

A large, solid brown rectangular graphic. At the top left corner, there is a small, dark red shield-like shape with a black horizontal bar above it. The text 'ESMT BUSINESS BRIEF' is centered within the brown rectangle. 'ESMT' is in white, and 'BUSINESS BRIEF' is in a dark red color.

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On the Verge of a Paradigm Shift in the Energy Sector?

From Centralized to Decentralized Energy Generation

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Contents

Executive Summary	3
1. Scenario: How to Deal with High Energy Prices	3
2. The Paradigm Shift: Prolonging the Existing Value Chain	3
2.1 The Current Energy System	3
2.2 The New Energy System	3
3. The New Value Chain: Indications for Size and Margins	3
3.1 Changes in the Upstream Markets	3
3.2 Creation of Downstream Markets	3
4. Implications for Players Involved: The New Competitive Landscape	3
About ESMT	3

Executive Summary

Translating IPCC climate models into CO₂ emissions per head results in 2030 emission targets of 5 percent of today's emission levels for the US and 10 percent for Europe.¹ In an energy environment where externalities like CO₂ are priced and where fossil fuels are becoming scarce and more expensive, only a major transformation of the 20th century energy and mobility infrastructure will be able to cope with these climate and fossil fuel scarcity challenges. With increasing energy prices, energy efficiency and decentralized energy generation will be key ingredients for this energy paradigm shift.

Focusing on this paradigm shift, the business brief as a thought experiment intends to:

- Identify implications for the value chain, namely the creation of new value-chain segments;
- Indicate potential shifts in market size and margin of the respective value-chain segments;
- Derive implications for players involved, namely the emergence of a new competitive landscape.

The business brief addresses all energy players involved, especially incumbents who face the challenge to balance the tasks of securing and optimizing traditional business while at the same time taking part in new disruptive innovations.

We argue that:

- The value chain will be prolonged by value-chain segments focusing on decentralized generation: district generation, generation@poc,² energy efficiency, eMobility;

¹ IPCC, *Climate Change 2007: Mitigation*, contribution of Working Group III to the Fourth Assessment (2007).

² Point of consumption.

- While the overall energy market will expand, the segment of centralized energy generation (fuel supply, fossil centralized energy generation) will shrink with smaller margins in the long run (non-fossil centralized generation being the exception) to the benefit of the growing, decentralized energy generation segment, which will show increasing margins;
- Players involved should take the expanding decentralized generation market seriously and prepare for this mind shift:
 - Customers should evaluate how to become more independent from centralized energy generation, for example how to turn from energy consumers into self-sufficient energy producers.
 - Incumbents currently moving toward non-fossil generation should evaluate how to take part in the expanding market segment of decentralized energy generation and whether investments in this sector might provide more leverage than investments in the non-fossil centralized generation segment.
 - Regulators should rethink whether policy measures for fostering the development of the decentralized generation segment might complement their measures for market power in the centralized generation segment.

We will start with a scenario of how customers might deal with high energy prices to illustrate potential implications from an energy consumer point of view. We then will move toward implications for the value chain, size and margins of value-chain segments, and finally to implications for players involved.

1. Scenario: How to Deal with High Energy Prices

Madrid, Thursday, January 31, 2030 at 6:00 p.m. The energy company had just billed its customers for the month. The price per kilowatt hour (kWh) in 2029 had been between 85 cents for some night hours up to €25 for peak hours during December evenings and July afternoons.

A three-bedroom apartment in the European megalopolis. Inside live Adrian Svengerov (60), the city treasurer, his wife Caroline (53), and her mother Helena (85). They had moved closer to the city center to allow Helena, a dialysis patient, to receive medical care at the excellent university clinic. Today, Adrian had decided to work at home to be more productive and to avoid the 2.5 hour commuting time.

It had not helped. Adrian stared gloomily at the giant video screen wallpaper where his wife had laid out his incoming mail. The monthly bill from his energy provider was over €670 - more than 17 percent of their entire monthly net income. Of course, he had not been caught completely off guard - hourly rates and running costs could be monitored on the screen any time he wanted. He opened a bottle of his favorite Danish white wine and brooded.

Where were the good old days - when a kilowatt hour had cost 20 cents, regardless of whether you bought it at normal or at peak times? It was back then that he had made the decision to sell the city's power grid and utility plant to balance the budget.

He reviewed his family's energy consumption as he did every month. In the kitchen and utility room stood the newest generation of highly energy-efficient appliances - refrigerator, dishwasher and washing machine. Each device could automatically turn itself on and off, depending on the energy price at that specific time of the day. They had already installed LED lighting throughout the house over 15 years ago. The power for their electric car was partially subsidized. The subsidy had been introduced in order to incentivize the use of the 20 million electric and hybrid cars to stabilize the intelligent grid, which had to deal with the high percentage of irregular supplies of solar and wind energy. Here, too, they had taken advantage of a built-in "recharge only when pro kWh price falls below X €" function.

This proved, however, to be a less than satisfactory solution for Helena's dialysis machine. It had been incompatible with the power utility's demand management system, designed to reduce usage during peak periods. As a result, the family had to use the more expensive, high-quality, outage-proof electricity, even though battery technology had become quite advanced over the past few decades. The surcharge for 99.9 percent outage-proof electricity, the year's unusual weather patterns and resulting poor wind harvest, and the typically high winter consumption had produced a horrendous energy bill. Adrian had also become painfully aware of his problems at work. As higher energy and mobility costs prompted people to move to other communities in droves, the municipality had once again plunged into the red.

About 40 kilometers away.

James Young (47), city director of a community, walked inside his home. His boys jumped on him in the hopes of pulling their dad into a wrestling match. His wife, Marianne, had prepared a fondue to celebrate the twins' birthday and had prepared some nice gifts. This was a day for good news: James had been informed that he had won first prize in a contest for his successful work. More and more well-educated families with above-average incomes had been moving into the community.

Thanks to a growing tax base, the local government had been able to finance excellent schools and to provide innovative services. Biomass and garbage was being used in the city's CHP³ unit. The system delivered heat and energy to the newly renovated and reopened city swimming pool and fitness center, to public buildings and businesses, and to the electricity grid in the densely populated city center. The community had had the foresight to invest early on in its own grid infrastructure, which had made it possible to connect electric automobiles. As a result, the city's taxpayers paid much less to "fill up" than the residents of neighboring communities.

The strategy had paid off as a valuable source of income for the area's decentralized power producers, which included the families themselves. This month alone, his family had supplied the network with over 250 kWh at attractive periods, earning them more than €570 - more than 15 percent of their

³ Combined heat and power.

net household income. Even after the investment and finance costs for their home's insulation, solar panels, heat pump, windmill and a small CHP station - as well the expensive monthly 5-liter gas tank fill-ups required to support the system - the family had been still able to cover the cost of the boys' gifts.

2. The Paradigm Shift. Prolonging the Existing Value Chain

2.1

The Current Energy System

The current energy system inherits three assumptions from its creation during the industrial revolution and its history as public utility (in Europe after WWII).

The first assumption is that, at any given time, all customers can demand as much power as they want for a fixed price per unit and the system will deliver.

The second assumption is that economies of scale in large power plants outweigh the overall energy-efficiency benefits of allocating production closer to consumption.

The third assumption is that externalities such as emissions or nuclear waste are not priced.

Those assumptions were valid throughout the 20th century. Under the pressure of dwindling fossil resources, rising energy prices, and carbon and security constraints, they are no longer valid.

More specifically, the old energy system faces the following major issues:

1. Conversion losses from thermal production are significant.

An analysis by IEA⁴ shows that conversion losses from thermal production total 63 percent - most of which is inducted into cooling water. Transportation of thermal energy is economically feasible only over short distances.

2. With climate change, cooling and water usage of big power plants is becoming more and more problematic.

Nuclear power plants in France and the United States have to shut down during summer because the temperature of water discharged by reactor cooling systems surpasses the maximum allowed under those countries' environmental laws. Dying aquatic life is one issue. The bigger concern is that rivers do not carry enough water to cool those power plants. Disconnecting one or several nuclear plants creates an energy problem since, in addition, a warm and dry summer leads to an increased usage of air conditioning and to a decline in output from hydroelectric power plants.

3. Big power plants, often far from the locations where the energy is used, require additional grid investments and additional balancing and reserve power.

Electricity transport, even in 380 kV lines, entails significant losses - in Europe about 7 percent of electricity generation.⁵ In addition, hot cables heat air.

4. Big central power plants are very expensive - €1 to €5 billion per plant, depending on fuel type.⁶

In liberalized energy markets, growing risk is associated with such projects. Taking the risk of investing billions under growing political uncertainty is a challenge even for companies with solid financing power. Out of the 59 announced new projects in Germany, only 17 are at this moment likely to be realized.⁷

5. New locations for central power stations are often politically not feasible.

The common NIMBY policy (not in my backyard) often turns into BANANA

⁴ IEA (2008). *CHP: Evaluating the Benefits of Greater Global Investment*

⁵ COGEN (2000). *Electricity Transport Regimes and Their impact on Cogeneration*. Briefing Nr. 15 (September 2000).

⁶ Kuhr, R. and Vivenzio, T. (2005). Investing in MegaProjects: A Comparison of Cost and Risk. Presentation given at PowerGen (December 2005).

⁷ Köpke, R. (2008). Der Kraftwerksneubau in Deutschland stockt. *Energie & Management* 14 - Special Energy (April 2008).

(build absolutely nothing anywhere near anything), leaving only upgrades for existing locations, and often not even that. Two German coal-fired power plant projects underline this political challenge: RWE with its suspended Moorburg project, and E.ON with its Staudinger project, which is being repeatedly challenged.

6. Central power stations based on nuclear or coal either incorporate emission or waste disposal issues.

Nuclear power, even with advanced technology, carries the risk of proliferation and the question of ultimate waste disposal. Carbon capture and sequestration raise the question of CO₂ storage, creating a new disposal problem.

7. Big central power stations are vulnerable to failure and terrorism.

Recent solar thermal proposals appoint even larger central infrastructure projects for solving the energy question.⁸ Solar thermal power plants in the Sahara could, through HVDC⁹ lines, deliver the needed electrical power to Europe and replace all nuclear and fossil generation. While Americans may rely upon solar thermal energy in Arizona, California and Nevada, the average European may be reluctant to do so with power plants located in Algeria and Libya.

8. The current transportation and distribution grid is largely based on out-of-date technology created and developed a century ago.

The current transportation and distribution grid was designed as a one-directional system, from central power generation to multiple points of consumption. It is already several decades old (e.g., in the United States, where many parts of critical installations are more than 40 years old¹⁰) and lacks bi-directional elements to integrate decentralized energy production and customer consumption behavior.

2.2 The New Energy System

The new energy system needs to be different from the old energy in three critical regards.

First, new pricing models will change consumption patterns. Pricing will not only reflect load curve and power-exchange prices at the given hour but will also reflect the quality of power. While at present, all customers obtain the same

⁸ "Sahara-Strom für Europa. Supergrid soll EU-Versorgung sichern," *Handelsblatt*, July 2008.

⁹ High-voltage direct current electric power transmission.

¹⁰ "We are talking about equipment deployed before a man walked on the Moon, before cell phones and the Internet, when Frank Sinatra was in his prime." Martin Rosenberg, "Continental Grid Vision Needed," *EnergyBiz Magazine*, Nov/Dec. 2007.

high-quality power, delivered within a strict range of voltage and frequency necessary to run high-technology industrial components, in the future customers will be able to choose different qualities and levels of supply. They may opt for automated demand-side response, wherein customers accept that power providers shut down appliances such as refrigerators or air conditioners for some minutes in order to manage critical peak loads.¹¹

Second, the urge to improve overall efficiency of the energy production system will lead to the use of industrial-process energy for electricity generation as well as combined heat and power generation.¹²

Third, Smart Grid architecture will enable integration of fluctuating generation from renewables like wind and sun, car batteries of advanced plug-in hybrid or pure electricity cars serving as a decentralized energy accumulator (and providing positive and negative balancing energy) and of decentralized power generation entities in districts, production sites or households.¹³

The major components of the new energy system encompass:

1. eMobility will use hybrid and pure electricity-powered vehicles and switch from liquid fuel to electricity not only for short-distance travel.
2. Smart appliances will temporarily power down to reduce expensive peak load and will power up at non-peak times to benefit from less expensive electricity prices.
3. Stand-alone family houses will have excellent thermal insulation and will consume only a fraction of the energy consumed today.
4. Households will require additional power for heat pumps and hybrid/ electricity-powered vehicles.
5. Bigger houses will have CHPs or will be supplied through joint district heating and cooling.
6. Smart Grid will enable utilities to deploy both centralized and distributed energy more efficiently, and allow customers to monitor and adjust their consumption behavior.

¹¹ California's SCE, an industry leader in advanced metering, plans to deploy 5.3 million smart meters to its residential and small business customers to shift and reduce peak demand as much as 1,000 MW from 2009 to 2014.

¹² Casten, T. R. and Ayres, R. U. (2007). Energy Myth Eight, Worldwide Power Systems are Economically and Environmentally Optimal. In *Energy and American Society, Thirteen Myths*, eds. B. Sovacool and M. Brown, 201-238. Springer-Verlag.

¹³ The UK Energy Retail Association manages a Google map where current projects and proposals are displayed: <http://www.energy-retail.org.uk/smartmeters.html>. PEPCO has rolled out a Smart Grid trial in 1,000 homes in Washington DC, Xcel Energy has announced plans to make Boulder, CO, the "first SmartGridCity," and ComEd is looking at Smart Grids in Chicago. Industry heavyweights like IBM and SAP are trying to establish standards and protocols for Smart Grid Initiatives.

With such a paradigm shift, it will not be some hundred large, centralized power plants providing the largest amount of electricity, but rather a multidimensional, decentralized, balanced system, where the generation from a variety of sources is optimized close to consumption.

Due to the importance of energy efficiency and the role of CHP (Combined Heat and Power)/ DHC (District Heating and Cooling) in reducing energy-related CO₂ emissions, the existing value chain will be prolonged.

In addition to the centralized generation of the upstream part of the value chain (current energy system), a new downstream part will arise, consisting of decentralized generation (district generation, generation@poc - point of consumption), energy efficiency and eMobility (new energy system, cp. Exhibit 1). As the transportation grid in Europe and the United States will be managed by a regulated system operator, we will leave this part of the value chain aside from our considerations.

Exhibit 1: The New Value Chain



3.

The New Value Chain: Indications for Size and Margins

What are the implications of the new energy system on the value chain, its size and margins?

Based on the new energy system described above, we assume a significant shift of market importance and margins from upstream activities to downstream activities (cp. Exhibit 2). While the whole energy market will expand, we expect the upstream segments to lose while downstream segments gain importance.

Exhibit 2: Value Chain: Shift of Market Importance and Margins

	Upstream			Downstream			
	Fuel supply	Centralized generation		Decentralized generation		Energy efficiency	eMobility
		Fossil	Non-fossil	District generation	Generation @poc		
Size 2008	●	●	●	●	●	●	●
Size 2030	●	●	●	●	●	●	●
Trend margin	↓	↓	↑	↑	↑	↑	↑

3.1 Changes in the Upstream Markets

Within the upstream markets, we consider the segment's fuel supply (oil, gas), fossil central generation and non-fossil central generation.

With increasing fuel prices, economies will protect supply sources, if available, and start investing in alternative technologies. The higher the oil/gas price, the more will be invested in alternative infrastructure and technology, which will lead to a shrinking of the centralized generation market.

With oil and gas (and uranium) resources available for only a few remaining decades, fuel-supply companies may benefit from increasing prices for the remaining life span of the industry. Yet, the question will be whether these companies will use the cash flow to invest in increasingly difficult and risky exploration projects or in new market segments.¹⁴

After a period of market and margin increase, we expect thereafter that the fuel-supply market and the margins will decrease due to more competition from other technologies and even the higher exploration investments necessary.

Concerning the central generation market, we currently see a forward integration of fuel-supply companies such as BP and Gazprom. This move is motivated by risk diversification in times of increasing nationalization of energy sources and timely positioning in renewables markets for periods of lower traditional revenues (BP), or simply by orienting the strategy on a vertical-integrated business model (Gazprom).¹⁵

Due to the shift to non-fossil centralized and decentralized generation, we assume a shrinking fossil generation market with dwindling margins caused by higher fuel costs (coal, gas, oil), higher necessary investments and the lack of achieving significant efficiency gains.

For non-fossil centralized generation (e.g., wind, nuclear), we believe in market growth until the shift toward decentralized generation also limits the growth of this value-chain segment. Margins will increase due to the low importance of fuel costs, high potential efficiency gains of renewables and rising energy prices.

With fuel-supply companies entering the central generation market, we are convinced that we will see further consolidation. Due to the maturing of the market, critical success factors for industry consolidation become important, such as:

¹⁴ "Rockefellers drängen Exxon zu Öko-Wende" *Financial Times Deutschland*, May 2008.

¹⁵ Burger, C. (2008). *Consolidation Index: Critical Success Factors for Industry Consolidation*. ESMT Business Brief No. BB-108-001.

- *competitive competence*
A company indicates a high competitive competence when it copes with the rules of the marketplace better than any other competitor. Key performance indicators are productivity per employee and market capitalization.
- *financial competence*
High competitive competence is not sufficient, though, to shape a process of industry consolidation. In addition, financial competence is needed to raise funds, for example for takeovers. Key performance indicators are earnings before interest and tax (EBIT), equity, return on equity (RoE), gearing and the structure of investors (in order to raise additional funds).
- *internationalization competence*
As consolidation today refers either to a multinational trade region (EU, NAFTA, APEC, etc.) or a globally driven environment, a company has to assess its preconditions for a successful internationalization process. Key performance indicators are the existing foreign business and the management board's international expertise.
- *change competence*
Consolidation usually imposes heavy reorganization upon a company (due to new business models, rapid internal growth, and/or mergers and acquisitions). It is therefore vital to identify reorganization needs in time and to successfully drive the reorganization process. Key performance indicators are the scale and number of successfully completed reorganizations.¹⁶

Considering that, especially in the upstream market, private companies such as Exxon, BP, Shell, and E.ON compete with state-owned companies such as ARAMCO or Gazprom, a significant size is necessary to play a market-leader role.

3.2

Creation of Downstream Markets

Based on the arguments mentioned above, new downstream markets will arise. Both district generation and generation@poc will offset centralized generation capacity, whereby district generation will cover the energy demand of a whole district and generation@poc will cover the energy demand of production facilities or buildings/households. In both cases, integrated power and heat/cooling generation will lead to significant efficiency gains. In addition, with low/decreasing system costs, margins will rise in this market segment. With generation@poc, households and manufacturing sites will turn from consumers of energy into suppliers.

Another new market will be energy efficiency that focuses on the energy management of entities. Tasks incorporate the reduction of energy consumption,

¹⁶ Ibid.

the evaluation and integration of decentralized generation systems (e.g., integrating micro CHPs, solar or heat pumps and eMobility) up to taking over investments as a contractor, including the selling of generated energy. As in the financial services market, we can imagine a market structure with both independent suppliers, such as MLP/Edward Jones as well as integrated suppliers, such as Deutsche Bank and UBS.

Furthermore, an eMobility market (hybrid and electric automobiles) will evolve, driven by high conventional fuel costs and the possibility to store intermittently renewable and decentrally produced energy.

Due to higher energy prices, we expect the energy efficiency as well as the eMobility market and margins to grow.

The creation of the downstream markets will be accompanied by the setting up of a new and technology-intense distribution grid infrastructure, smart metering and decentralized load management, and by the integration of car and battery manufacturers. Electrical power will therefore gradually replace liquid and fossil fuels as mobility fuels and enablers for heating and cooling.

4. Implications for Players Involved: The New Competitive Landscape

Analyzing the competitive landscape, different players are currently acting in the upstream and downstream parts of the value chain.

Exhibit 2: Competitive Landscape along the Value Chain

Competitor groups	Upstream			Downstream			
	Fuel supply	Centralized generation		Decentralized generation		Energy efficiency	eMobility
		Fossil	Non-fossil	District gen.	Generation @poc		
1 Oil & gas (e. g. BP, Gazprom)	●●	●	●				
2 Utilities (e. g. EON, EDF)	●	●●	●				
3 Home heating companies (e. g. Vaillant, Buderus)				●	●●	●	
4 Metering companies (e. g. Actaris, Elster Group)						●●	
5 Production companies (e. g. Bosch, Siemens)			●	●	●		
6 Energy management suppliers (e. g. Gridpoint, Greenviroment)						●	
7 Car manufacturers (e. g. Toyota, GM)							●

● Activities in 2008 ● Potential activities in 2030

In the upstream parts of the value chain, we expect oil and gas companies to push their activities in the centralized generation segment, especially non-fossil. Besides expanding non-fossil centralized generation, utilities will also expand fuel-supply activities to reduce the dependence on oil and gas companies. With the takeover of Ersol, production companies like Bosch will try to enter the non-fossil centralized generation segment and we expect this trend to continue.

While in the upstream market, consolidation will be the major trend, whereas the key issue in the downstream markets will be to establish the new markets. Several competitor groups need to decide which roles they want to play, including:

- Utilities (e.g., E.ON, EDF, Vattenfall, EnBW, municipalities) already active in centralized generation and with expertise in load management;
- Home heating companies (e.g., Buderus, Vaillant) with access to potential decentralized generation entities;
- Metering companies (e.g., Actaris, Elster Group) as providers of measurement systems to allow for energy efficiency;
- Production companies (e.g., Bosch, Siemens) with the ability to build decentralized generation systems;
- Energy management suppliers (e.g., Gridpoint, Greenenvironment) that manage energy systems or focus on outsourcing the energy system - our so-called energy efficiency market;
- Car manufacturers (e.g., Toyota, Honda, GM) focusing on hybrid and electric cars.

Potential players for the decentralized generation market, the energy efficiency market and the eMobility market will have to create new business models that take into consideration a way of thinking that encourages consumers of power to become producers.

The implications for the players involved seem straight forward - yet potentially difficult to face.

Customers should evaluate how to become more independent from centralized energy generation, for example how to turn from energy consumers into self-sufficient energy producers. The rise of decentralized generation will enable customers to take a more active role in choosing between a growing number of options to satisfy their energy needs. They will have to make long-term

investment decisions that are aligned with their residential and mobility needs during different periods of life and carefully monitor the efficiency, costs and benefits of their decisions, since energy costs will continue to rise and affect their income even more. The net present value of their energy decisions, the potential pain and gain, will make consumers more sensitive to all energy-related questions than they are today.

Incumbents currently moving toward non-fossil generation should evaluate how to take part in the expanding market segment of decentralized energy generation and whether investments in this sector might provide more leverage than investments in the non-fossil centralized generation segment. The redistribution of the margins in the energy business will attract new kinds of entrepreneurs who are different from the oil and utility barons that dominated the industry in the first half of the 20th century and will also require a different model from the public service model that took over in the second half of the 20th century. There will be venture-capital-educated engineers, electronics and semiconductor manufacturers, information technology managers, politicians and local communities trying to solve energy challenges on a case-by-case and often local basis.

Regulators and policymakers should rethink whether policy measures for fostering the development of the decentralized generation segment might complement their measures for market power in the centralized generation segment. Regulation in the grid, for example, focuses on efficiency gains of a distribution system while the transformation of the energy sector is asking for a Smart Grid. Attention is given to the avoidance of market power in the centralized generation market, where incentives for the evolution of the new downstream segments would be needed in addition.

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About ESMT

ESMT European School of Management and Technology was founded in October 2002 on the initiative of 25 leading German companies and institutions. The founders aimed to establish an international business school, based in Germany, with a distinct European focus. As a private institution of higher education, ESMT provides executive education (since 2003) and an international MBA program (since 2006). ESMT headquarters is located in Berlin with a further campus in Cologne. ESMT is fully accredited by German authorities as a private institution of higher education.

High impact learning

ESMT research and teaching focuses on practice relevance and applicability. High impact learning allows participants to translate what they have learned into action as soon as they get back to their companies and to bring about changes on the job. ESMT imparts participants with state-of-the-art analytical methods in management and teaches them to solve real-life management issues. The aim is to enable participants to take responsibility and accomplish change. ESMT faculty, made up both practice-oriented academics and theory-oriented experts, supports this style of teaching.

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