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SHELL'S RESPONSE TO CLIMATE CHANGE AND THE CHALLENGES IN INNOVATION

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Abstract
Energy security and climate change are some of the fundamental challenges that industry and society face today and in the future. At Shell, we address the CO2 challenge through four avenues :

i. natural gas, a low CO2 intensity fossil fuel that can reduce emission by 50% when it replaces coal in a power station,
ii. biofuels, where we are the world's largest supplier of fuels containing renewable components and are developing capabilities to produce sustainable biofuels
iii. CCS : we will advance technologies in CO2 capture and transportation, and contribute our capabilities to characterize reservoirs and inject CO2 underground and
iv. Efficiency; we will continue improving the energy efficiency of our operations and reducing flaring of natural gas.

Developing new energy sources requires significant effort and typically takes 30 years. The energy industries need to work with governments to create fit for purpose incentives and with technologists to bring about new innovations faster.

1. Energy Demand and Global Warming

"Global corporations have no future if the planet has no future" R. Kabu, Honorary Chairman, Canon. There are three key trends that set out our future in society and the energy industries: surge in global energy demand, tight supply and environmental impact such as global warming. Shell's customers will demand more oil and chemical products and natural gas supplies. They will insist on quality, low cost, and supply security. At the same time, mitigating the threat of global warming will require reducing CO2 emissions from fossil fuels.

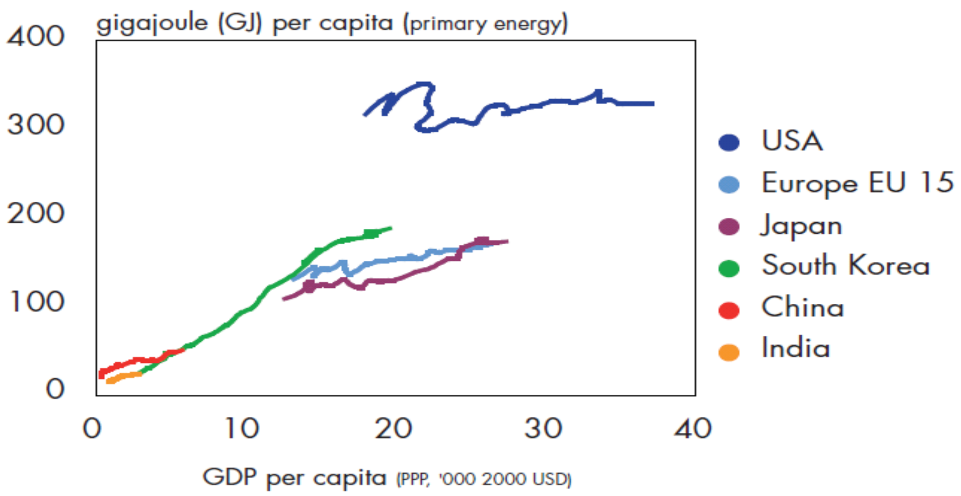

Figure 1 Specific Energy Demand[5]

1.1 Global Energy Demand Doubles

Energy underpins the way we live today and supports the hope of a better future. The twin engines of population growth and economic development will double energy demand by 2050. Population is anticipated to grow from the current 6 billion to 8,2 billion by 2030[7] and with the industrialisation of developing nations, specific energy consumption is expected to rise (Figure .1), overall leading to the doubling of energy demand by the middle of the century.

1.2 Tight and Changing Energy Supply

Against the backdrop of demand growth in the long term, there is a significant challenge in the supply side, leading to a broader energy mix, with increasing proportion of renewables and biofuels whilst fossil still remaining the primary energy source. Shell's Blue-print scenario (a scenario where the energy and climate change challenges are solved simultaneously by society) predicts a 30% proportion of wind, solar and renewable in the mix, fossil and nuclear supplying the remaining 70%.. IEA presents a less optimistic (Figure 2) view for renewables. (Mtoe denotes Million tones oil equivalent)

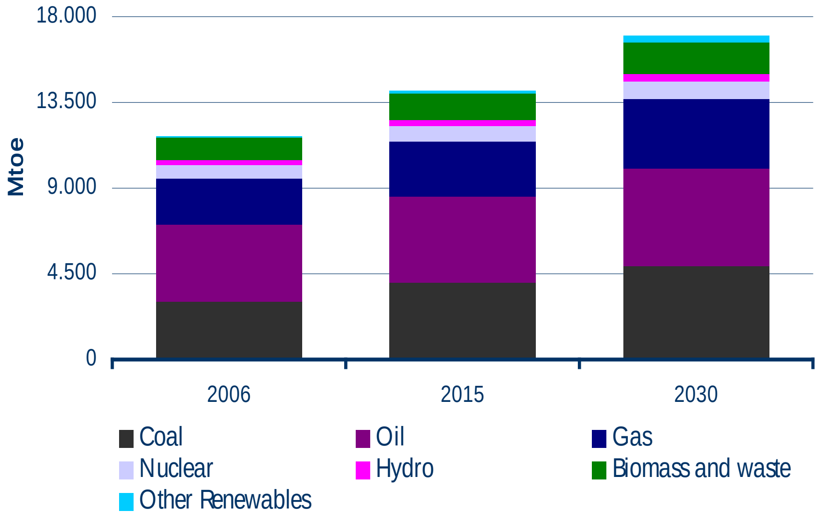

Figure 2. Energy Supply[7]

2. Global Warming

According to widely accepted scientific evidence global warming is unequivocal, global surface temperature has increased by 0,8 C since the industrial revolution[2]. Moreover, the warming trend is accelerating :11 out of 12 years between 1995 and 2006 were the hottest since measurement started (1850). There is a consensus amongst the leading organisations (IPCC, IEA, Stern team) that a stabilisation at 450-500 ppm CO2 level, equivalent with 2C rise is necessary. In order to achieve this, a 50 to 80% reduction of CO2 emissions will need to be reached by 2050, relative to the level of 2000[7].

McKinsey[4] in a wide-ranging and detailed study evaluated the potential and cost of reducing CO2 emissions. Their main conclusions was that it is feasible to reach stabilisation of global surface temperature at a 2C rise : the technology is available and can be developed by 2030, sufficient implementation capacity is estimated to be available and funding is not expected to be an limiting factor either, as the solution to global warming would require 5% of the capital that is invested around the world under normal circumstances.

Both McKinsey[4] and Stern[6] conclude that the solution to global warming would cost society 1% of world GDP. However, a 10 year delay in investment would lead to a costlier (more CO2 needs to be abated) and a higher risk pathway, as it leads through a higher temperature maximum. The abatement options broadly fall into four categories (Figure 3.)

1. energy efficiency
2. low CO2 energy supply (gas, biofuels, the use of CCS, etc)
3. opportunities with terrestrial carbon (forestry) and
4. new technologies.

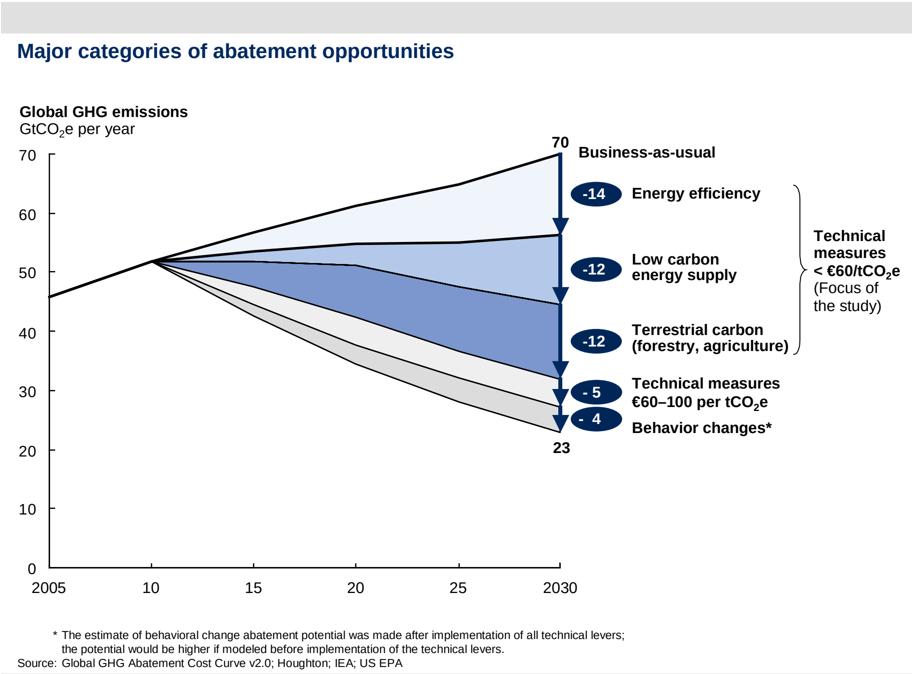

Figure 3. Main Categories of GHG Abatement

3. Energy Development

We have to recognise that the product life-cycles in different industries are very different : the development and commercialisation of a new energy technology takes significantly longer than the same in computer or mobile phone industries. A mobile phone company would need to develop and market a new phone within 18 months if it wants to beat the competition. According to historic evidence, for a new form of energy supply, it takes 30 years to reach 1% market share[3].

In order for industry and society to progress faster with the deployment of new energy sources, we need to put in place technology and life-cycle stage specific policies to support new development. Additionally, society and industries need to engage in demand side management, which tends to follow roles different to large energy infrastructure development.

4. Shell's Response to Climate Change

Our main contributions to reducing CO2 emissions are in four distinct areas:

Natural Gas: Economically de-carbonizing the power generating sector must be the first priority in reducing CO2 emissions from fossil fuels. With Shell's leading position in LNG and new technologies in recovering natural gas from tight formations, we can supply natural gas to replace coal in power generation. Even without CCS, this can cost-effectively reduce CO2 emission by 50%, and with CCS it could virtually eliminate CO2 emissions from power generation.

Biofuels: Our main contribution in reducing CO2 emission in transportation will be to supply lower-carbon fuels. We are the world's largest supplier of fuels containing renewable components and are developing capabilities to produce sustainable biofuels components—using current processes and developing technologies for advanced biofuels that do not compete with resources for food.

Carbon Capture and Storage: De-carbonizing power generation and large industrial emitters of CO2 will eventually require CO2 to be captured and stored. Shell will advance technologies in CO2 capture and transportation, and contribute our capabilities to characterize reservoirs and inject CO2 underground. We also will participate in demonstration projects involving our facilities.

Reducing Shell's CO2 Emissions: Shell will continue with improving the energy efficiency of our operations and reducing flaring of natural gas.

While these four areas are our main focus, we will contribute in other ways to reducing CO2 emissions: providing advanced fuels and lubricants that help customers save energy, helping customers manage their energy use, supporting market-based approaches to managing carbon emissions, supporting low cost CO2 abatement mechanisms—like forestry, and using our understanding of the global energy system to advocate for improved efficiency standards in transportation, building standards, and urban planning. We present here examples of our efficiency and CCS programmes.

4.1 Efficiency

We have a systemic, global efficiency improvement programme in place, that aims at reducing CO2 emissions via flare reductions, operation improvements and capital investments both in our upstream and downstream operations. The programme involves a large number of projects, here we present a few examples. Overall, our operational and continuous flaring has fallen by more than 70% since 2001. For example, between 2000 and 2008 the joint venture operated by SPDC reduced flaring by 30% in the Niger Delta (Figure 4.).

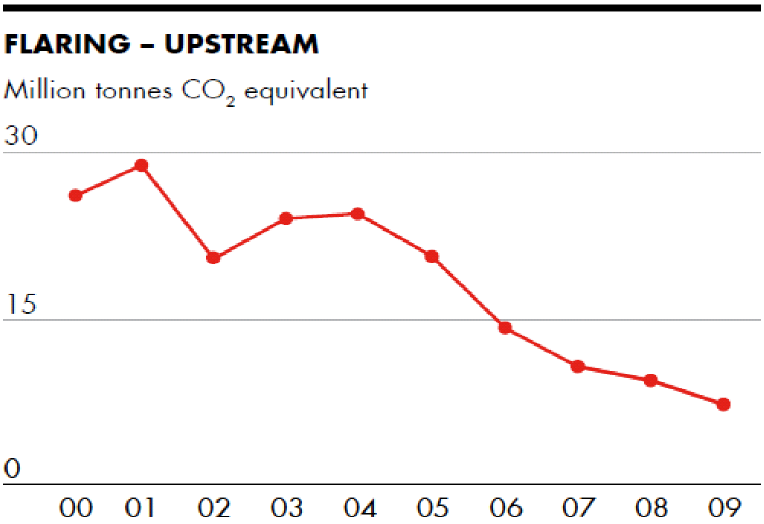

Figure 4. Flare Reduction

In our downstream business, the manufacturing business strategy outlines the ongoing forward plans for CO2 and Energy Management (CEM). The DS-M CO2 and Energy Management programme is operating within a framework based on four key themes:

- CEM Standard and Tools
- Driving Operational Excellence
- Capital for Energy Efficiency
- CO2 Technology Programme

Energy efficiency tactics implemented by the CEM program in 2009 far exceeded savings delivered in previous years (Figure 5.).

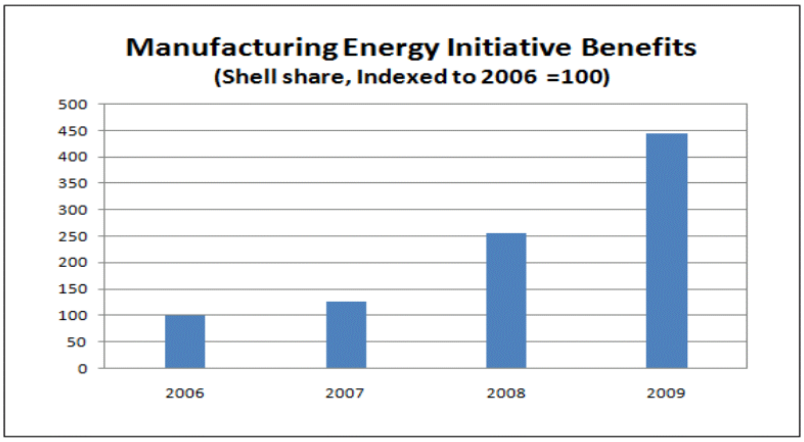

Figure 5. Operation Improvements in Downstream

4.2 The CCS Challenge

The challenge for CCS is to reduce its overall cost through learning from demonstration projects . Shell is involved in a number of opportunities World-wide. (Figure 6). CCS is driven almost entirely by climate change considerations, therefore requires clear incentives linked to policy goals that gives price signals to the value of emissions avoided.

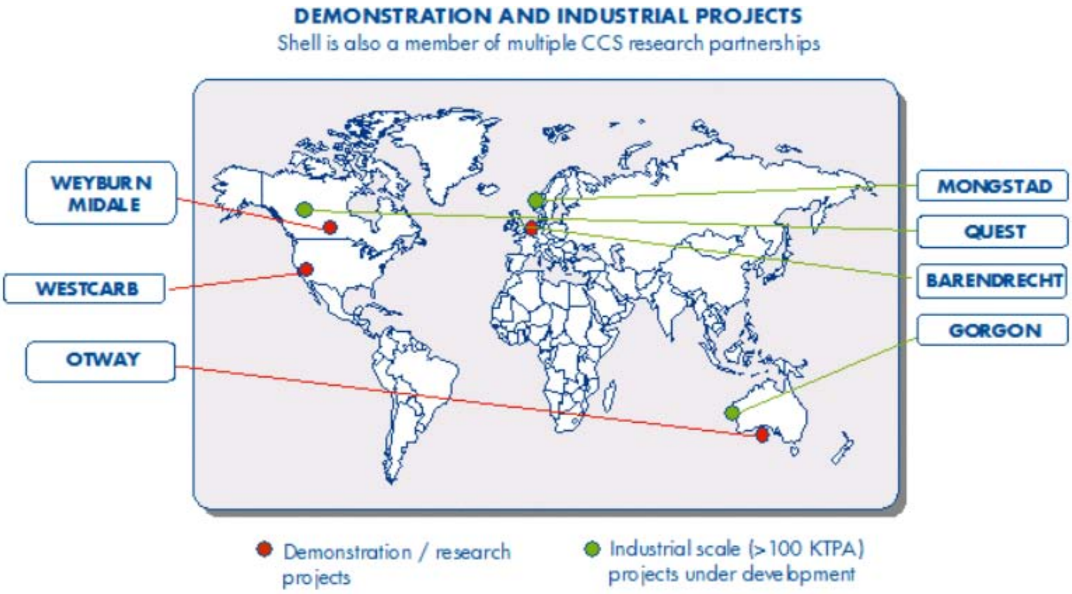

Figure 6 CCS Projects

4.3. The Role of Innovation

Shell's commitment to responding to the Climate Change issue is demonstrated by active research programs that include technologies that can be used specifically to address the challenges. The technology research portfolio of Shell includes many elements that are being incorporated into our plans and operations and that represent solutions to the CO_2 challenge. The table (Table 1) below gives a summary of the fields of endeavour that Shell is engaged in the area of technology development and deployment that will have a positive impact on our and our customers CO2 footprint.

Table 1. CO_2 R&D

Shell Response	Shell Technology	Technology Solutions	Impact	Active Research in Shell
Efficiency	Distillation devices and schemes	Column internals, on-line optimizers, heat integration, divided wall columns	High	Yes
CCS	Designer solvents	High capacity, low reaction heat solvents, column internals	Very high	Yes
Use of Natural Gas	LNG, FLNG, Cryo-separations	Integrated distillation processes and separations equipment	Very high	Yes
Biofuels	Feed densification, oil extraction	Processes and equipment	High	Yes

4.4 Distillation Research and Development

Shell believes that Innovation is a key success factor to tackle the Climate change issue. Technology innovation as described above in the Shell R&D efforts is one avenue. Here we look into a few illustrative examples in the field of distillation.

Operation: Many opportunities exist for innovative operational processes, monitoring and control, minimizing reworks and recycles, producing products to specification, etc. An example of the latter that pertains directly to distillation can be found in the manufacture of ethylene and propylene where very small increases in purities result in large increases in energy consumption. Therefore, purities need to be kept as close as possible to specifications.

Design: A lattice beam construction – a proprietary configuration developed by Shell-helps to add separation capability to a distillation column (more trays) with the consequent reduction in reflux requirements and associated energy and CO2 savings (Figure 7).

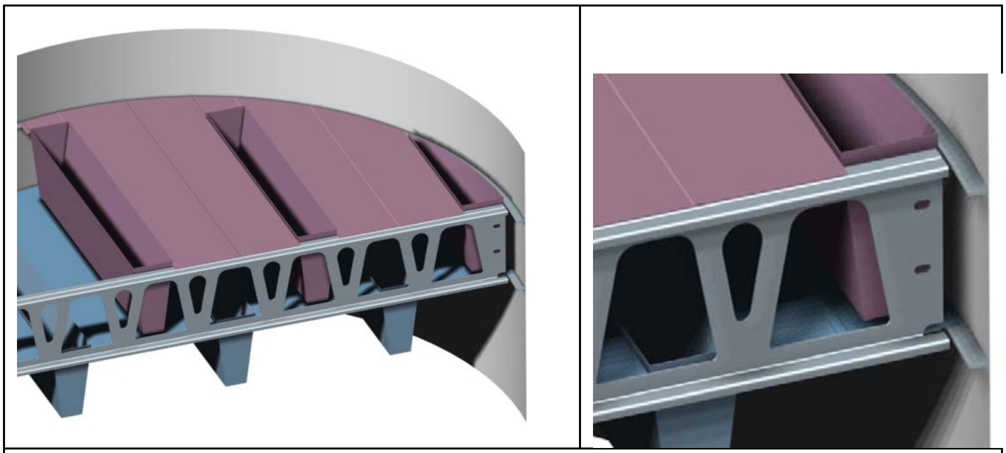

Figure 7. – Lattice Beam Construction Supporting Two Shell HiFi™ Trays.

The application of our ConSep trays in the fractionator of a Hydrocracker unit helped to de-bottleneck the distillation column. In turn, catalysts with greater productivity and longevity can be installed. (Figure 8). The larger productivity and longevity of the catalyst system result in lower energy consumption per unit of product produced.

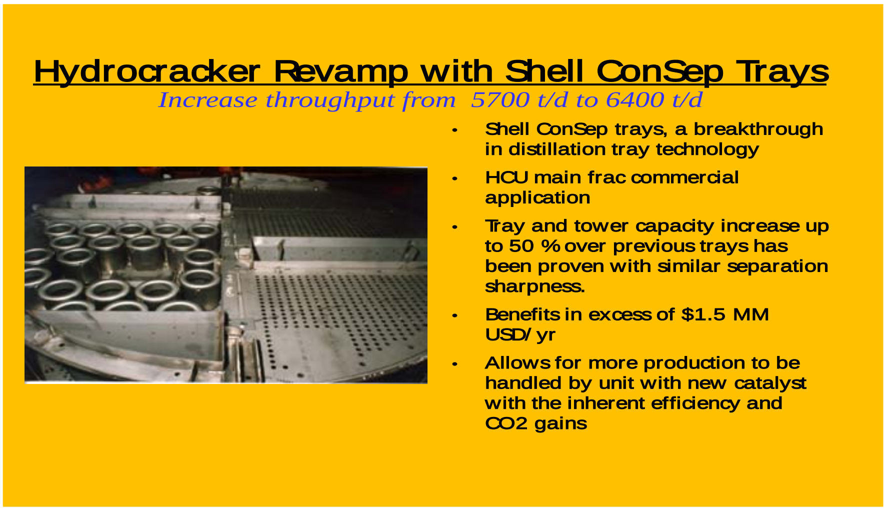

Figure 8. High Capacity Distillation Revamp

5. Speeding up Innovation

In order to meet the energy and climate change challenges, there is a need to speed up innovation and implementation, which would require incentives that fit the development life-cycle stages. Early stage innovation could be best supported through grants to provide flexibility and freedom. At a later stage, co-development with industry, academia with state support has proven successful. But often the commercialisation and implementation proves to be The Valley of Death for new technology – new public private initiatives are hopefully about to break the spell in the case of CO_2 reduction technologies. Let us take Divided Wall Column as an example. The apparatus can drive over 30% efficiency improvements in selected applications. The first patent was filed in 1940's[1] and the first applications built during the early 90's. There is scope for improvement from here.

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