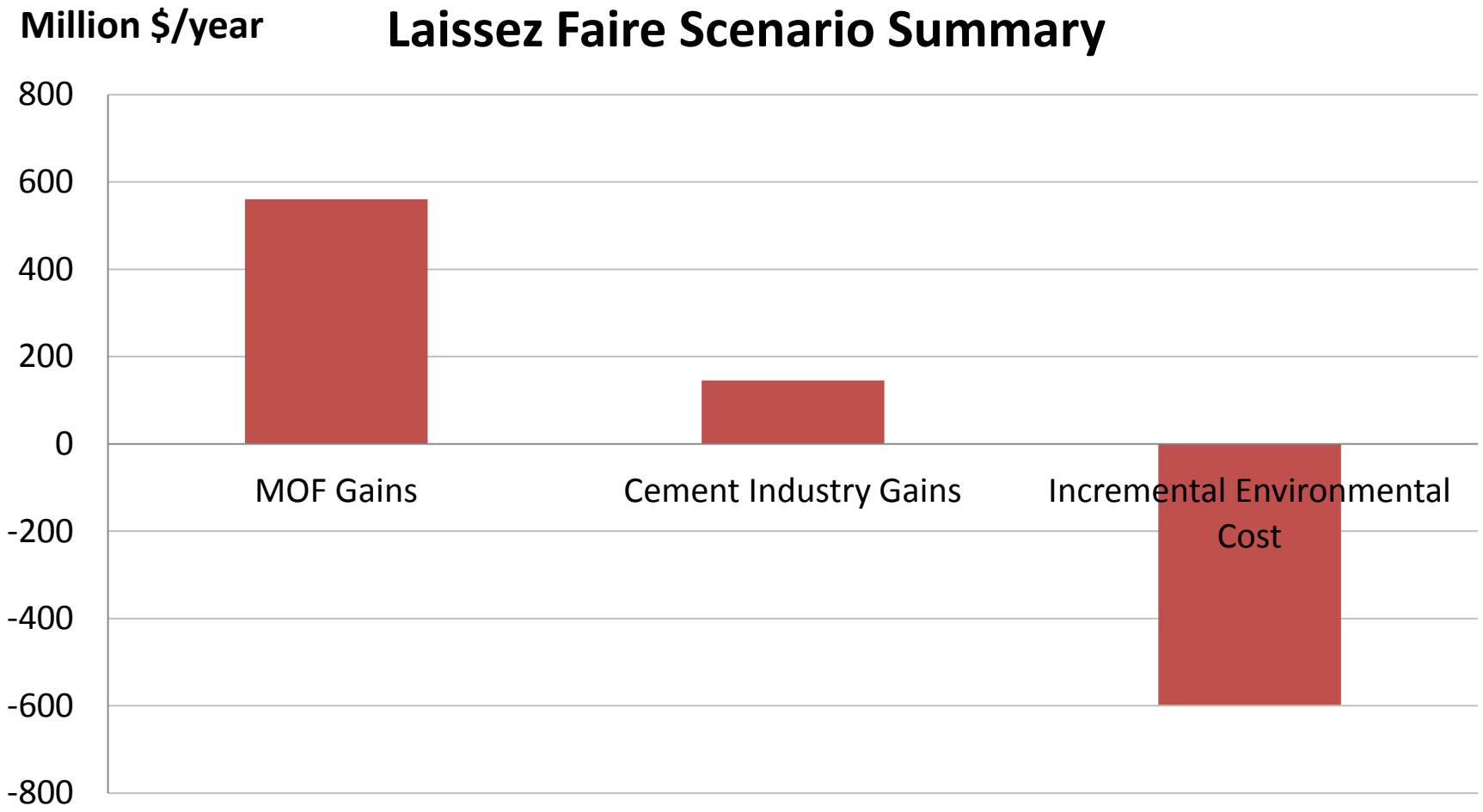
$/mm BTU



Scenario 1 Assumed Energy Consumption Breakdown



Scenario 1: Let the market decide strategy allocates most of the real cost to society.



Scenario 1: The Laissez Faire strategy will likely result in an uncontrolled expansion of coal usage.

- The rest of the industry and power sector are likely to follow.

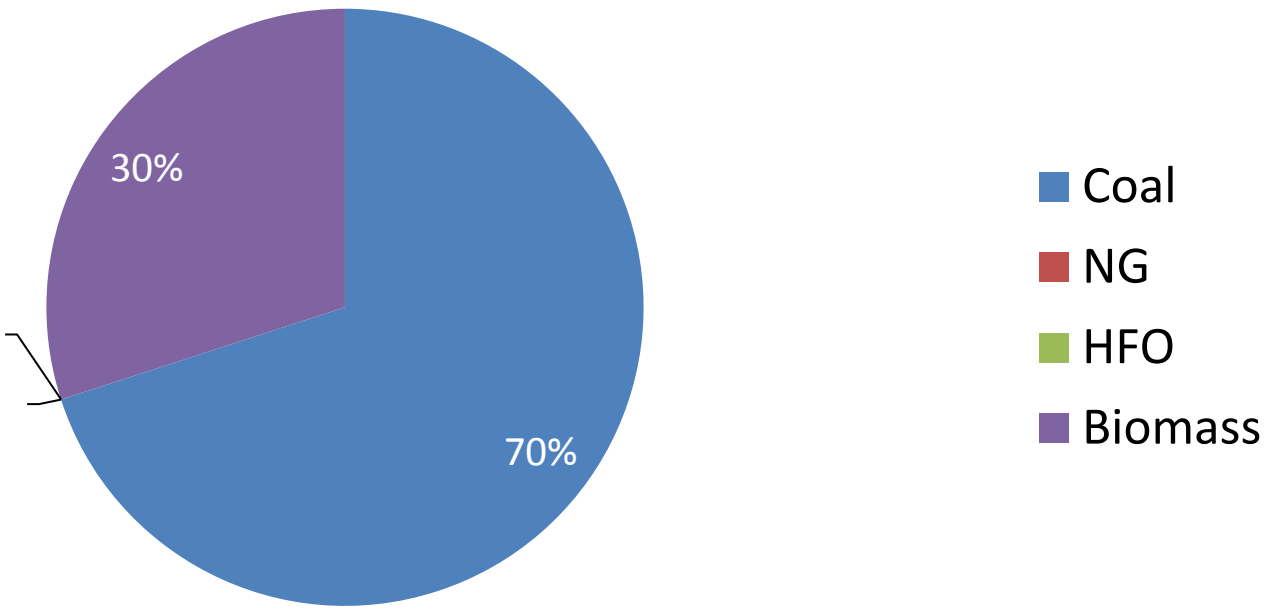
- It requires extensive analysis to estimate the environmental, social and economic effects of a coal-economy, and the full potential impact on the growing renewable energy industry, but the external costs are expected to be prohibitive, particularly for the Nile Delta region.

Scenario 2: Cap on Coal

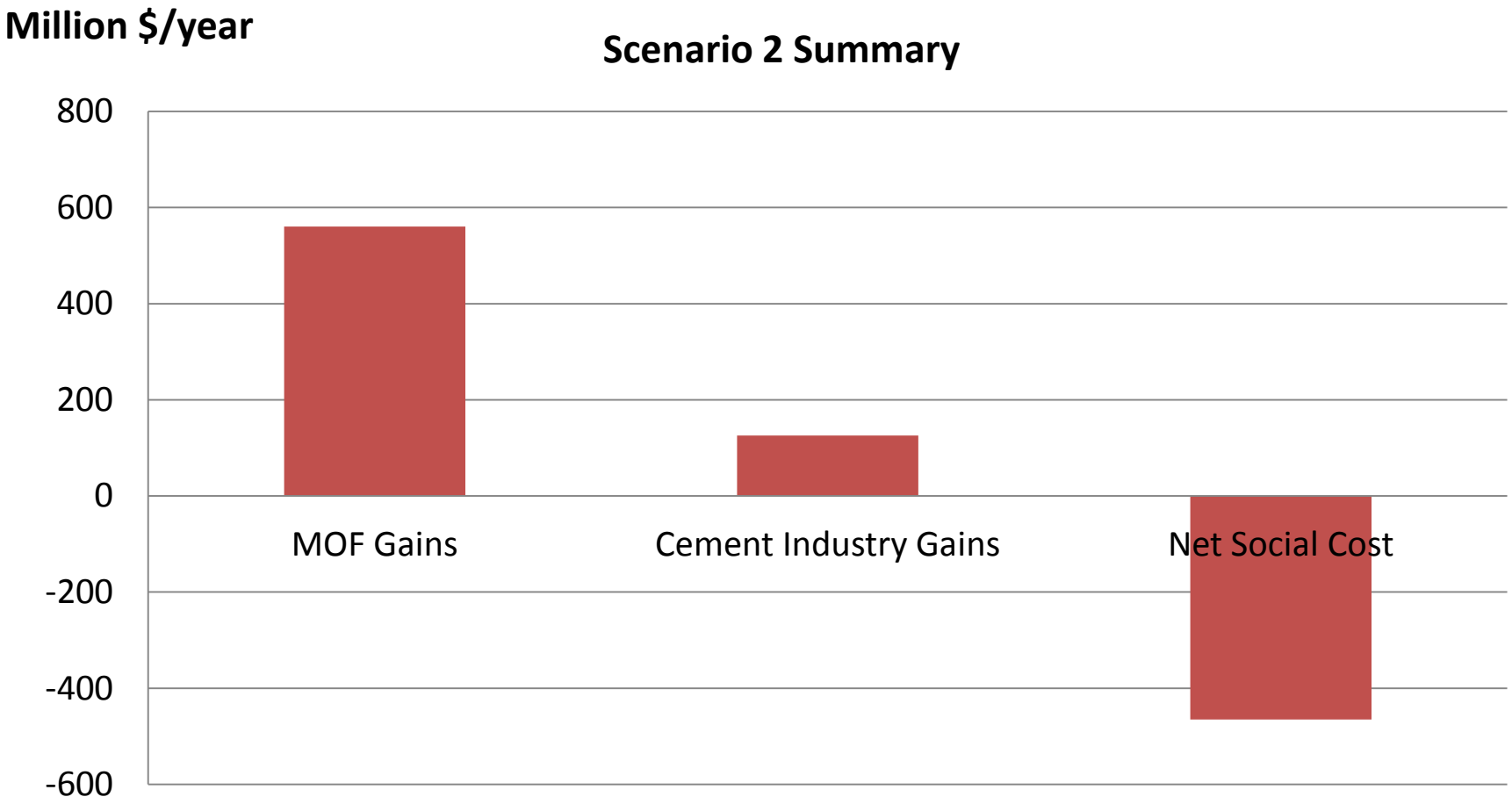
- **Assumptions**

1- Government eliminates all subsidy and but imposes an upper limit on coal usage equal to 70% of thermal energy requirements of the cement sector.

Scenario 2 Assumed Energy Consumption Breakdown



Scenario 2: Cap on coal to set a ceiling for social cost.

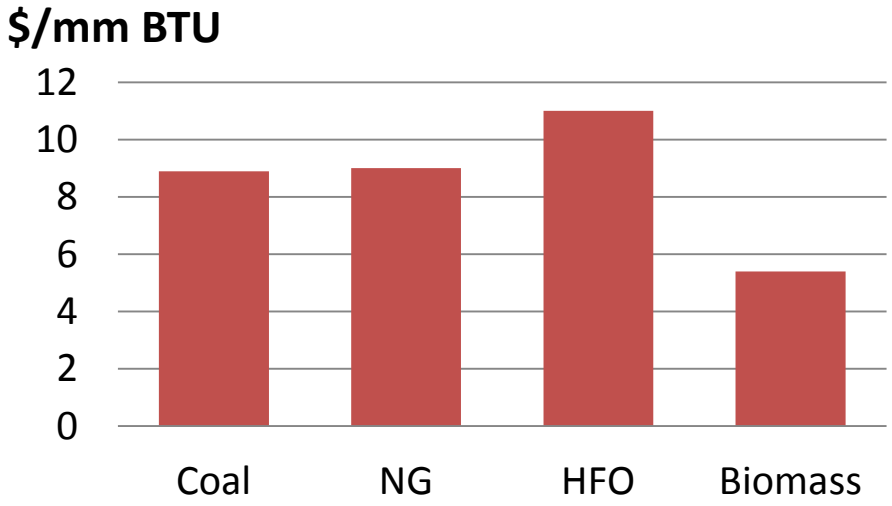


Scenario 3: Coal externalities tax

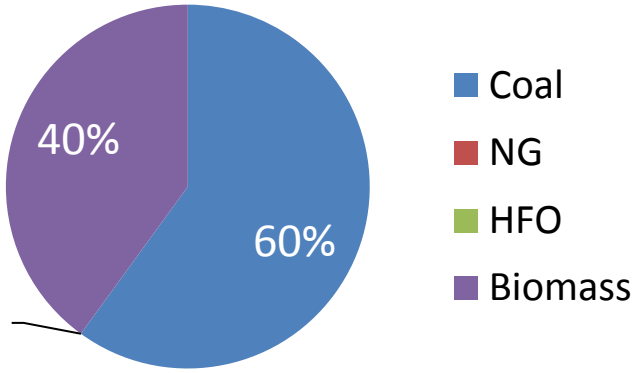
- **Assumptions**

1. Government eliminates all subsidy and sets a tax on coal equal to the cost of its externalities.
2. Industry maximizes usage of solid waste fuels; coal still becomes important due to upper limit on how much waste can be used. Natural gas might also continue to be part of the energy mix equation if local supply increases.

Scenario 3 Energy Prices

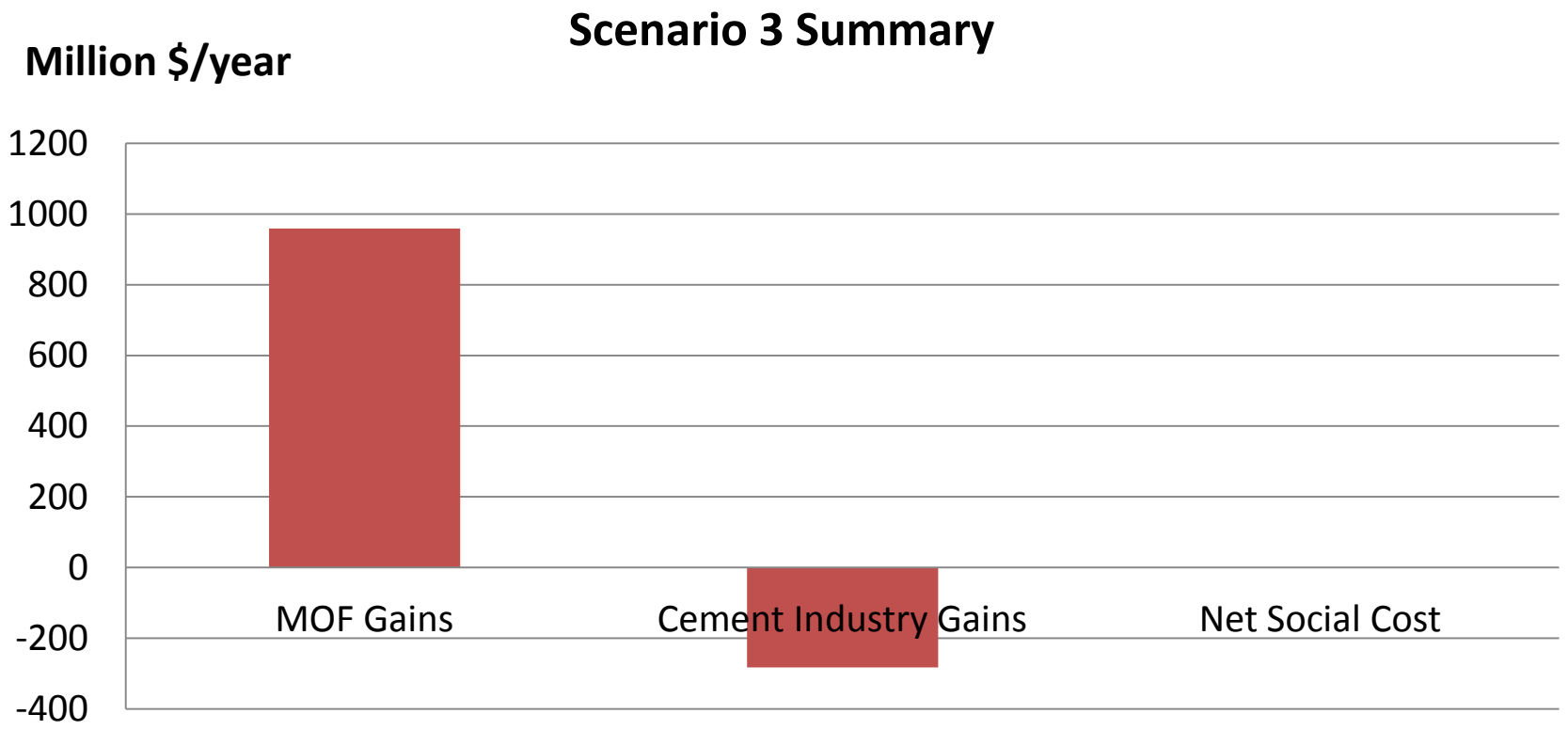


Scenario 3 Assumed Energy Consumption Breakdown



Scenario 3: Coal externalities tax means the industry pays the full social cost to the government.

It is highly probable that in this case, the industry does not switch to coal.

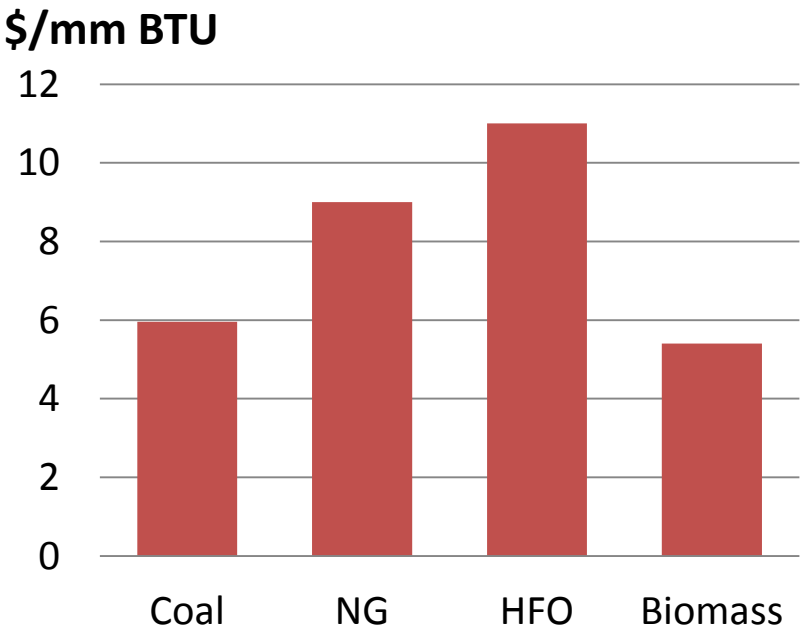


Scenario 4: Carbon Tax

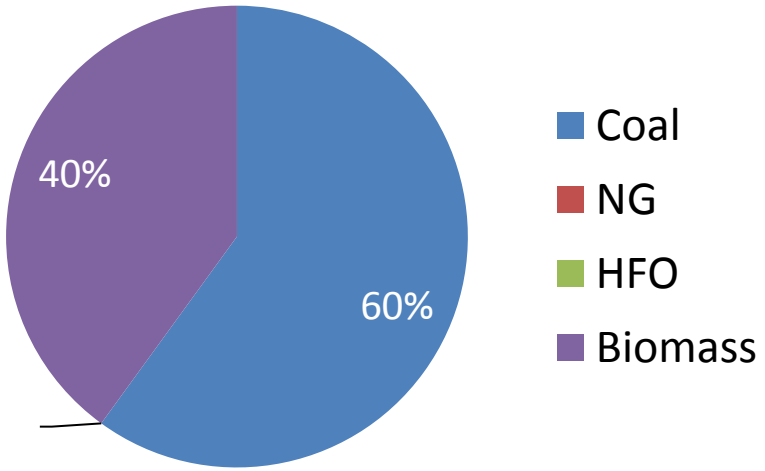
- **Assumptions**

1. Government eliminates all subsidy and adds a tax on carbon equal to the social cost of carbon only.
2. Industry maximizes usage of solid waste fuels; coal still becomes important due to upper limit on how much waste can be used.

Scenario 4 Energy Prices in Egypt

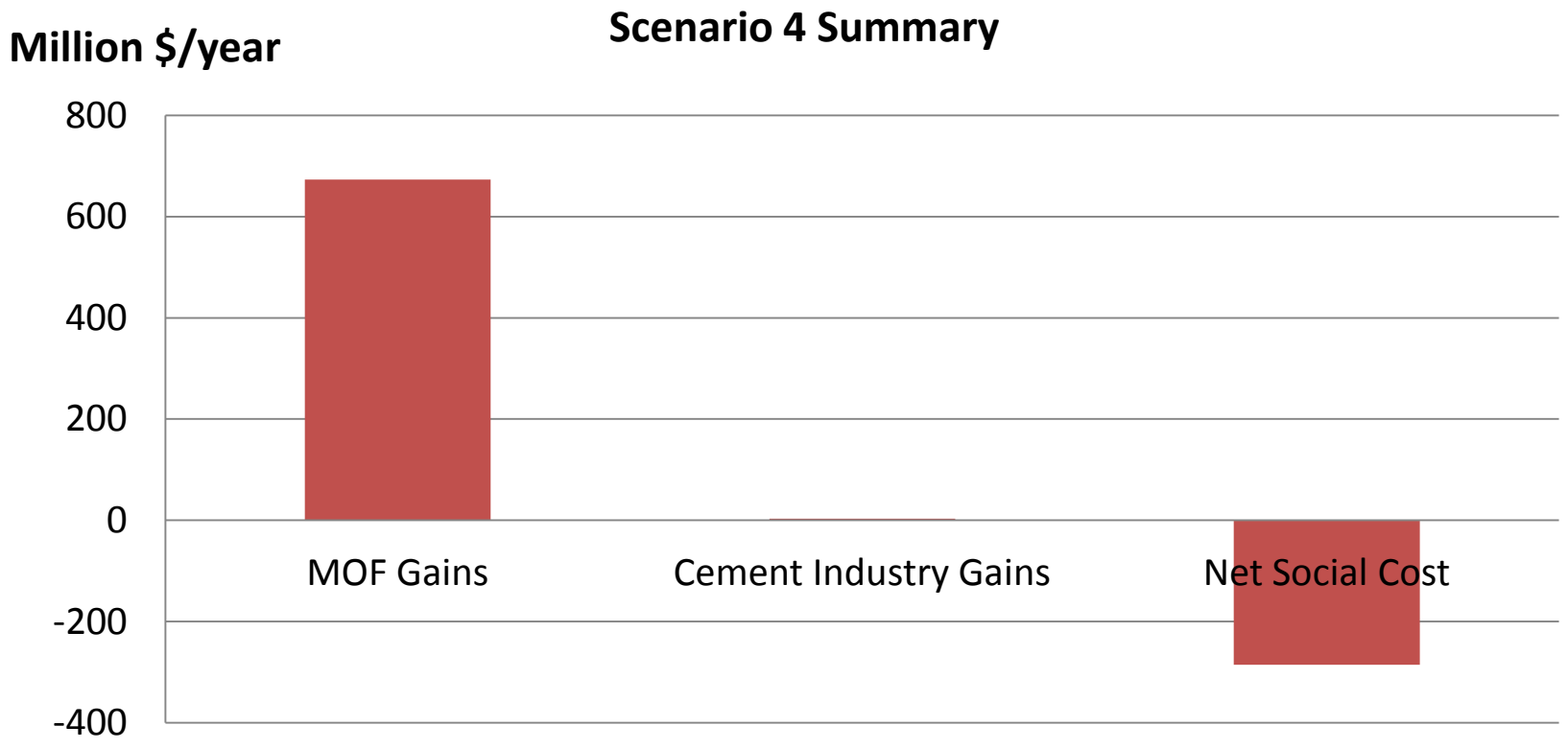


Scenario 4 Assumed Energy Consumption Breakdown



Scenario 4: A carbon tax will keep coal demand in check.

Social cost of carbon partially paid for by industry; risk of coal-driven economy reduced.

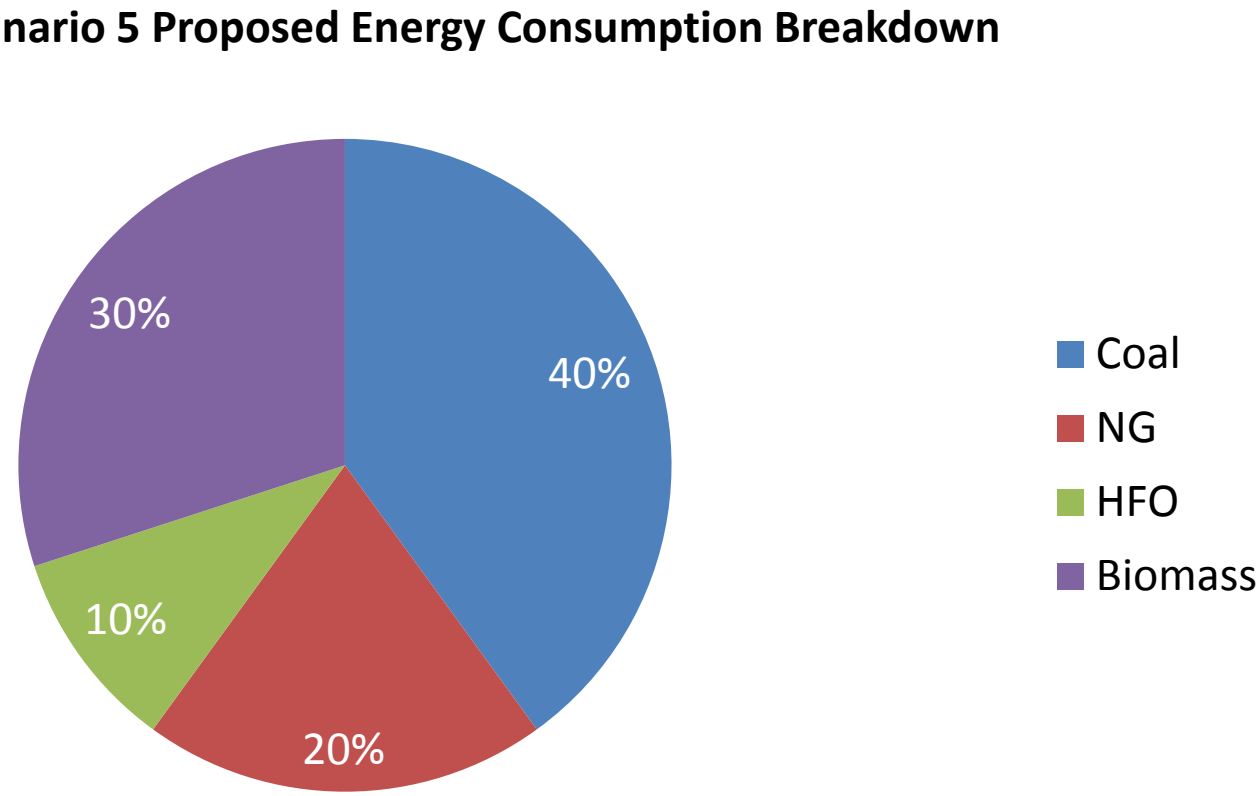


Scenario 5: Cement Industry Expert Perspective

- There are two major burners in the cement process: the precalciner and the kiln.
- The kiln burner consumes around 40% of the total energy, and is more sensitive to disruptions in operations.
- Expert recommends full switching of kiln burner to coal, deploying state-of-the-art coal-firing technology without using a fuel mix to minimize safety and operational risks.
- Expert recommends partial switching of precalciner burners to fuel mix of NG/HFO with solid waste fuel, and expects that a mix of up to 50% solid waste fuel will not cause problems.

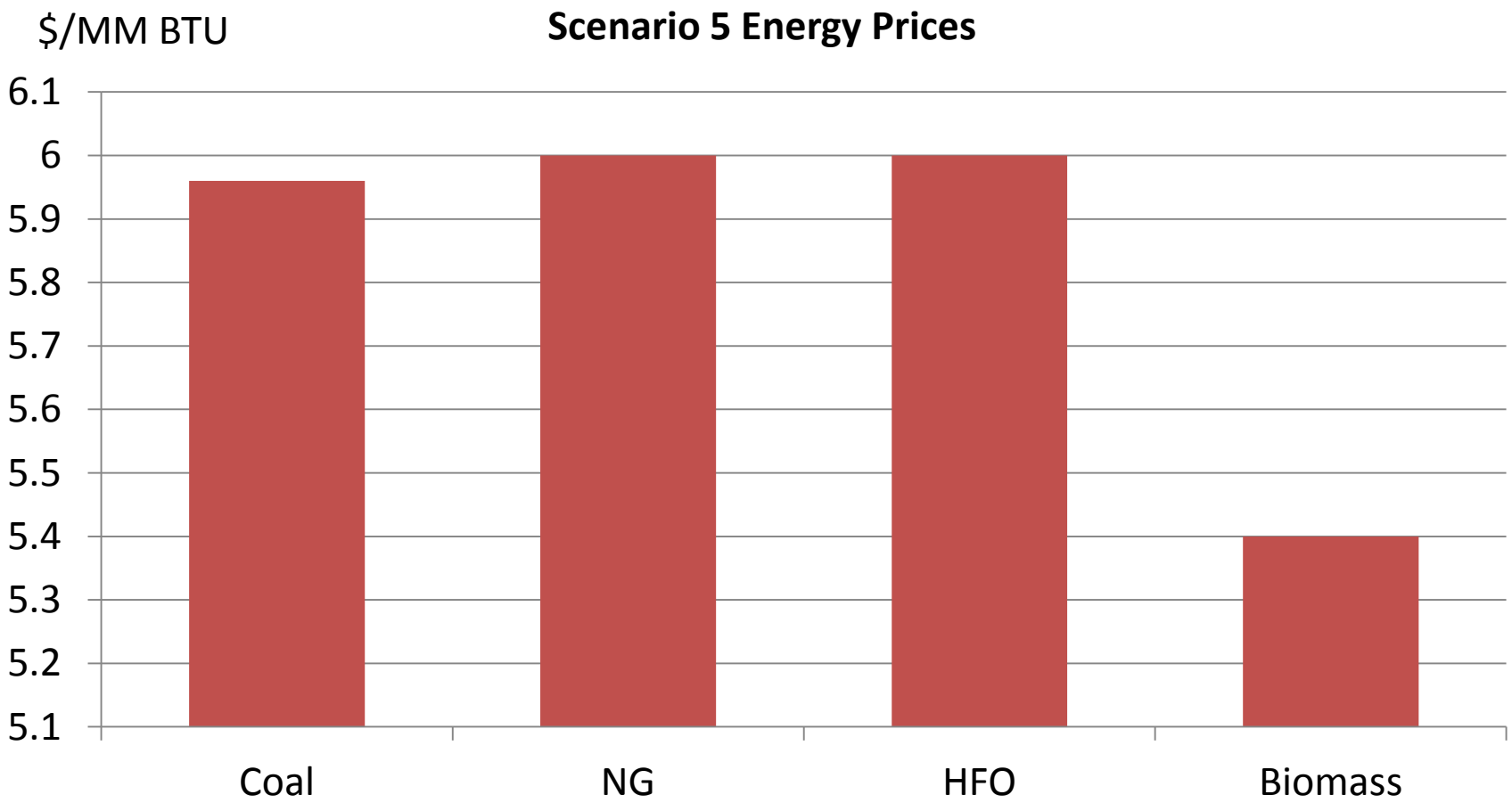
Based on Private Interviews

Scenario 5: Cement Industry Expert suggests that the right fuel mix will continue to include NG and HFO.



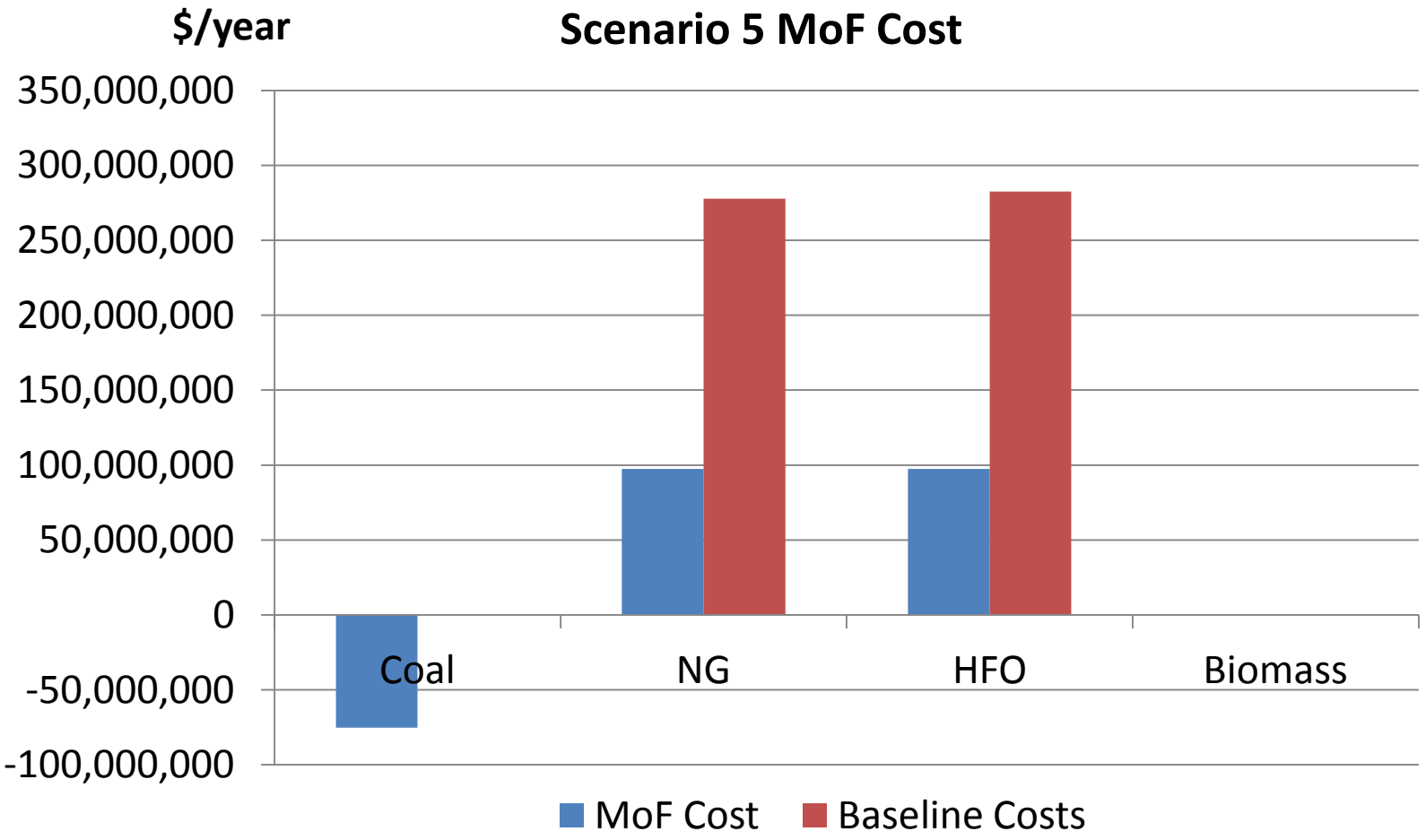
Based on Private Interview

Scenario 5: In such a scenario, the cost to the cement industry will be offset by subsidy.

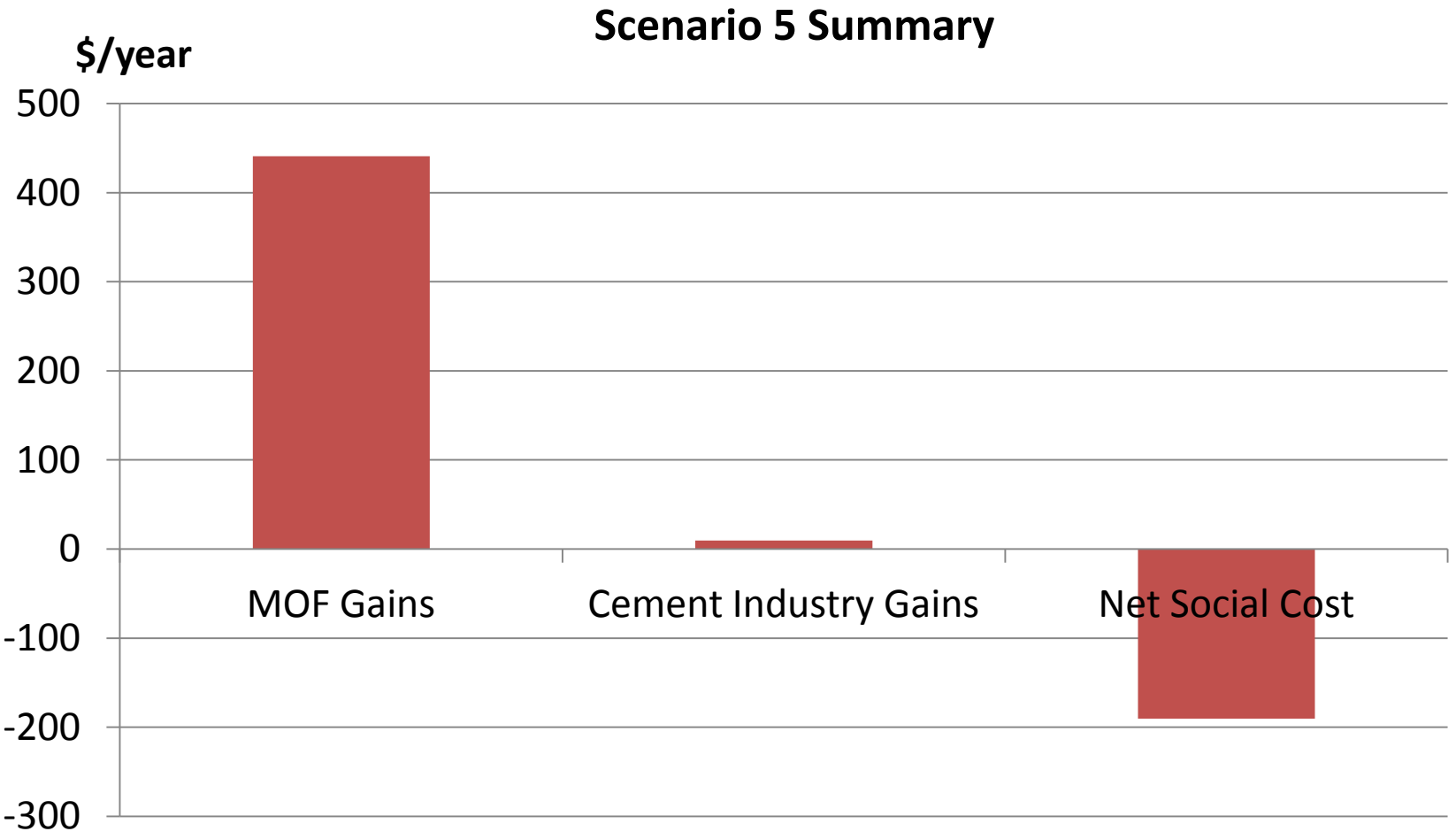


Based on Private Interview

Scenario 5: The cost of subsidy for the government will be offset by gains in carbon tax.



Scenario 5: Cement Industry Expert Perspective Results Summary

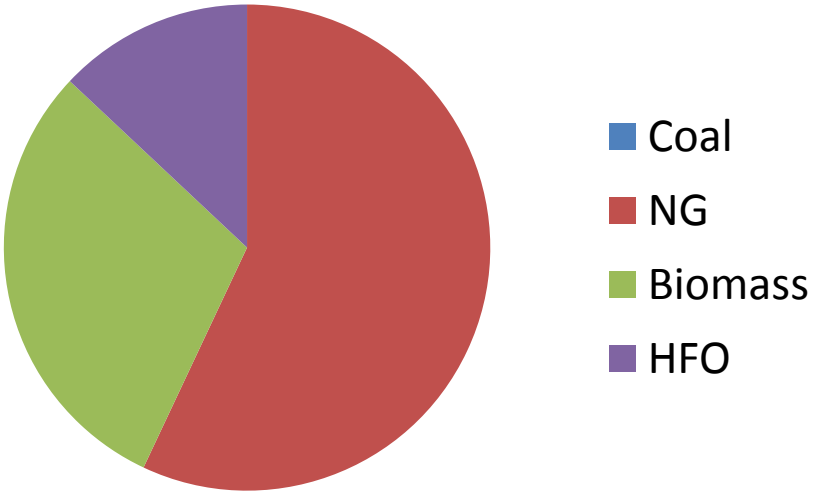


Scenario 6: No Coal, Natural Gas Subsidy

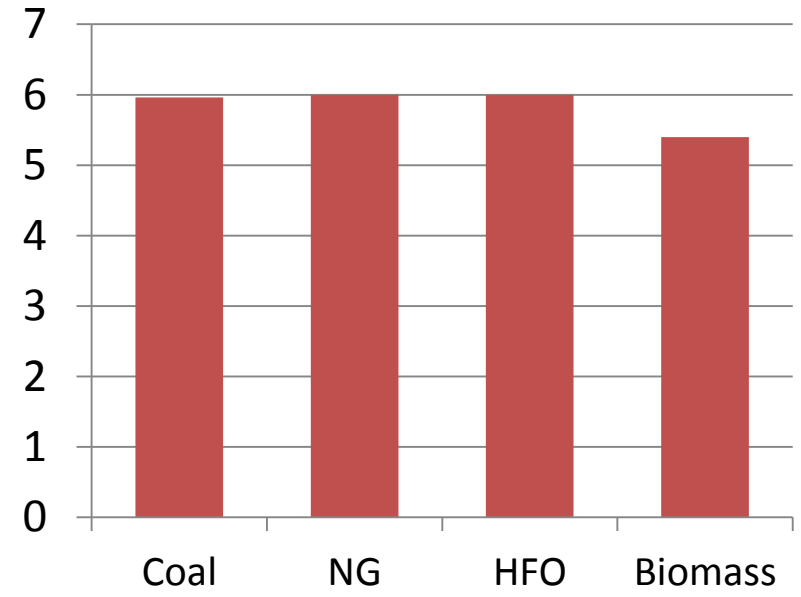
- **Assumptions**

1. Government retains natural gas subsidy and encourages switching from HFO to biomass and natural gas.
2. Government discourages switching to coal.

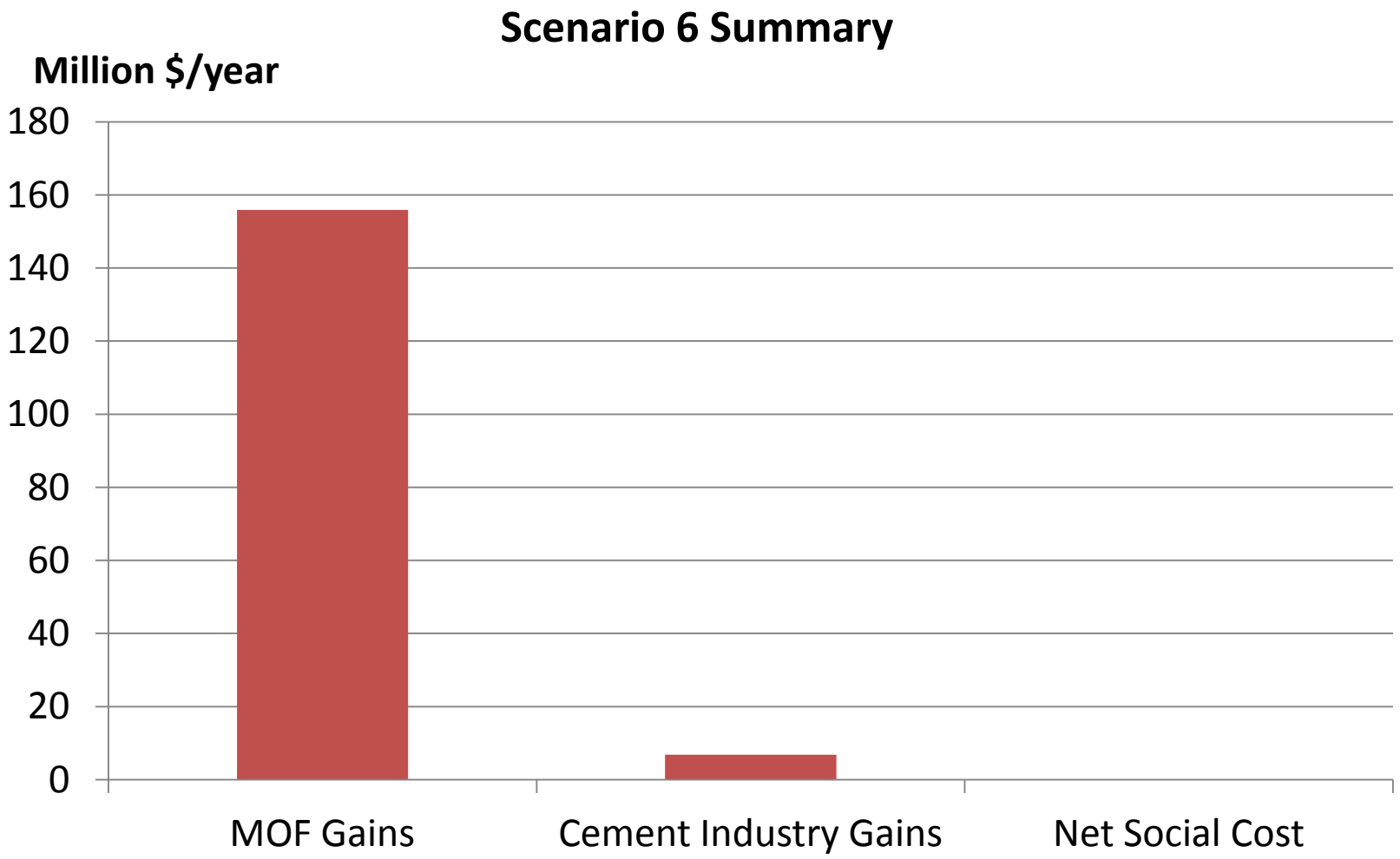
Scenario 5 Assumed Energy Consumption Breakdown



Scenario 5 Energy Prices



Scenario 6: No Coal, Natural Gas Subsidy

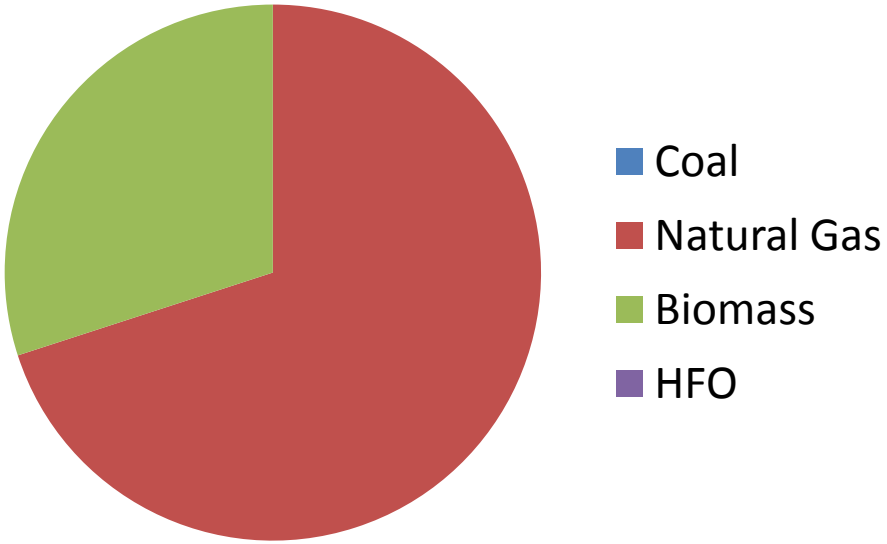


Scenario 7: No Coal, no Subsidy

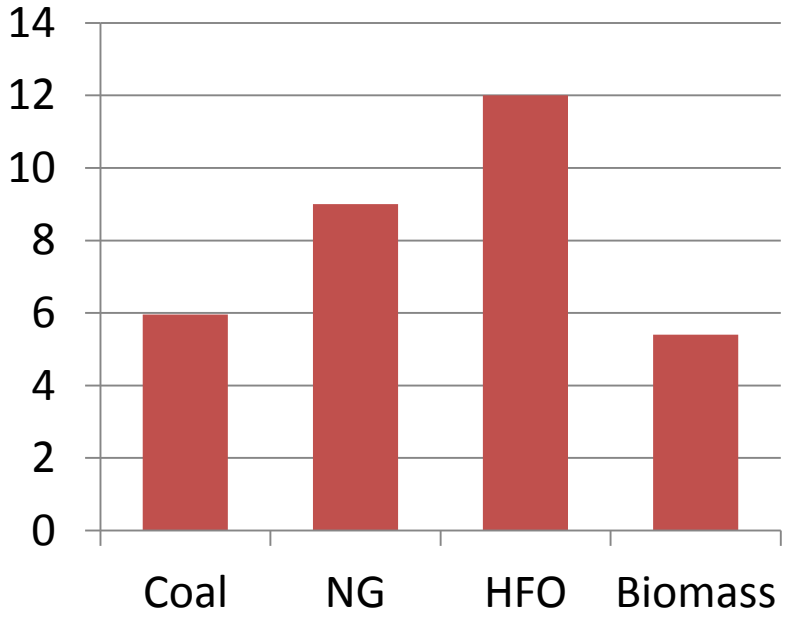
- **Assumptions**

1. Government removes all subsidy and encourages switching from HFO to biomass and natural gas.
2. Government discourages switching to coal.

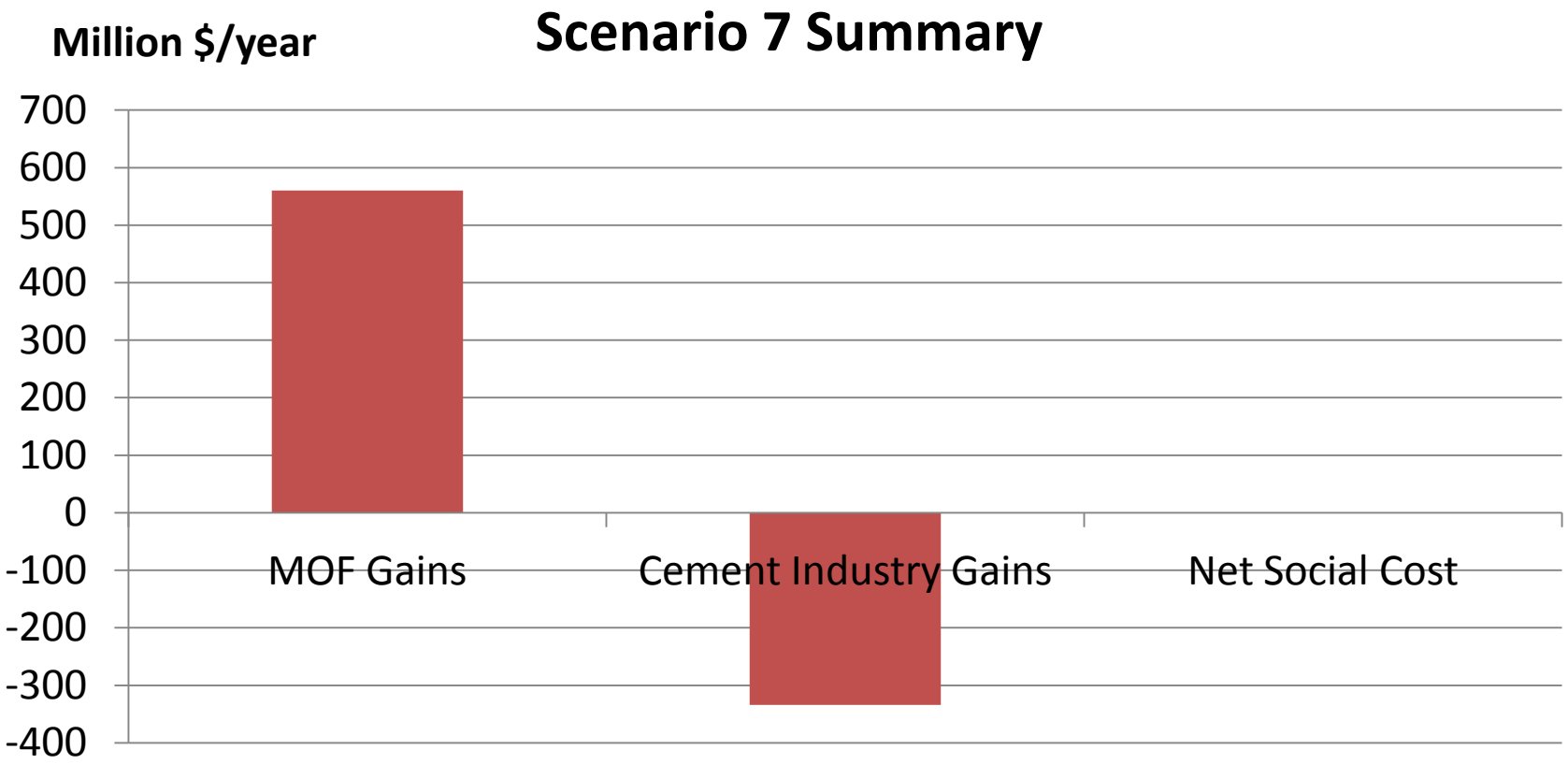
Scenario 7 Assumed Energy Consumption Breakdown



Scenario 7 Energy Prices



Scenario 7: No Coal, No Subsidy

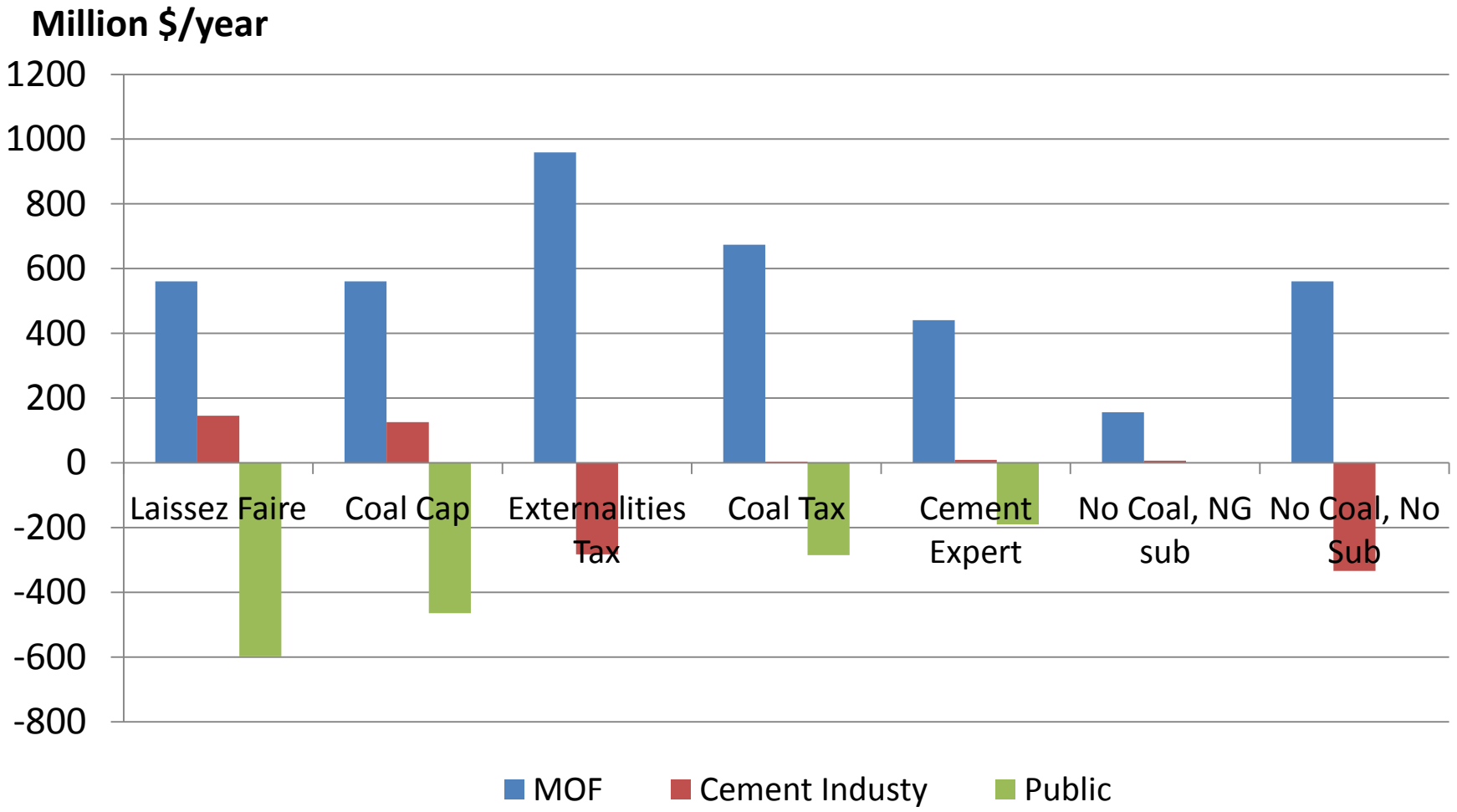


If the cement industry relays the extra costs to the final consumer, the total increase in price of cement will be around EGP47/tonne cement, around 8% of its current price (close to estimates by Shehata, 2007).

Shehata A., "The Impact Of Reducing Energy Subsidies On Energy Intensive Industries In Egypt", ECES, 2007

Government Intervention Scenarios Summary

Costs and Benefits for Government Intervention Scenarios



Policy Recommendations

Recommendation 1: Enforcement of the EIA-based permission process on a case-by-case basis.

- The analysis herein clearly indicates the presence of health, environment, social and economic external costs of fuel switching, particularly in the case of coal.
- The analysis also suggests that the external costs are location- and technology-specific, and therefore warrant a detailed case-by-case analysis.
- In accordance with Egyptian Law 4/1994, any process modification associated with polluting industries must acquire a permission by the EEAA by providing an EIA study detailing environmental impact, on a technology- and location-specific basis.
- Ongoing attempts by some cement companies to switch to coal outside the due process must be postponed in accordance and compliance with Egyptian environmental laws and regulations.

Recommendation 1: Risks and Mitigation Measures

- Environmental compliance in Egypt is low and it is therefore difficult to ensure that approved EIAs are enforced.
- The study team therefore recommends:

1- Separating cement plants into zones, according to current pollution and population density, and allowing coal usage only where cost of low compliance is not disastrous.

2- Cement plants with approved EIAs and in low risk-zones shall include in their plans an online monitoring of compliance system, to be operated by EEAA, and a clear fine payment process for violations.

3- A payment system for external social and environmental costs incurred by communities affected by a switch to coal usage for cement plants after EEAA approval must be developed.

4- The study team recommends payments be proportional to the estimated external costs of switching to coal firing.

Recommendation 1: Risks and Mitigation Measures

- The current financial position and cost of switching/subsidy removal for cement companies are variable, and can be critical.
- The study team therefore recommends the Ministry of Industry develop relief packages in the form of loans to ease the transformation for companies most at risk.

Recommendation 2: Develop a centralized coal procurement process for EEAA-approved plants.

- To prevent an uncontrolled expansion of coal usage in the cement industry, coal procurement must be regulated and controlled by a centralized process within a centralized energy pricing strategy (without eliminating the role of the private sector).
- Only plants with EEAA-approved permits that have agreed to pay external costs of coal-firing as determined by policy are to be supplied with coal.
- The government must set standards for incoming coal to guarantee Egypt does not become the destination for lowest rank coal.
- Failure to centralize coal procurement can result in the development of a secondary unregulated coal market.
- The study team recommends establishing a multi-institutional taskforce to study and develop the procurement process.

Recommendation 2: Risks and Mitigation Measures

- A potential choice for managing the coal procurement process is EGPC. However, EGPC is already under significant financial pressure, both in terms of solvency and foreign currency liquidity. There is a risk that EGPC will not be able to afford managing the financial burden of coal import.
- The study team therefore recommends establishing a clear and transparent process for advancing payments from the industry to fund EGPC's coal import activities, and allowing the industry to compete for favorable coal prices.

Recommendation 3: Develop a carbon taxation system for coal usage.

- **Objectives**

1. Drive industry to energy efficiency.
2. Prevent a full switch to a coal-driven economy.
3. Indirectly incentivize the biomass and RDF renewable energy industry.
4. Limit and monetize the environmental and health impacts of coal.

- Energy investment have a long horizon, and consequently, pricing the carbon tax for coal should be according to a clear and transparent system to allow the industry clear inputs for planning.
- Taxation system should be based on detailed analysis of external costs that accounts for relative proximity to population centers.

Recommendation 4: Develop a technology transfer agreement program

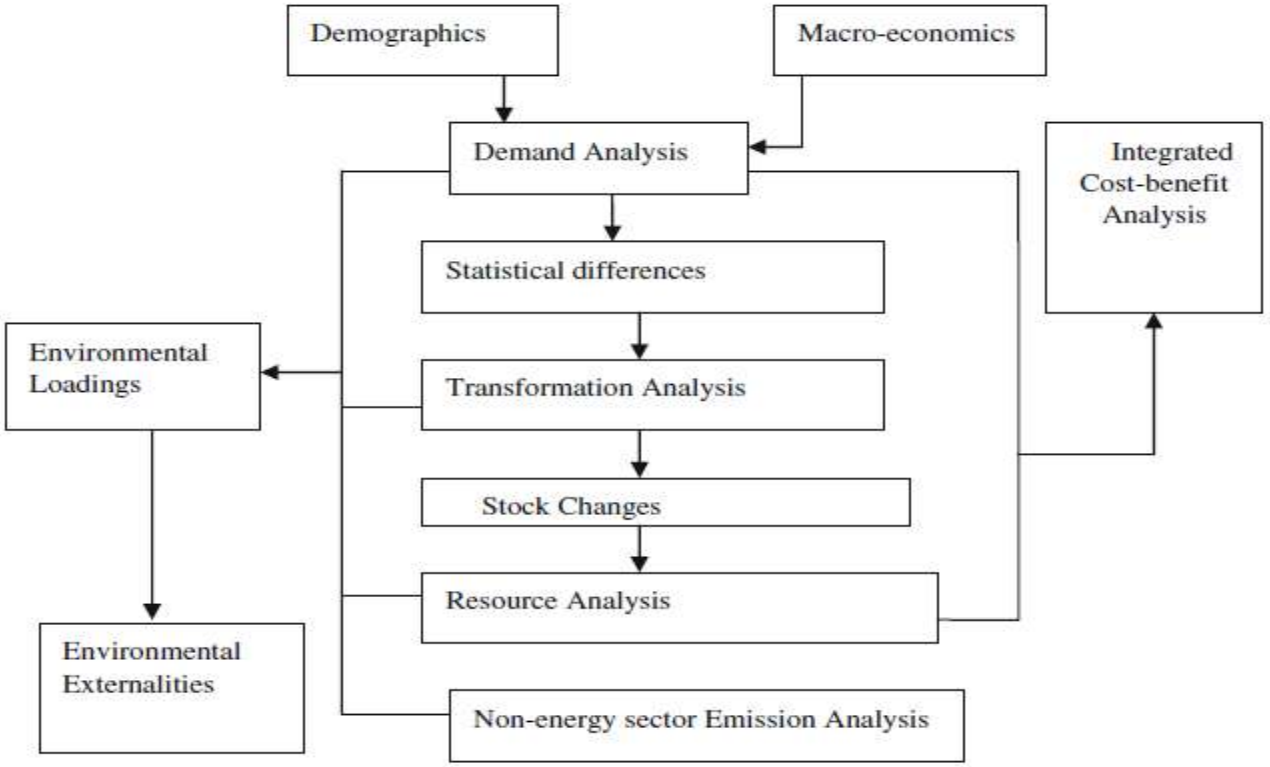
The government should develop incentives for the industry to participate in a technology transfer agreement for:

1. Higher energy efficiency.
2. Safe and environmentally compliant switching to coal.
3. Switching to renewable energy, particularly solid waste fuels.

Recommendation 5: Initiate a multi-disciplinary study of the costs and benefits of a larger role for coal in Egypt's energy mix.

- A decision to strategically include coal as part of Egypt's energy mix will have significant economic, environmental, social, industrial and national security impact.
- The study team recommends that such a decision be framed within a wider vision for Egypt's energy and growth plans.
- The study team further recommends initiating a holistic study with a multi-disciplinary team to analyze the costs, benefits, risks and policy framework for a potential transformation of such magnitude.

Annex to Recommendation 5: Planning energy policy involves multi-dimensional, multi-scale analysis and forecasting.



The Long-Range Energy Alternatives Planning (LEAP) Model

Annex to Recommendation 5: BRIC/MIST countries are largely dependent on coal, with complementary policies to support renewables, that Egypt has yet to enact.

Ec/kWh	Brazil (March 2004)	China	India	Turkey
Wind power	6.93-7.86	3.4 (Varies with bidding results)	5-7.03	5-5.5
Small hydro	4.5	No fixed price	4.83-5.84	-
Biomass	3.61-6.5	4.37 (fixed premium of 2.33)	4.53-8.86	-
Solar PV	--	No fixed price	25.42 (fixed premium of 20.68)	-
Solar thermal	--	No fixed price	21.97 (fixed premium of 17.23)	-

An example of feed-in tariffs for renewable energy electricity in select BRIC/MIST countries.

University of Bath on behalf of the EU Commission, "Cost Assessment of Sustainable Energy Systems", 2008

Annex to Recommendation 5: BRIC/MIST countries have local conditions that make coal more favorable than in the Egyptian case.

- China, Russia, Indonesia and Turkey are all important coal producers.
- India's dependence on coal historically started due to influence of English policymakers (where coal was central to power generation).
- Egypt's demographic distribution and water availability is likely to set limits on the potential expansion of thermal power generation, particularly coal.
- Starting with a coal based infrastructure reduces the marginal cost of expanding coal power production, as the cost of infrastructure has already been paid for.
- Egypt's energy and materials transport infrastructure will require significant investments to accommodate a large-scale switch to coal.

Special thanks to colleagues who had kindly shared with us what they have of literature and to our peer reviewers.