CBS CASE COMPETITION

THE CASE

MOVING ENERGY FORWARD

2012

DONG energy

Setting the stage

From his office in Gentofte, VP of Strategy Jakob Bøss looks out over the bumper-to-bumper morning traffic on one of the major freeways feeding into Copenhagen city. He is about to meet with his boss, CEO Anders Eldrup, to discuss proposals from invited consulting teams from around the world on how DONG Energy – one of the leading energy groups in Northern Europe – should move forward.

DONG Energy was formed in 2006 upon the merger of six energy companies, encompassing exploration and production of oil and natural gas; energy trading; and electricity production, distribution, and sales to end users. A true energy powerhouse was formed, one that now meets more than half of Denmark's electricity needs and that has an increasing international presence. Since the merger, DONG Energy has grown its revenue by more than 50%, to over 54 billion Danish kroner, investing 15-20 billion Danish kroner annually.

DONG Energy executives can certainly be proud of their achievements, but they still face immense challenges. DONG Energy provides energy to an increasing number of customers while simultaneously coping with the need to reduce CO_2 emissions. At the same time, fossil fuel reserves are limited and in the long term, alternatives must be found.

DONG Energy has long successfully delivered a stable energy supply to its customers. A significant transformation is now, however, underway: Particularly in the Northern European markets in which DONG Energy operates, there is a move towards renewable energy sources.

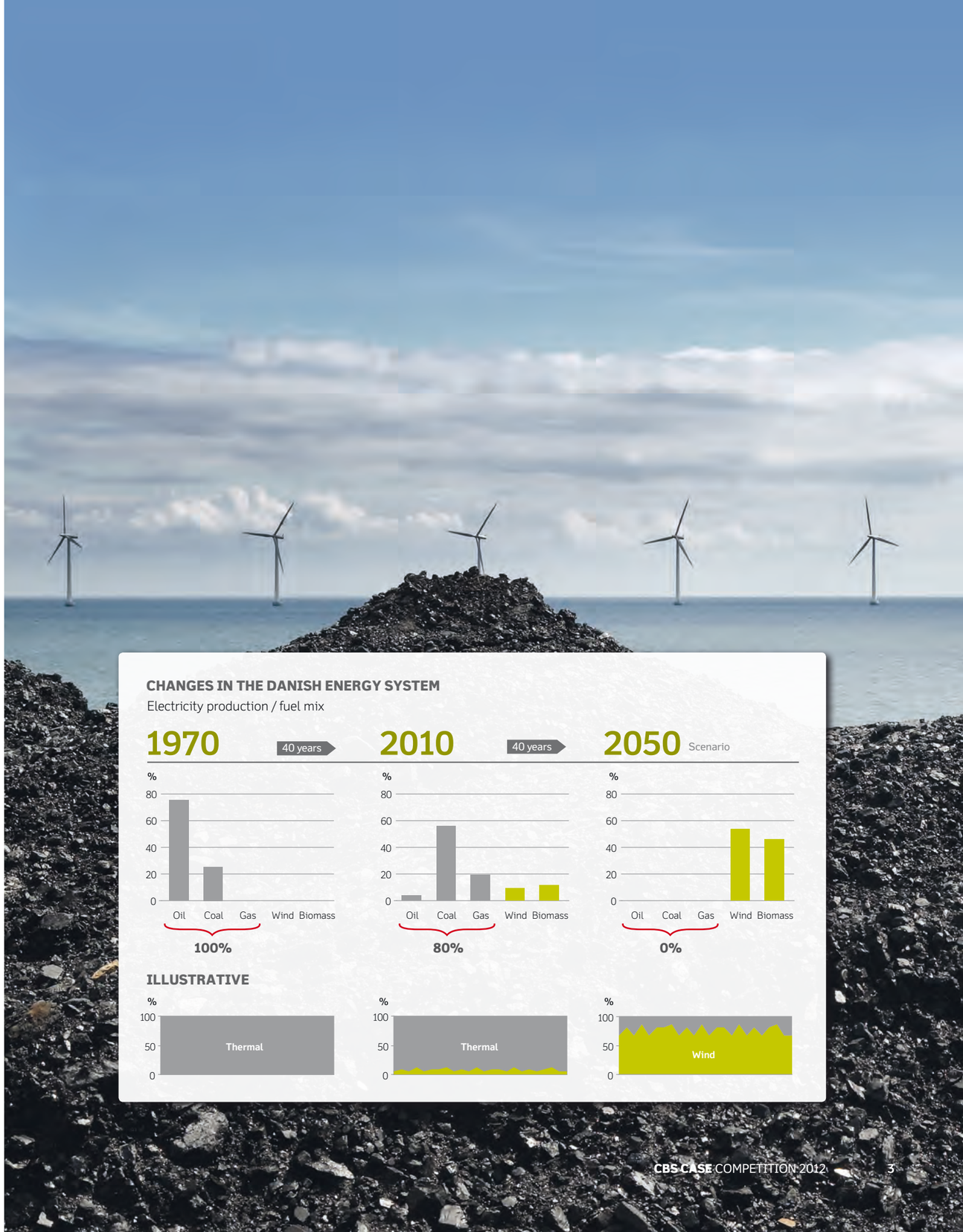
DONG Energy has pursued wind power as an alternative to fossil fuels and has developed strong, world-leading competencies within this field, representing an important first step in lowering CO_2 emissions. However, wind has a will of its own, and while wind farms provide clean energy, they lack the reliability of traditional power plants.

As Jakob Bøss says, "We can control the production from our thermal power plants, but we cannot control the wind." Electricity production used to be dictated by demand, but with more wind power in the system, demand must now increasingly follow the intermittent wind production.

Due to the need for moving the entire energy sector towards renewable energy sources, DONG Energy has simultaneously developed other technologies. Bøss continues, "The world can move closer to a clean and reliable energy supply if biomass is utilized intelligently but, these technologies are in an emerging state. We have yet to find an answer to how to successfully scale them and realise the full potential of biomass." However, one thing is clear: Energy demand is rising, and the current means of supplying energy is unsustainable. This necessitates substantial changes to the current energy system.

At an earlier meeting, Eldrup stated the problem clearly: "We are not looking for scientific solutions from these teams. We expect to see specific and creative business solutions for how to further leverage our market positions, portfolio of technologies, and partnerships."

In the car on their way to the teams' presentations, Eldrup and Bøss begin discussing DONG Energy, how the company has grown to become what it is today, and their perspectives on how energy will be produced and delivered in the future.



The Background

Introduction: In the 19th century, the world was just starting to discover the wonders of energy. An energy industry that began by providing streetlights to large cities fuelled the industrious 20th century and shaped the world we live in today. What started with localised gasworks in Danish cities has evolved into an intricate energy distribution network delivering a commodity that forms the backbone of our modern society – a backbone that we have all come to take for granted.

1970

1973, Danish Oil and Natural Gas (DONG) became a reality. Due to the oil crisis of 1973-74, the Danish government decided that Denmark needed to reduce its dependence on oil as the country's sole energy source, which had fuelled the development of the welfare state throughout the 1960s. The goal was to convert the energy sector into a multi-tiered energy supply system by increasing focus on natural gas, exploration for North Sea oil, central power plants, district heating, and later, wind power.

Throughout the 1970s, in response to the oil crisis, the energy sector prioritised security of supply, with one solution being to convert power plants from oil to coal. Coal could be acquired at more stable prices from a diverse set of suppliers. On the demand side, consumers were urged to cut back on energy consumption, for instance through campaigns highlighting the advantages of better home insulation and legislation that enforced car-free Sundays. Although some remained sceptical of government intervention, the need for a high security of supply was deemed too important to be left to market forces.

1980

In the 1980s, concern for the environment began increasing in Europe, leading to the production of a specific action plan for Denmark. Among other things, this recommended the use of less-polluting fuels, which meant transitioning from coal and oil to natural gas and biomass. Even though security of supply remained important, concern for the global environment became a greater driving force in determining energy policies around Europe.

1990

In the mid and late 1990s, the EU developed far-reaching initiatives to liberalise energy markets. These initiatives, which were implemented within the energy sector over the following decade, opened the way for international competition. For DONG, the prospect of becoming a small player in a very large market made clear the necessity of transforming from a natural gas company to an integrated energy company. An integrated European gas market would introduce new, larger competitors. Integrating more activities would make DONG less sensitive to price fluctuations and margin pressures at certain points in the value chain and would increase DONG's competitiveness with the new players in the market.

2000

From the second half of 2000 and onwards, it became clear to DONG and others that consolidation in the sector was needed to create players that were sufficiently large to withstand foreign competition. As a result, a merger took place of DONG, a natural gas company; ELSAM and Energi E2, electricity producers with coal-fired power plants and wind; Københavns Energi; Frederiksberg Forsyning; and NESA. Combined, these companies distributed energy to over 1 million Danish consumers.

The new energy player, DONG Energy A/S, would span all segments of the value chain and would be prepared to compete with other European players. Efficiency would be achieved through improved scale and scope, which are vital for survival in the energy sector of a liberalised Europe.

Focus shifted back to environmental concerns, and climate change became a hot topic. Denmark emitted around twice as much CO_2 as Sweden. This was because Denmark had relied on coal-fired power plants to reduce its oil dependency since the 1970s, whereas Sweden had focused instead on nuclear and hydro power. At the EU level, several policies and regulations were put in place to decarbonise the European power sector, including national targets for reducing CO_2 emissions, increasing the amount of renewable energy, and pricing CO_2 emissions via the EU-ETS system. As a consequence, DONG Energy decided to alter its energy mix in the direction of more sustainable energy sources.

About DONG Energy

Introduction: DONG Energy is an integrated energy company that is present in both the up- and downstream segments of the value chain. DONG Energy produces and trades in the key commodities of oil, gas, power, and renewable energy, which are managed by five business units, namely Exploration & Production, Generation, Renewables, Energy Markets, and Sales & Distribution.

Exploration & Production

Exploration & Production explores for and produces oil and natural gas in Denmark, Norway, the UK, Greenland, and the Faroe Islands.

Generation

Generation is responsible for generating heat and electricity. Generation operates CHP (Combined Heat & Power) plants in Northern Europe. The business unit is opening gas-fired power plants in the UK, Norway, and the Netherlands at the same time as it is closing down or converting to biomass a number of coal-fired power plants in Denmark.

Renewables

The main activities of Renewables are development, construction, and operation of wind farms. In 2011, the constructed renewable generation capacity stood at around 1,500 MW, a figure that is expected to grow to over 3,000 MW by 2020.

Energy Markets

Energy Markets is responsible for commodities trading in the international energy markets and optimises risk exposure for the entire DONG Energy group through energy trading in the European energy exchanges.

Sales & Distribution

The Sales & Distribution business unit operates in the downstream segment of the value chain, supplying over 1.2 million customers in Denmark, Sweden, and the Netherlands with an efficient and reliable supply of electricity and gas.

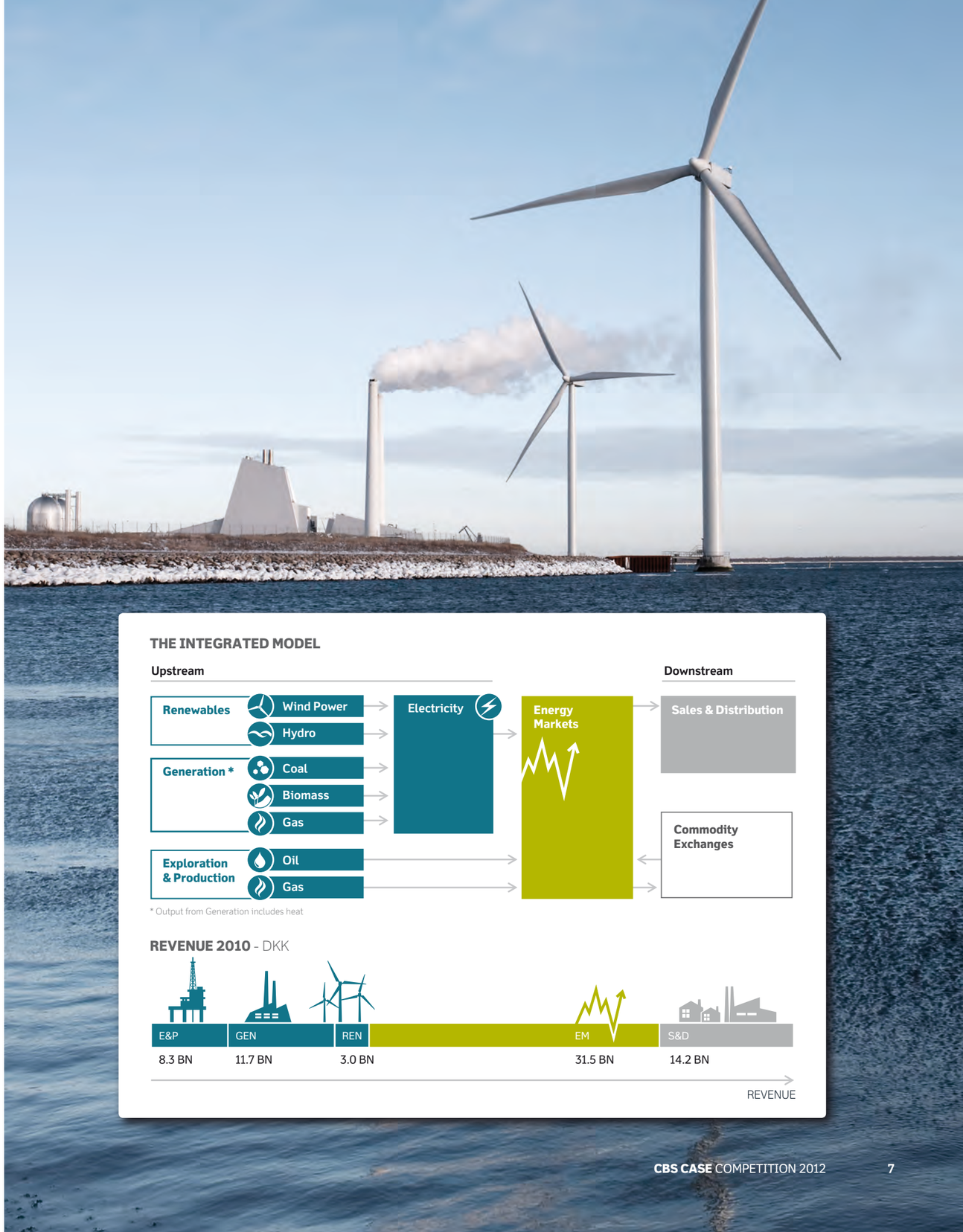
Value of integrated model

By possessing a portfolio spanning activities from exploration and production to generation, trading, sales, and distribution, the group achieves a number of synergies in terms of strategy and scale. While the production of energy provides significant growth opportunities, the downstream business provides stable cash flows from distribution and sales operations.

With the Energy Markets business unit inside DONG Energy, the company has better opportunities for optimising the value of the commodities it produces and managing overall exposure to the European and global commodity markets. Furthermore, the continual evolution of the energy sector makes it uncertain where value will be made within the value chain. Presence across the entire value chain therefore reduces exposure towards changes in an industry that is undergoing profound change.

EBITDA MARGIN 2010

EXPLORATION & PRODUCTION	GENERATION	RENEWABLES	ENERGY MARKETS	SALES & DISTRIBUTION
61.1%	19.0%	58.6%	9.4%	14.4%



The Strategy

As one of the leading energy groups in Northern Europe, DONG Energy produces, distributes, and trades energy products throughout the region. As a consequence of its geographic focus, activities outside of Northern Europe were divested during the 2006 merger. It is important for DONG Energy not just to deliver energy to its customers but also to do so in a *clean* and *reliable* manner.

This vision is expressed in the goal of producing 85% of all heat and power using renewable energy sources by 2040, thereby greatly reducing CO_2 emissions from power and heat production. This vision was set out in 2009 and is referred to as the 85/15 vision. It is expected to be achieved through an energy mix focusing on wind power, biomass, and natural gas. Transformation of power production will require significant investments from DONG Energy in the years to come. As Jakob Bøss says, "How we value investments varies from project to project, but in general we assess the expected return and strategic fit while also taking into account the risks involved. It is a constant challenge to ensure that limited funds are put to their most efficient use."

DONG Energy is the world leader in design, construction, and operation of offshore wind farms, holding a global market share of around 30%. This position is challenged by other large players and is maintained through continual growth in production capacity. The offshore wind farms industry is in many respects driven by economies of scale in procurement of turbines and components, optimisation and rationalisation of the construction process, and selection of the best sites. It is therefore paramount for DONG Energy to possess the best know-how as well as good access to funding. With a market that will grow significantly in the coming years, DONG Energy's strategy is to maintain its market leadership through continuous supply chain industrialisation and innovation partnerships.

Thermal power plants using coal and gas provide reliable energy but emit CO_2 in the process. Although increased production of electricity from wind power reduces CO_2 emissions, wind energy is less reliable a power source than are thermal power plants. Flexible power plants, international transmission capacity, and flexibility in consumption are thus key levers for ensuring a balanced future energy system as more – and more intermittent – energy is added to the system.

In 2010, New Bio Solutions was added to the roster of DONG Energy's business areas as part of Generation. New Bio Solutions aims to commercialise technology for utilising biomass for energy purposes. Biomass is a major potential source of energy on a global scale, and there is great potential for improving utilisation of these new biomass technologies.

Besides Generation and Renewables, the other business units are central to DONG Energy's business as a whole, even if they are not as central to realising the 85/15 vision. Not least Energy Markets which manages the overall risk exposure.

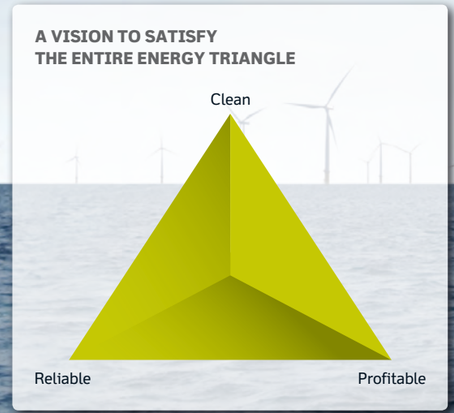
The other major growth area for DONG Energy besides offshore wind is Exploration & Production (E&P), which is a mid-sized – and growing – oil and gas company operating in the North Sea. E&P has strong competencies and experience as an operator within exploration, development, and production.

Today, E&P produces from fields in Denmark and Norway. In order to maintain its reserves and production, E&P participates in licensing rounds in the areas in which it operates, which also include the UK (the West of Shetland area), the Faroe Islands, and Greenland. E&P also uses acquisition to gain access to reserves and production. Bøss says, "For many years to come, we will still depend on oil and gas, not least in fuelling our cars and for advanced materials, and on natural gas as a reliable, low-carbon fuel to complement renewable energy in our power system. For DONG Energy, a key point of our strategy is to contribute to a high security of supply in these areas through our own production of oil and gas."

S&D supplies gas and electricity to around 1.2 million customers in Denmark, Sweden, and the Netherlands. The division also owns and operates over 25,000 kilometres of power and gas distribution grids, connecting these customers to the transmission grid. Transmission grids are the high-capacity cables that run through Denmark and connect to other countries.

EU regulations prevent DONG Energy from owning the transmission grids, which are controlled by a state-owned entity. DONG Energy must furthermore allow other companies access to its distribution grid and vice versa. "In our downstream operations, we need to continually improve our operational efficiency while at the same time bringing to the market new products and services that enable our customers to support the green transformation," Eldrup comments.

In supplying the world's demand for energy, there is the challenge of, on the one hand, supplying to an evergrowing population and, on the other hand, reducing pollution when supplying this energy. However difficult this may prove to be, DONG Energy has made these two challenges the core of its 85/15 vision – to provide clean and reliable energy. DONG Energy is confident in its strategy's sound commercial prospects and anticipates a doubling of its operating profit by 2015 (compared with 2009).



Generation

Introduction: Generation is the division of DONG Energy that operates thermal CHP plants. Heat, like electricity, is delivered to consumers through a (district heating) grid. District heating accounts for 62% of Danish space and water heating, a share that is increasing. The thermal CHP plants include gas- and coal-fired plants as well as some that are fired by biomass.

Generation is in the process of substantially altering its portfolio as part of DONG Energy's overall green transformation.

Transitioning away from coal

Although DONG Energy has some of the most efficient coal power plants in the world, the decision has been made not to build any new coal-fired power plants and to convert existing coals-fired power plants to biomass. As a consequence, in early 2011, the company divested its coal-related engineering department to the Rambøll engineering consultancy.

In 2006, ten coal-fired plants were in operation. By 2010, the number was halved, and by 2014, only two are expected to remain.

Biomass as an energy source

Since the 1990s, Danish energy companies have been required to combust a certain amount of straw as part of their overall fuel mix – a feat that is not easily accomplished. Early attempts were unsuccessful. Straw not only combusted poorly but also contained alkali salts and other materials that corroded boilers and covered them with slag. DONG Energy experimented with a f eedstock washing technique to mitigate these issues, a development that later led to the technologies producing 2nd generation bioethanol.

Straw contains many nutrients that help plants grow yet wreak havoc in a power plant. Amongst the nutrients are nitrogen, potassium, and phosphorus. When these are combusted, nitrogen reacts with oxygen to form NOx, an air pollutant that causes acid rain. NOx is normally captured in a catalyser, not unlike that found in most cars, and turned into harmless substances. But as potassium clogs up the catalyser, large quantities of NOx are free to escape. Phosphorus, on the other hand, is completely annihilated by the high temperature. Other substances in the straw pollute the ash left behind so it cannot be used for cement production as can coal ash. These factors limit the potential for co-firing straw with coal to 10-15%. In dedicated boilers, biomass can be used as the sole fuel.

In addition to traditional combustion of biomass, New Bio Solutions is working to develop and market new technologies that enable a more intelligent use of biomass, for instance converting straw into 2nd generation bioethanol and biomaterials, treating household waste with enzymes to produce fuels or biogas, and turning difficult biomass fractions into biogas.

Renewables

Introduction: Renewables focuses on harnessing nature's forces to generate electricity. Both hydro and wind belong to this business unit. The primary focus is offshore wind, and the continuing construction of offshore wind farms is instrumental to achieving DONG Energy's 85/15 vision. While offshore wind is more expensive than onshore wind, there is more space available, higher average wind speeds, and fewer concerned parties such as neighbours.

The European Commission has touted offshore wind as the "energy of tomorrow", and there are sufficient suitable sites around Europe's coasts to supply seven times the energy requirements of the continent.

DONG Energy was the world's first company to build offshore wind farms, with the first demo farm in 1991. DONG Energy later went on to build the world's first commercial farm in 2000. Despite being a small player in the global electricity market, DONG Energy continues to be a global leader in the niche of offshore wind, both in terms of market share and its involvement in many of the world's largest wind farms. Indeed, DONG Energy has constructed around half of the current offshore wind capacity worldwide.

DONG Energy has developed unique capabilities in analysing, maturing and executing offshore wind projects as well as in operating offshore wind farms. The analysis and maturation phases require detailed cost and production estimates to calculate the economics of a given wind farm.

The phases encompass considering a wide variety of details, such as farm layout and seabed conditions. Careful planning is becoming increasingly important as more and more farms are being constructed in remote locations. Construction is handled by highly specialised barges, and in 2009 DONG Energy acquired one of the world's leading installers, A2SEA, eliminating what can often be a bottleneck in offshore wind farm construction.

Once farms are up and running, DONG Energy's monitoring and maintenance systems detect and correct any issues before damage occurs, to minimize both downtime and maintenance cost. Production at wind farms is forecasted by the minute and production at CHP plants is constantly regulated accordingly.

Financing

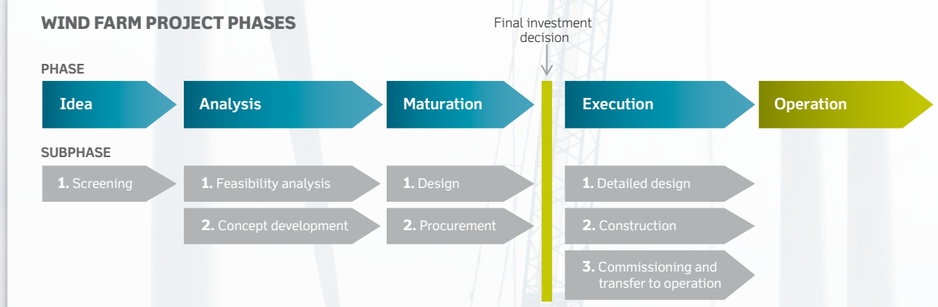
The installed offshore capacity in Europe is expected to grow rapidly in the coming years, and an additional 34 GW is expected by 2020. This corresponds to a CAPEX investment of approximately DKK 1,000 billion, a bill that would be impossible for utilities to shoulder alone. Being a small player in the overall energy market, DONG Energy will have to be very successful in obtaining external financing if it is to maintain its current market share. In the past, DONG Energy has had success building wind farms together with other players as well as selling stakes in farms to institutional investors.

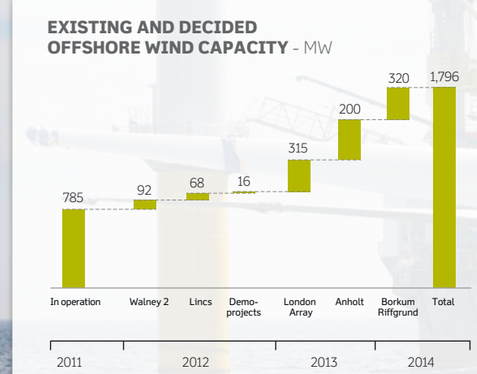
Wind farms provide stable returns for institutional investors. As the operating partner, DONG Energy, handles the running and maintenance of the farm and assumes operational risks. Subsidy schemes ensure that a significant portion of the total revenue is based on fixed prices and ensure a secure outlet for generated electricity for a number of years, depending on the country of operation, after which the farm competes on market terms. This means that payoffs to investors are determined by how much the wind blows, which may be volatile in the short run but can be predicted with great accuracy over longer periods. Institutional investors require low risk, stable return, and long investment horizons, hence the attractiveness of wind farms investments. As stakes in wind farms are not exchange traded, there is an extensive process in identifying interested counterparties and executing the deals.

Wind farms represent a new investment class for institutional investors, and asset managers are unfamiliar with how to value them, therefore making some hesitant to invest. So far, DONG Energy has been successful in selling shares of offshore wind farms to pension funds, but it will need to increase its funding efforts if it is to continue being the frontrunner in offshore wind.

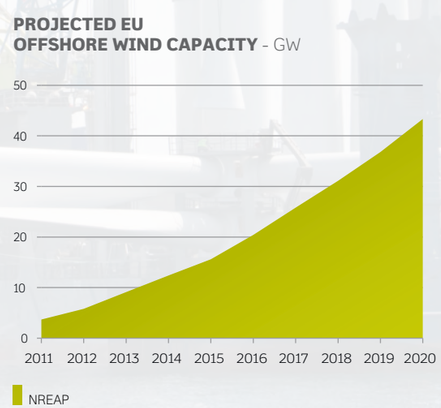
While wind energy is clean, it is inherently unreliable and must be complemented by more flexible sources.

Financing and legal framework in key countries
www.casecompetition.com/casesolving/2012/QR-01





* DONG Energy pro rata ownership share



Achieving flexibility

In order to ensure a reliable energy supply, flexibility must be built in so as to continuously ensure the balance between demand and supply. There are three main ways of achieving this.

Production

Energy companies can make the generation of electricity more flexible in many ways. One way is to operate more flexible power plants. By optimising start-up and shut-down times and costs, they can respond more efficiently to market changes. Another flexibility "tool" is energy transmission between countries. Energy was once very localised; now, however, the energy grid has made possible transmission over great geographical distances. Although this ensures that the most efficient and cheapest energy source is used, the grid does have its limits: The interconnectors have a fixed capacity, which may constrain energy transmission.

Consumption

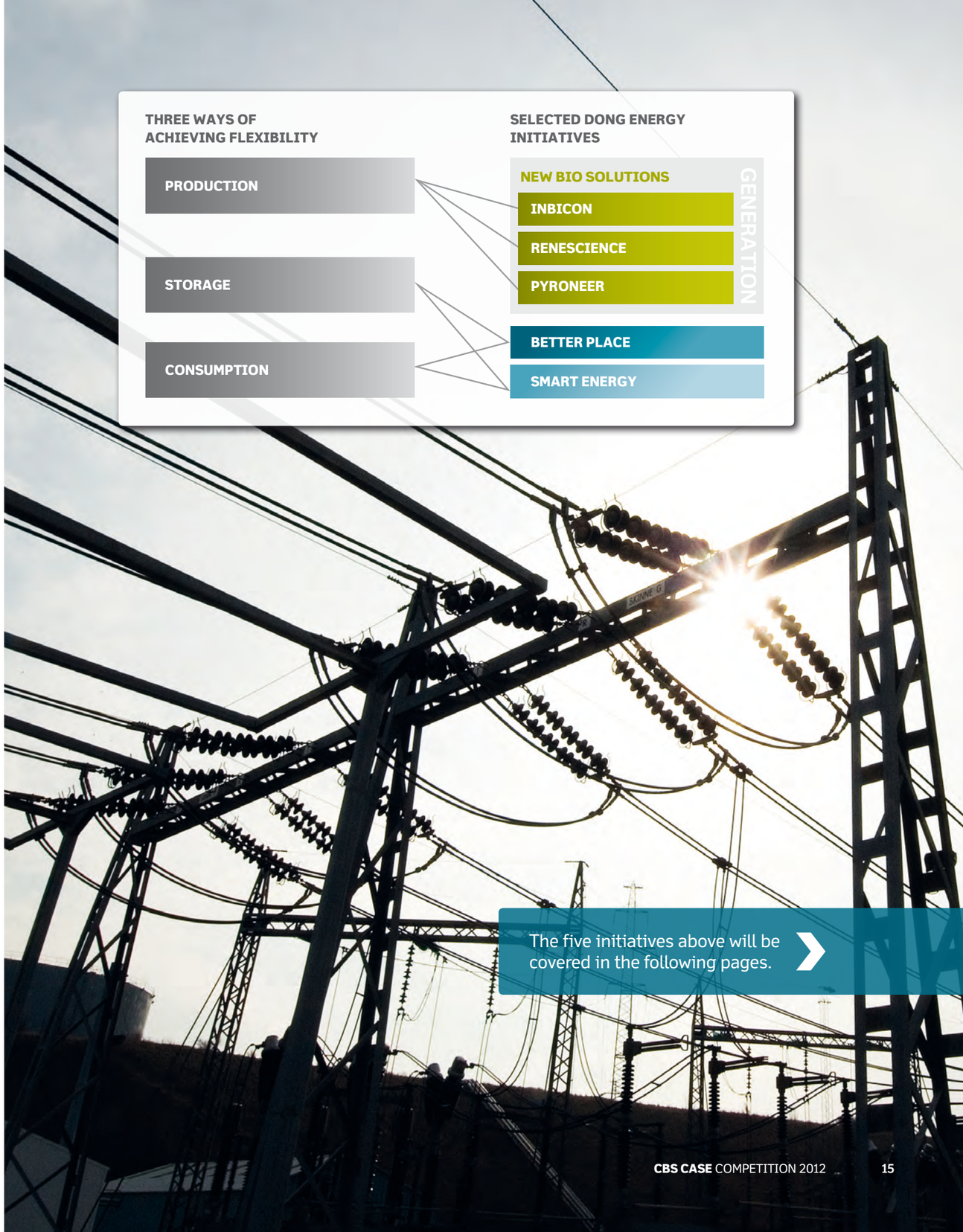
Adjusting the supply side does not change the fact that energy demand fluctuates significantly over the course of the day, week and year. Therefore, adjusting consumption based on production can also help. Smart energy, including smart grids, is about building intelligence into the energy system to control consumption and production behaviour from all actors. This can enable energy companies to use prices to regulate demand, respond more quickly to demand spikes, send power to electric car batteries during periods of excess supply, etc. Smart energy – taken to the extreme – is energy's answer to the invisible hand of the free market.

Storage

The conventional energy system is built on the premise that it is not technically feasible to store energy and hence that production and consumption must be balanced at all times. However, technology is advancing, and new opportunities are emerging.

One example is Better Place and its electric cars, which in essence are batteries on wheels that can help store energy when there is excess supply from, for instance, wind farms. Central storage facilities, such as pumped hydro or compressed air, are other examples of storage technologies. An example of centralised "storage" is hydro power from water reservoirs in Norway.

Water stored at an elevated level contains energy that can be released at will. For regions such as Denmark with flat landscapes, it is not feasible to build largescale hydro, or pumped hydro, power plants. This poses a challenge as these regions are then forced to think differently.



The five initiatives above will be covered in the following pages.

New Bio Solutions

Introduction: With its New Bio Solutions business, DONG Energy is working towards solutions that make it possible to reduce our dependence on fossil fuels through the intelligent use of biomass for energy purposes.

New Bio Solutions competes in a relatively new industry. While fuel ethanol has been produced from food crops for years in what is known as 1st generation bioethanol, it is clear that this is not the way forward. As the world's population rises, so too does the need for both food and energy. Simply converting one to the other will not help. A wide range of companies have started seeking other solutions as increasing yield and the area of farmed land can only go so far.

A variety of inputs are being considered, each of which can be processed in several different ways. Some processes use residual products, such as straw, bagasse, and manure as inputs. Others look at new crop types, such as algae, which take up little or no land and photosynthesises up to three times more efficiently than current crops. Outputs include liquid fuels such as ethanol and biodiesel, gases such as methane and dimethyl ether, and a variety of chemicals. By-products include anything from animal feed to fertiliser. Please refer to the QR-feature for more information.

New Bio Solutions contains technologies at different stages of maturity. While DONG Energy has begun to license the Inbicon technology, both REnescience and Pyroneer are in the testing phase. All of these technologies are promising but in an early stage of commercial development. It is still unclear which of these will prove to be the most successful.

Players in the industry

New Bio Solutions cuts across several traditional value chains: The input material producers in agriculture and forestry, those with process knowledge such as biotech and chemical companies, and downstream players in fuel and electricity. Players from all of these industries are competing to gain a foothold in the market. As the QR-feature shows, each brings unique capabilities and assets to the table, yet no single company has all the pieces needed to solve the New Bio Solutions puzzle.

How the industry will be shaped in the next 10 or 20 years is anyone's guess, but the transformation is sure to be a game-changer for many of the industries involved.

Challenges for the industry

While New Bio Solutions promises to someday compete with oil and natural gas, some of the products are not drop-in replacements. In many cases, the shift to fuels and chemicals based on biomass will bring about dramatic changes. Existing infrastructure will need to be adapted, and new supporting industries will have to emerge. Even if prices of products from New Bio Solutions decrease, they will have to compete in a society currently shaped by fossil fuels, regular incineration works, etc.

Furthermore, New Bio Solutions at DONG Energy is competing in a market space in which big oil and chemical companies have strong and sometimes opposing interests in the outcome of a possible new industry. The QR-feature explores some of the issues that will have to be overcome to commercialise New Bio Solutions.

New Bio Solutions value chain
www.casecompetition.com/casesolving/2012/QR-02

Players in the industry
www.casecompetition.com/casesolving/2012/QR-03

Challenges for the industry
www.casecompetition.com/casesolving/2012/QR-04

Inbicon

Inbicon develops and sells technologies for the production of 2nd generation bioethanol. Inbicon's historical foundations lie in the pre-treatment of feedstock. The process is a direct descendant of the washing techniques tested for biomass combustion at DONG Energy's co-fired CHP plants.

Experiments with washing began in the early 1990s, and at the turn of the millennium, when it became apparent that similar "washing" made production of 2nd generation bioethanol possible, DONG Energy was years ahead of its competitors.

To this day, washing, or pre-treatment, continues to be at the heart of Inbicon's process. Pre-treatment is needed to make the cellulose in biomaterial available to the enzymes that then convert it to sugars. Unlike other methods that use added chemicals and extreme pH-values, the Inbicon process uses mostly steam. This reduces costs and eliminates the need to clean the pre-treated biomass of elements that inhibit the enzymatic process and contaminate residual products.

This makes the Inbicon process very efficient and ensures that every element of the biomass can be used. C6 sugars are converted to ethanol, and C5 sugars, which are currently uneconomical to convert, are used to form a molasses that can be used as high nutritional value animal feed. The residual product, pure lignin, is dried and compressed into pellets, which can be combusted to generate the pre-treatment steam and electricity. This can be done at the ethanol plant, but it is even more efficient if the plant is co-located with a CHP plant combusting the pellets in its highly efficient boiler.

Over the years, Inbicon has constructed several test facilities showcasing its technology, and in 2009 it built the world's first large-scale 2nd generation demo plant in Kalundborg, northwest of Copenhagen. The plant is around one-fifth the size of future full-scale plants and has allowed DONG Energy to perfect its technology – not only for wheat straw but also for different crop types grown in all major regions of the world. In handling different crop types, the major differentiator is feedstock handling; all other factors, while technically important, can be controlled via software.

Commercialization

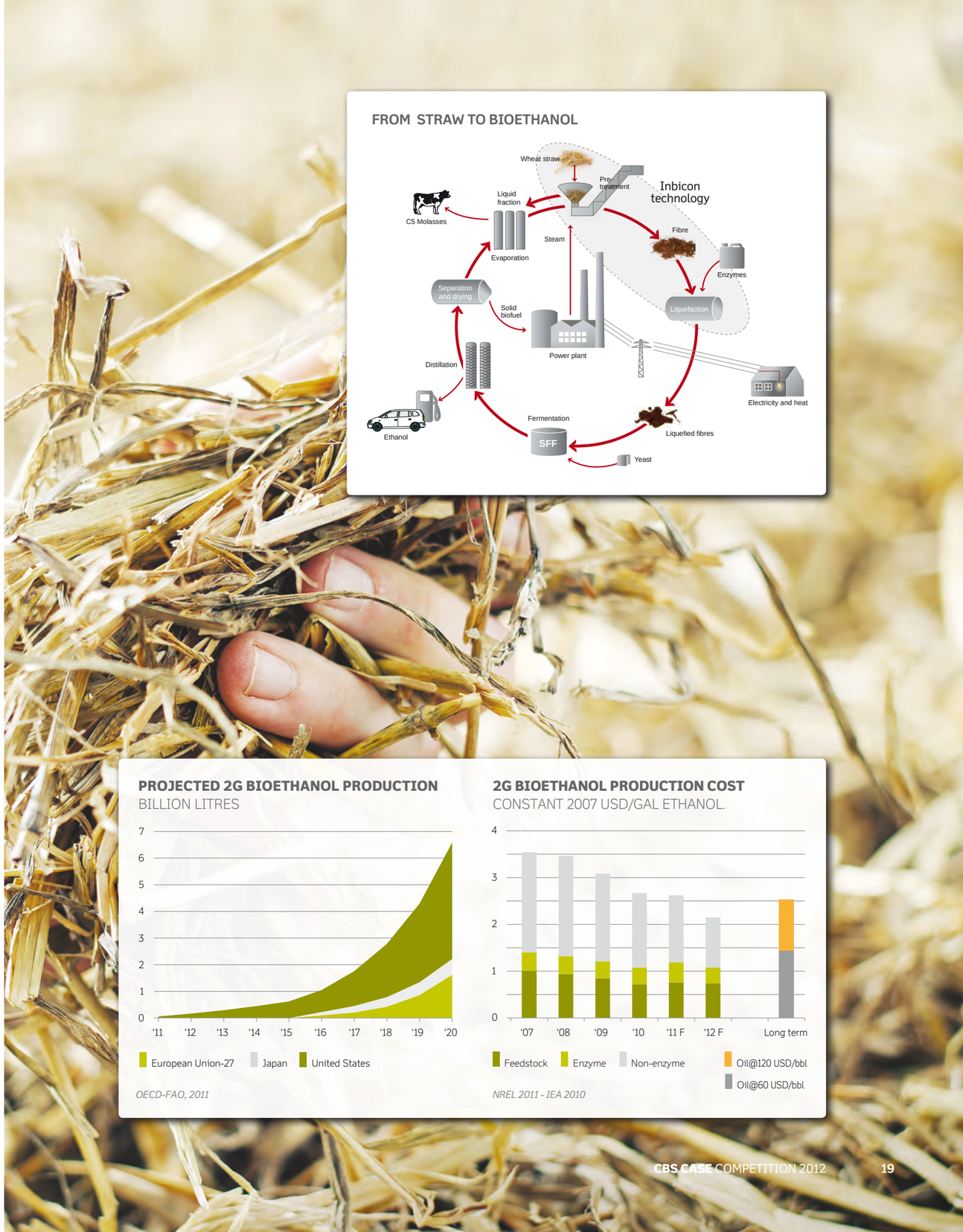
As construction of cellulosic ethanol plants is very capital intensive, Inbicon's business model has thus far involved licensing its technologies to other players, such as energy or agri-industrial companies. While it is still not a turnkey solution, Inbicon and its partners have experience across the New Bio Solutions value chain and can assist customers in all aspects of plant construction and operation.

Potential customers are those who have the capital and vision to invest in what may be the fuel of tomorrow. In many parts of the world, raw materials for the production are cheap – many feedstocks currently have no alternative use. But they also have a low energy density, which makes transportation costly. Ethanol plants will therefore need to be situated in areas with extensive farmed land as well as a functioning infrastructure.

See the QR-feature for more information about Inbicon's current partners and customers, usable feedstock, and global legislation.

Inbicon homepage
www.casecompetition.com/casesolving/2012/QR-05

Commercialisation of Inbicon
www.casecompetition.com/casesolving/2012/QR-06



REnescience
value from waste

Traditionally, municipal waste has either been placed in a landfill or incinerated. The drawbacks to landfills are well known. The local environment is polluted, and harmful substances may eventually find their way into the groundwater, polluting local water supplies. Besides the smell, landfills also release methane, a greenhouse gas that is twenty times more potent than CO_2. Incineration is a much better way to handle waste and allows some of the energy in the waste to be recovered. It is, however, far from an optimal process. REnescience is a technology that allows waste to be handled more efficiently.

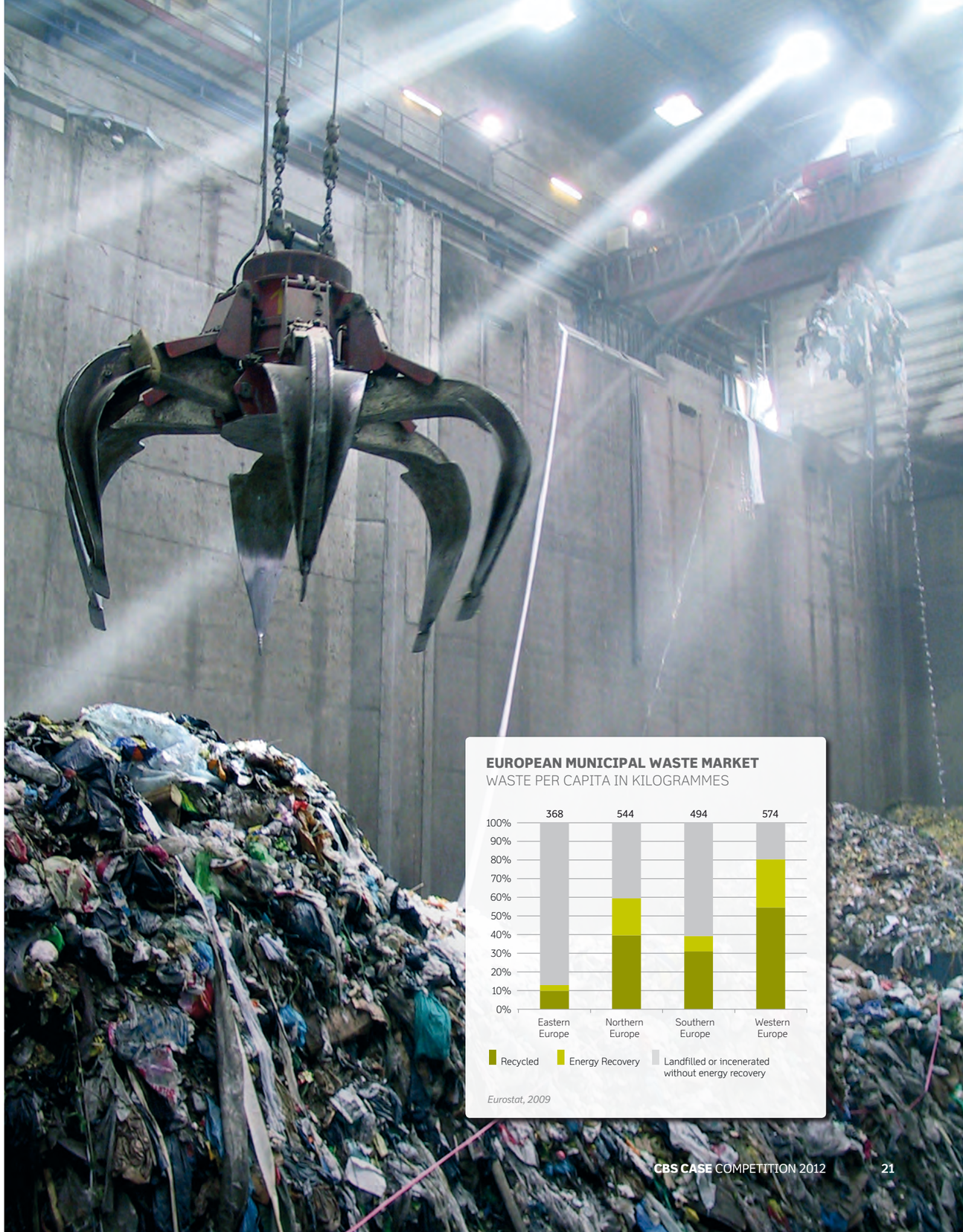
Simply put, REnescience allows the separation of solid waste into four different components: An organic part, metal, glass, and a residual product that is composed mainly of plastics. The organic part can then be turned into biogas while glass and metals are recycled. The residual product is combusted for energy.

Using REnescience, 45-50% of the waste's energy content can be converted to electricity if both the biogas and the residual product are combusted. The gas may also be upgraded to natural gas and subsequently grid-injected. This is a great improvement over the 20-25% recovery rate from incinerating untreated waste, which additionally does not allow for gas collection. Furthermore, when incinerating waste, the nutrients it contains are lost. When REnescience is used, these nutrients are instead kept in their bioavailable form and represent the residue of the biogas production. This residual product contains no harmful substances in amounts that exceed legal limit. It can thus be readily used as a fertiliser.

The REnescience process is actually rather simple. Waste is boiled in a large container, and enzymes that dissolve the organic material are then added to turn this material into a liquid. The waste is then mechanically separated into solid and liquid parts. On a volume basis, REnescience biomass yields eight times as much biogas as manure, and the conversion to biogas is nearly twice as fast.

The cost of setting up a REnescience plant is less than that of a comparable waste incineration plant, and the plant optimally handles around 10 tonnes of waste per hour. The first demonstration facility was set up in 2009, and DONG Energy is looking for opportunities to go into full-scale production from 2013. Around 1.2 billion tonnes of waste are dumped in landfills every year worldwide, and around one-third of all food produced is thrown away. The potential for waste management technologies is immense. The question is how the transition process to more efficient waste handling can be made profitable and what role DONG Energy and REnescience will play. The biggest improvements in efficiency can be made in countries that currently dump their waste in landfills, yet these countries will also have to make bigger investments in infrastructure, such as waste handling and residual incineration, to implement the REnescience technology.

REnescience homepage
www.casecompetition.com/casesolving/2012/QR-07



Pyroneer
Biomass Gasification

Pyroneer is a technology that turns low-value biological materials such as industrial waste, manure, and other biological residual products into biogas that can be co-fired in a traditional CHP plant. The residual product is an ash that can be used as fertiliser.

Both inputs and outputs are comparable to normal biogas production. Yet the process used in Pyroneer is nothing like the anaerobic digestion or fermentation traditionally employed to generate biogas.

In Pyroneer, the biomaterials are heated to around 650°C. This temperature would normally cause the materials to burst into flame, but since they cannot burn in the absence of oxygen, they are instead only partially combusted into combustible biogas and ash.

Temperature control is critical: If the temperature gets too high, the ash dis-solves, and some of the nutrients in the biomass will be destroyed while others will turn into polluting gases. When the temperature is kept exactly right, all hydro-carbons are gasified while all other substances remain in the ash and can be returned to the ground as fertiliser. Since the hydrocarbons are relatively clean, they can be co-fired in coal-fired plants in concentrations up to a maximum of 50%, a huge improvement over the 10-15% possible with straw.

The gases are not as clean as biogas produced in the traditional way since they contain a large quantity of tar. The gas is thus only suitable for use in large boilers, like those in CHP plants, and cannot be used in smaller combustion engines. While it is possible to clean the gas of this tar and turn it into a grid-injectable natural gas, doing so is not yet feasible. The upside is that Pyroneer can gasify biomaterials that are not feasible to convert at normal biogas plants and that the conversion takes place in minutes rather than days or weeks.

A 6 MW plant is currently operational, and DONG Energy is working to begin constructing larger plants in 2013. Both industrial-scale plants of 5-25 MW that can supply individual factories and utility scale plants of 50-150 MW that can supply entire cities are being considered. The question is which industrial players will be interested in having a local supply of natural gas that can be used to produce heat or steam and also whether utilities will find it worthwhile to implement Pyroneer as part of their energy portfolios.

Pyroneer homepage
www.casecompetition.com/casesolving/2012/QR-08

PHOSPHORUS SHORTAGE

Phosphorus is an essential nutrient for both plants and animals, yet phosphorus reserves are limited. Continuing to combust biomass in the way we do today will deplete our reserves. Experts predict a global shortage in 20 years, and within 40 years, Morocco will control the last remaining reserves. By 2100, natural bioavailable phosphorous will no longer be available. Clearly, something must be done. REnescience and Pyroneer are possible remedies.

Better Place

Better Place, one of DONG Energy's partners, is another company that is proactive in reducing the planet's CO_2 emissions. Better Place has developed a technology that makes it possible to have interchangeable batteries in electric cars. In so doing, they are clearing a major hurdle for electric cars: Limited range.

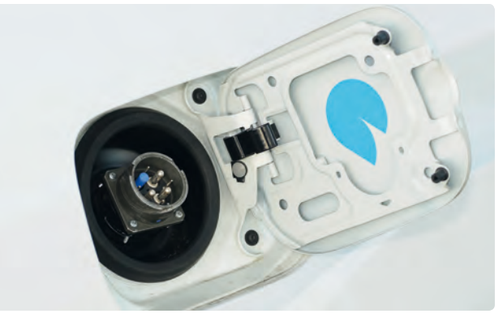
As a car's battery runs flat, drivers will no longer have to wait hours for it to be recharged at a power outlet. Instead, they can simply drive to a battery station and replace their depleted battery with a fully charged one. Currently, the cars are manufactured by Renault-Nissan, and Better Place runs and operates battery stations as well as provides customers with their own private charging outlets in their driveways.

Denmark is an optimal location for commercialising Better Place. Not only is 20% of electricity provided by renewable sources, but Denmark also has a tax system that favours electric cars. Whereas regular cars are taxed at 180%, electric cars are not taxed at all.

Better Place cars can be a valuable resource to DONG Energy. Not only will they enable DONG Energy to sell more electricity and help decrease the environmental impact of the transport sector, they are also a way to store electricity. The grid-connected cars and batteries, that is, those plugged into outlets, can charge when there is excess electricity supply and can offload capacity onto to the grid when there is a sudden excess demand. Compared with other storage solutions, the capacity is low, but the system is very responsive.

DONG Energy has invested in Better Place and regards it as a part of the solution for the energy system of tomorrow. Yet Better Place still struggles with the stigma attached to electric cars of the past – that they are slow, impractical, and have limited range. To be successful, Better Place will need to convince consumers that these concerns are no longer valid.

Better Place homepage
www.casecompetition.com/casesolving/2012/QR-09



Smart energy

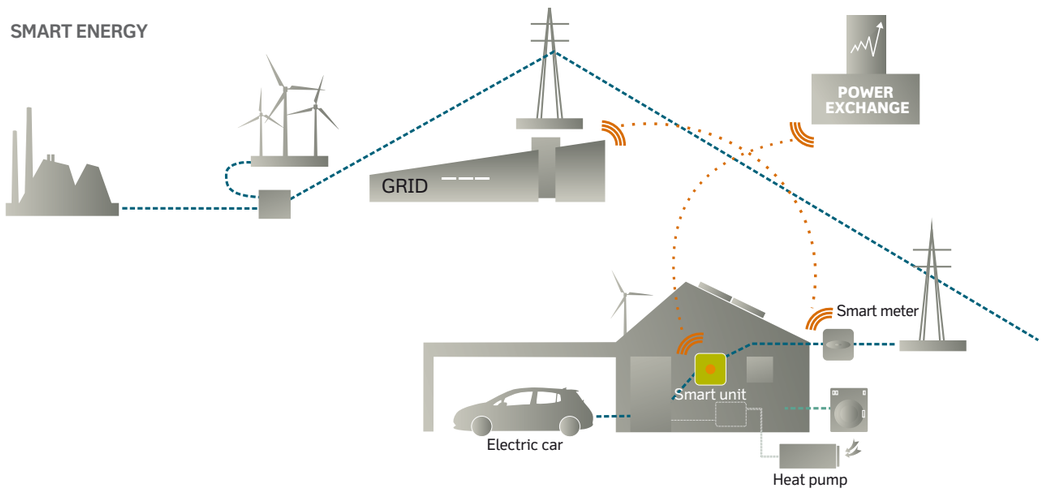
Smart energy is a catchall phrase for technologies and initiatives that attempt to manage the demand side of the energy equation. Only so much can be achieved by increasing the flexibility of supply, and our energy consumption patterns must change if DONG Energy and other players are to succeed in delivering energy in an environmentally friendly manner.

There are two paths to implementing "smart" consumption. One is to enable consumers to manually adjust consumption based on prices. This requires smart meters. The pricing lever can be used to incentivise users to cut back on consumption when there is excess demand and schedule their discretionary energy consumption for non-peak hours. Yet consumption is often based on ingrained patterns, dictated by convenience, culture, and lifestyle. Major energy users that see electricity as a cost that can be managed are willing to change consumption patterns. The bulk of users are not. DONG Energy is looking into a second path, which bypasses the user altogether.

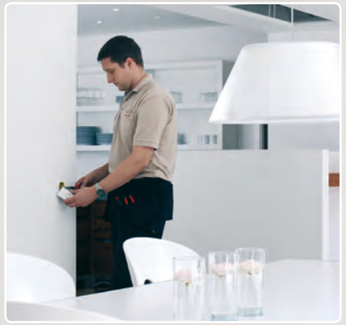
The company has recognised that, for a number of uses, such as heating or charging car batteries, users do not care when the energy is consumed; all they care about is that their house is comfortable and their car is charged.

If control of heating, charging, and similar energy uses are delegated to DONG Energy, the company can actively manage at least a part of the demand. For this, DONG Energy has developed the Power Hub platform. If done correctly, end users will not notice a thing. Yet this requires devices that are constantly connected to DONG Energy's Power Hub, which can intelligently balance the needs of the user with those of DONG Energy.

Some devices may even send energy back onto the grid when there is excess demand. DONG Energy is working to bring additional resources onto the Power Hub. Examples may include Better Place cars, heat pumps, emergency power systems, etc. For smart energy to gain ground, it is paramount that it can provide real value for the customers.



The five initiatives and others like them will affect both supply and demand in the market for electricity and change the energy system and energy mix over the coming years.



The electricity market
– supply and demand

Introduction: Electricity is a very special commodity. It is completely homogenous and can be produced in numerous ways. However, due to the current impracticalities of storage, production needs to occur at the moment consumption takes place. With demand fluctuating by the second, this can be a daunting task. Demand is influenced by numerous factors, from the time of day to the weather, from global economic business cycles to regional cultures. Few other products in the world can be said to exhibit the same behaviour.

Building the supply curve

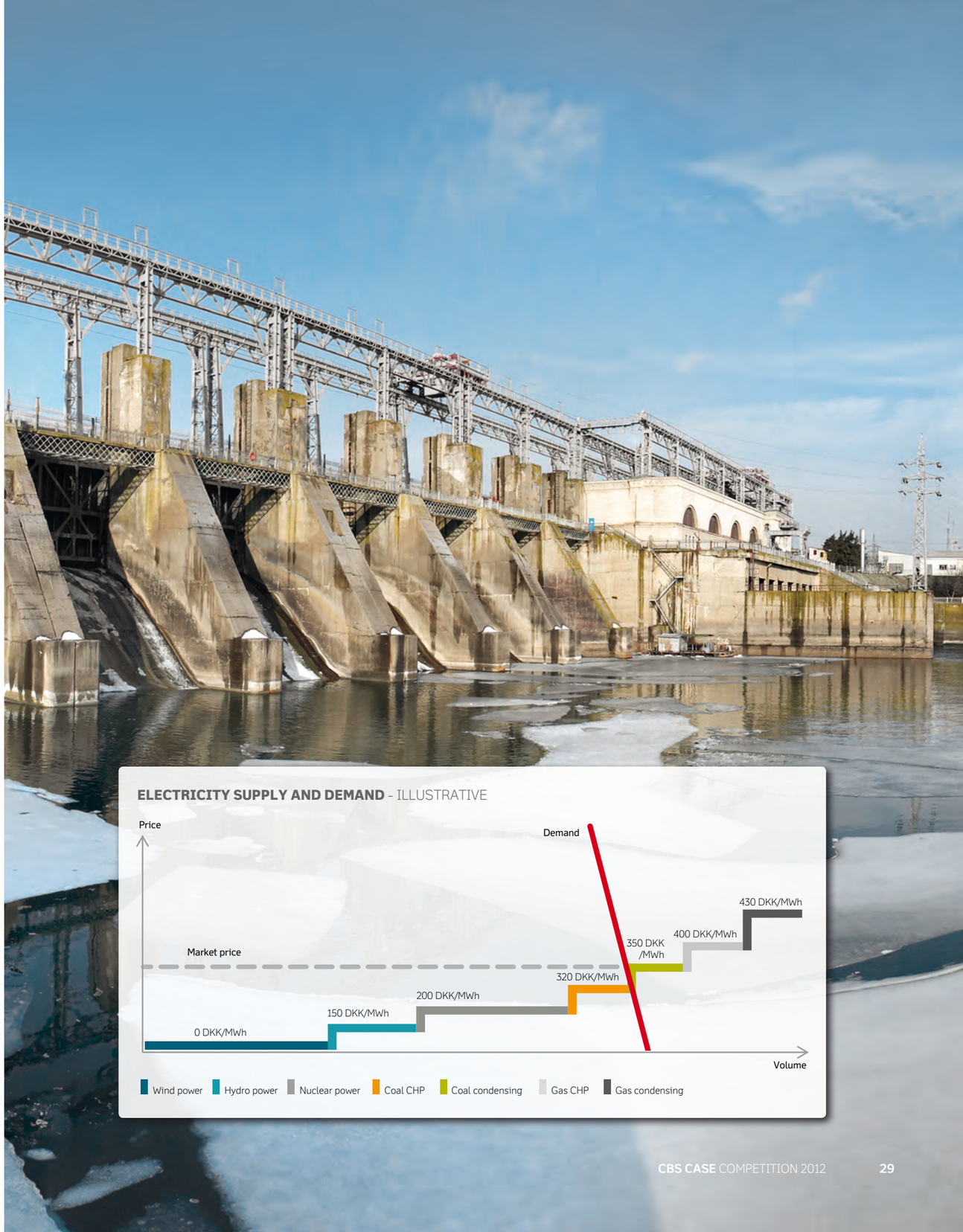
The supply curve for electricity is formed by adding together the individual supply curves of all energy sources. This forms a staircase supply curve, as shown to the right. The cheapest sources, such as wind and nuclear, enter the supply curve first due to their low marginal cost. The more expensive power sources, such as gas turbines and coal-fired power stations, are added afterwards. The intersection between the supply and the demand curve will then determine which energy source will be the "marginal" energy source, and its marginal cost will determine the clearing price in the market.

The supply curve is heavily influenced by availability of electricity from low cost technologies, such as hydro power, as well as fuel and CO_2 prices. Heavy rainfall in Norway and other Nordic countries will fill water reservoirs. This will yield cheap hydro power, which will be sold on the commodities exchange. This will lower the spot price for electricity, inevitably leading to lower production at coal- and oil-fired power plants. Strategic actions from DONG Energy and competitors constantly change the energy mix and thereby influence the overall market for electricity.

Building the demand curve

The demand for electricity is inherently inelastic, and the quantity demanded is relatively unaffected by price changes. Many consumers are not directly aware of price changes throughout the time of day or the year but, rather, see the total bill at the end of a given period. Yet there are many other factors that affect demand for energy, not least weather conditions.

Many homes are heated by district heating, and a warm winter will no doubt decrease the energy need and hence the need for thermal power plants to be in operation. The long-term trend, however, is for increasing shares of energy supply to be converted into electricity, thus increasing demand.



Closing Statement

As the car approaches its final destination in the heart of Copenhagen, Anders Eldrup and Jakob Bøss's discussion likewise comes to a close.

At the moment, a classic "tri-lema" exists between the energy sources. Those that exist in abundance pollute too much. Those that don't pollute are too unreliable. And those that achieve flexibility, exist in abundance, and don't pollute are simply too expensive at this point.

Their talk leaves one burning question unanswered:

How can DONG Energy leverage its portfolio of technologies and partnerships to profitably lead the next revolution in the energy sector – providing a clean yet reliable energy supply?

Filled with energy, they approach the room where the presentations are to be held. The two executives hope that the teams have managed to understand the complexities of the energy industry as well as grasp the potential of the new technologies and how they are to be commercialised. They look forward to presentations with actionable strategies for a focused part of the portfolio – not necessarily covering the entire span of DONG Energy.

They are anxious to hear the teams' suggestions for DONG Energy. Not on how energy will move them but rather how they will move energy – forward.

Good Luck!

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