DEVELOPMENT OF THE INTEGRATED ENERGY PLAN

PRESENTATION AT STAKEHOLDER CONSULTATION WORKSHOPS

FEBRUARY 2017
PROBLEM STATEMENT

• Energy is the life blood of the economy which impacts on all sectors as well as individual livelihoods. Integrated energy planning is required to ensure that current and future energy service needs can be met in the most cost effective, efficient and socially beneficial manner while also taking into account environmental impacts.

• A lack of coordinated and integrated national planning for the energy sector has led to underinvestment in much needed energy infrastructure.
  – There is currently inadequate supply in both the electricity and liquid fuel industries due to a lack of timely investments in new capacity.
  – Electricity generation is constrained due to insufficient capacity and inadequate availability of existing infrastructure.
  – There is a high dependence on import of liquid fuels as the current production capacity does not meet national and export demand. No investments have been made in new capacity since the start of the new democracy.

• Planning at individual organisation level is commercially driven and therefore investments which are required in order to ensure that the policy objectives of the country have been left under invested.

• The IEP aims to guide future energy infrastructure investments, identify and recommend policy development to shape the future energy landscape of the country.
The 1998 White Paper on the Energy Policy of the Republic of South Africa (Energy White Paper) is the primary policy document which guides all subsequent policies, strategies and legislation within the energy sector. It provides specific policy statements on what government intends for the energy system as a whole and sets out five key objectives. These objectives have subsequently formed the foundation and informed the development of energy policy in South Africa and still remain relevant. Various other energy policies have been developed and are in different stages of implementation.

- Increasing access to affordable energy services
- Improving energy governance
- Stimulating economic development
- Managing energy-related environmental impacts
- Securing supply through diversity
The IEP seeks to quantify and provide feedback on the extent to which policy objectives outside the sector may impact on the attainment of energy sector imperatives and vice versa.
The Energy Planning Framework considers all energy carriers, all technology options and all key national policy imperatives and proposes an energy mix and policy recommendations which ensures that the energy sector can help achieve these in the most optimal manner.

**Energy Planning Scope**

**Primary Energy/Resources**
- **Renewables**
  - Solar
  - Wind
  - Biomass
  - Hydro
- **Fossil Fuels**
  - Coal
  - Crude Oil
  - Natural Gas
- **Nuclear Fuels**
  - Uranium
- **Resources extraction and sourcing**

**Conversion Technologies**
- **Power Generation**
  - Conventional Coal Plant
  - Nuclear
  - CCGT
  - OCGT
  - Solar
  - Wind
- **Fuel Processing**
  - Oil refineries
  - GTL
  - CTL
- **Regasification**

**Secondary Energy Carriers**
- **Electricity**
- **Heat**
- **Refined Petroleum Products**

**End-Use Technologies**
- **Industry**
  - Steam boilers
  - Furnace
  - Machinery
- **Commerces**
  - Air Conditioning
  - Light Bulbs
  - Households
  - Space Heaters
  - Refrigerators
  - Stoves
  - Geysers
- **Agriculture**
  - Irrigation pumps
  - Transport
  - Vehicles
  - Aircraft
  - Rail
- **Industrial Sector**
  - Process Steam
  - Motive Power
- **Commercial Sector**
  - Electronic Communication
  - Cooling
- **Residential Sector**
  - Space Heat
  - Refrigeration
  - Cooking
  - Hot water
- **Agricultural Sector**
  - Water supply
- **Transport Sector**
  - Person kms
The IEP takes into consideration existing policies:

- Informs development of future energy sector roadmaps
- Provides feedback to development & review of external policies

IEP AND OTHER PLANS

- Renewable Energy Roadmap
- Biofuels Strategy
- Solar Energy Technology Road Map
- Diversity of Supply
- Gas Roadmap (GUMP)
- Energy Efficiency Strategy
- Carbon Tax Policy
- National Climate Change Policy

- Transmission Development Plan
- Security of Supply
- Distribution Infrastructure Plan
- Electricity Roadmap
- Integrated Resource Plan (IRP)
- Universal Energy Access Strategy
- Beneficiation Strategy
- Transport Plan

CLIMATE CHANGE

SUPPLY

DEMAND

IEP 2016

INTERGRATED ENERGY PLAN (IEP)
8 KEY ENERGY PLANNING OBJECTIVES

- Ensure Security of Supply
- Minimise Cost of Energy
- Promote Job Creation and Localisation
- Minimise Environmental Impacts
- Diversify Supply Sources
- Minimise Water Consumption
- Promote Energy Access
- Promote Energy Efficiency

IEP

Economic Development
Social Development
Environmental Sustainability
IEP PROGRESS
(JUNE 2013 - FEBRUARY 2016)

- **June 2013:** The Draft IEP Report was approved by Cabinet for publishing for public consultation.
- **September to November 2013:** Wide consultation through public stakeholder workshops in all nine provinces. Substantial input was obtained from stakeholders through the workshops and also through written comments.
- **January – September 2014:** An inter-governmental policy working group and various multi-stakeholder sub-committees were established to deal with more thematic and substantive issues such as policy coherence, macroeconomic impact assessment, review of demand assumptions and externalities studies.
  - Representatives from industry, academia, civil society, industry associations participated in these sub-committees.
- **Based on input obtained the following further enhancements were made on the IEP**
  - Internalising of energy systems externalities (Estimation of the externality costs of different energy carriers)
  - Determination of job creation potential for different technology types (with focus on electricity generation technologies)
  - Inclusion of the “Peak-Plateau-Decline” emissions limits constraints as the Base Case
  - Additional scenarios modelled
  - Conduct a macroeconomic impact assessment on all scenarios
  - Incorporate latest assumptions data
    - Technology costs
    - Macroeconomic assumptions
- **August 2015 – February 2016:** Input obtained from the Ministerial Advisory Committee on Energy (MACE) and further circulated to other government departments for comments
ENERGY SYSTEM EXTERNALITIES

IEP Internalises Energy System Externalities (both negative and positive)

Source: Vivid Economics 2014
EXTERNALITY COSTS

An externality cost is a cost imposed on society due to the activities of a third party, resulting in social, health, environmental, degradation or other costs. Externalities may however also be beneficial (e.g. a mine builds a fire break between its operations and the neighbouring farm from which the farmer then directly benefits in terms of safety and security).

In the context of the energy planning framework, negative externalities of different pollutants resulting from the production of energy were considered.

The cost of the externalities were quantified by estimating the ‘cost of the damage’ to society* caused by such externalities. Examples of such factors that cause damage are: air pollution (caused by pollutants such as nitrogen oxide [NO\(_x\)], sulphur oxide [SO\(_x\)], particulate matter [PM] and mercury [Hg]), water contamination and soil erosion.

*Overall cost to society is defined as the sum of the imputed monetary value of costs to all parties involved.

<table>
<thead>
<tr>
<th>Externality</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO(_2)</td>
<td>Sulphur dioxide</td>
<td>7.60</td>
<td>2012 Rand/kg</td>
</tr>
<tr>
<td>NO(_x)</td>
<td>Nitrous oxide</td>
<td>4.50</td>
<td>2012 Rand/kg</td>
</tr>
<tr>
<td>Hg</td>
<td>Mercury</td>
<td>41 484.00</td>
<td>2012 Rand/kg</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate matter</td>
<td>11.30</td>
<td>2012 Rand/kg</td>
</tr>
<tr>
<td>PM(_{\text{Transport}})</td>
<td>Particulates in transport sector</td>
<td>280.70</td>
<td>2012 Rand/kg</td>
</tr>
</tbody>
</table>
### JOB CATEGORIES CONSIDERED

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>DEFINITION</th>
<th>EXAMPLE</th>
</tr>
</thead>
</table>
| Direct Jobs      | Jobs resulting from construction or operation of the technology                                                                                                                                             | • Construction workers  
• Brick layers  
• Plant operators                                                                                                                                 |
| Supplier Jobs    | Jobs resulting from first level suppliers during construction and/or operation                                                                                                                             | • Turbine manufactures  
• Cement producers  
• Steel manufacturers                                                                                                                                 |
| Indirect Jobs    | Jobs resulting further down the value chain during construction and/or operation. i.e. suppliers to suppliers                                                                                             | • Iron ore miners and smelters                                                                                                                                               |
| Induced Jobs     | Jobs resulting from more money in the economy because of the project.                                                                                                                                       | • Restaurants  
• Transport services  
• Medical facilities                                                                                                                                                        |
| Permanent Jobs   | These are jobs which have a longer duration and are more permanent in nature. Services are usually established in-house within the organisation.                                                                 | • All operations jobs are considered to be permanent jobs  
• Estimated per unit of capacity installed                                                                                                                                 |
| Temporary Jobs   | These are jobs which have a relatively short duration. Services are usually contracted.                                                                                                                    | • All construction jobs are considered to be temporary jobs  
• Estimated per unit of energy output                                                                                                                                         |
## LOCALISATION POTENTIAL
(BASED ON CURRENT POLICIES AND LOCAL CAPABILITY)

<table>
<thead>
<tr>
<th>Level of difficulty to localise</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localisable</td>
<td>The current policy framework is conducive for localisation; local supply of the required skills set is available; and there is sufficient demand for raw material to justify local production</td>
</tr>
<tr>
<td>Potentially localisable</td>
<td>The current policy framework exists or could be developed and implemented within a fairly short timeframe (3-5 years)</td>
</tr>
<tr>
<td>Collaboration</td>
<td>The current policy and regulatory framework could be developed and implemented within five years and some targeted investments would need to be made</td>
</tr>
<tr>
<td>Significant investment required</td>
<td>Regional cooperation and partnerships would need to be developed in order to create demand beyond South Africa’s borders</td>
</tr>
<tr>
<td>Global demand required</td>
<td>Some of the required technology components can be localised but South Africa would need to be competitive in exporting the technologies and services to the global market</td>
</tr>
</tbody>
</table>
The National Climate Change Response White Paper (NCCRWP) sets emission limit targets for all sectors. The energy planning framework considers the impact of the emission limit targets for the energy supply sectors only (electricity generation and the production of petroleum products).
## IEP SCENARIOS

<table>
<thead>
<tr>
<th>INDICATORS</th>
<th>BASE CASE</th>
<th>RESOURCE CONSTRAINED</th>
<th>ENVIRONMENTAL AWARENESS</th>
<th>GREEN SHOOTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Constraints</td>
<td></td>
<td>9.6 GW New Nuclear Build enforced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>Treasury moderate GDP growth</td>
<td></td>
<td></td>
<td>National Development</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High GDP Growth</td>
</tr>
</tbody>
</table>

### DEMAND-SIDE INTERVENTIONS

<table>
<thead>
<tr>
<th>DSM</th>
<th>1 million SWH</th>
<th>5 million SWH</th>
<th>10 million SWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy efficiency</td>
<td>Business As Usual</td>
<td></td>
<td>High Energy Efficiency</td>
</tr>
</tbody>
</table>

### VEHICLE EFFICIENCY (new vehicle improvement per annum)

<table>
<thead>
<tr>
<th>Car types</th>
<th>Improvement</th>
<th>Improvement</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars and SUVs</td>
<td>1.1%</td>
<td>2.50%</td>
<td></td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>0.8%</td>
<td>1.00%</td>
<td></td>
</tr>
<tr>
<td>Electric vehicle penetration</td>
<td>20% annual rate</td>
<td></td>
<td>40% annual rate</td>
</tr>
</tbody>
</table>

### Prices of Energy Commodities

<table>
<thead>
<tr>
<th>Commodities</th>
<th>Base Case</th>
<th>Resource Constrained</th>
<th>Environmental Awareness</th>
<th>Green Shoots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td>Moderate</td>
</tr>
</tbody>
</table>

### CLIMATE CHANGE

<table>
<thead>
<tr>
<th>CO₂ emissions limits</th>
<th>Upper bound “Peak-Plateau-Decline” (PPD) emission limit trajectory from the National Climate Change Response White Paper</th>
<th>PPD lower limit</th>
<th>PPD upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ externality costs</td>
<td>• R48-R120/t (2015 - 2019) • R120/t onwards</td>
<td>• R270/t 2015 - 2050</td>
<td>• R48-R120/t (2015- 2019) • R120/t onwards</td>
</tr>
</tbody>
</table>

Carbon Tax | Embedded in the externality cost of Carbon |
## IEP SCENARIOS

<table>
<thead>
<tr>
<th>INDICATORS</th>
<th>BASE CASE</th>
<th>BIG SWH</th>
<th>NUCLEAR RELAXED</th>
<th>NO SHALE GAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Constraints</td>
<td>9.6 GW New Nuclear Build enforced</td>
<td>None</td>
<td>None</td>
<td>9.6 GW New Nuclear Build enforced</td>
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**DEMAND SIDE INTERVENTIONS**

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<td></td>
</tr>
</tbody>
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**VEHICLE EFFICIENCY (new vehicle improvement per annum)**

- Cars and SUVs: 1.1%
- Trucks and buses: 0.8%
- Electric vehicle penetration: 20%

**Prices of Energy Commodities**

- Moderate
- Unavailable shale gas

**CLIMATE CHANGE**

- CO₂ emissions limits: PPD upper limit
- CO₂ externality costs:
  - R48-R120/t between 2015 and 2019
  - R120/t onwards
- Carbon Tax: Embedded in the externality cost of carbon
IEP PROGRESS SINCE FEBRUARY 2016

Change in IEP development framework to enable focused approach on the critical energy sub-sectors

Electricity Supply
- Electricity supply is mature and well-established. Planning process is also well-developed
- Sector is highly regulated with clear legislation which interlinks development of plans with regulatory activities
- Electricity elements of the IEP to be dealt with in detail in the IRP

Liquid Fuel Supply
- Sector is semi-regulated with planning undertaken by individual companies
- IEP to focus on more detailed analysis of liquid fuel demand and evaluate different scenarios for supply
- Liquid Fuel Roadmap to focus on logistics and specific nodal points

Gas
- Gas industry in South Africa continues to be underdeveloped with significant potential for growth in the future
- A detailed framework that explores the options for successfully stimulating the off-take of a gas market in the country is required
- Guideline for the foundational elements of this sub-sector taking into account current government programmes (i.e. Operations Phakisa, Gas-to-Power programme) as well as all future considerations (i.e. Shale Gas, Mozambican Gas discoveries)
Global Parameters (e.g. GDP, Discount rate, Exchange Rate, Fuel Costs)

**IEP**

**KEY PARAMETERS**
- Technology Costs (Capital, O&M)
- Plant performance
- Plant operational life
- Other technology parameters

**SCOPE**
- Electricity generation build plan
- Transmission build plan
- System Adequacy
- Electricity Price Path

**IRP**
- Technology Costs (Capital, O&M)
- Plant performance
- Plant operational life
- Production slates
- Other technology parameters

**Liquid Fuels**
- Liquid Fuel Supply Options
- Liquid fuel supply infrastructure
- Location and logistics

**Gas**
- Gas development scenarios
- Gas price scenarios
- Gas supply and infrastructure
- Legislation and policy

Level of maturity of national planning

All primary energy carriers

All primary energy carriers

Indigenous and imported gas
### IEP LIQUID FUEL SUPPLY SCENARIOS

<table>
<thead>
<tr>
<th>INDICATORS</th>
<th>BASE CASE</th>
<th>GREEN SHOOTS</th>
<th>CLEANER PASTURES</th>
<th>RESOURCES CONSTRAINED</th>
<th>SECURITY OF SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Constraints</td>
<td>• Minimum production constraints on crude oil refineries</td>
<td></td>
<td></td>
<td></td>
<td>New crude oil refinery enforced (200 000 bbl/day)</td>
</tr>
<tr>
<td>GDP</td>
<td>Moderate GDP Growth</td>
<td>High GDP Growth</td>
<td></td>
<td>Same as Base Case</td>
<td></td>
</tr>
<tr>
<td>VEHICLE EFFICIENCY IMPROVEMENT FOR NEW VEHICLES PER ANNUM</td>
<td></td>
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<td>20% annual rate</td>
<td>40% annual rate</td>
<td></td>
<td>Same as Base Case</td>
<td></td>
</tr>
<tr>
<td>Prices of Energy Commodities</td>
<td>• Moderate commodity prices</td>
<td>Same as Base Case</td>
<td></td>
<td>• High commodity prices • Extraction of shale gas uneconomical</td>
<td>Same as Base Case</td>
</tr>
<tr>
<td></td>
<td>• Shale gas available after 2025</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENVIRONMENTAL CONSIDERATIONS</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions limits</td>
<td>PPD Upper limit</td>
<td>Same as Base Case</td>
<td></td>
<td>PPD lower limit</td>
<td>Same as Base Case</td>
</tr>
<tr>
<td>CF2</td>
<td>No CF2 on existing refineries</td>
<td>CF2 implemented on existing refineries</td>
<td></td>
<td>Same as Base Case</td>
<td>CF2 implemented on existing refineries</td>
</tr>
<tr>
<td>Compliance to Clean Fuels 2 (CF2) Standards and Specifications</td>
<td>• All new refineries are CF2 compliant</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Total refining yield is marginally reduced as a result of CF2 implementation on existing refineries</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Compensation to the Oil Industry in order to upgrade existing refineries to be CF2 complaint has not been factored</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing refineries</td>
<td>• All existing crude oil refineries continue to operate throughout the planning horizon (the closure of some of the older refineries are explored in more detailed sensitivity analyses)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• The existing GTL plant ceases production after 2030 as a result of depleting gas feedstock</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• The CTL plant continues to operate until 2040</td>
<td></td>
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</tr>
</tbody>
</table>
PURPOSE OF WORKSHOP

Share the latest assumptions for Global Parameters (e.g. GDP, Discount rate, Exchange Rate, Fuel Costs)

IEP

IRP
- Latest technology parameters
- Presentation of model output for Base Case and first set of scenarios

Liquid Fuels
- Presentation on model output for Base Case and first set of scenarios

Gas
- To be developed in the future
THANK YOU
DEMAND PROJECTIONS

MOTLATSI SEOTSANYANA
(DEMAND MODELLING SPECIALIST)
TRANSPORT DEMAND MODELLING
Scrapping Curves for All Technologies
Projected Vehicle Parc

- Historical trend
- Projected trend

- Buses - Bus - Diesel
- Motorcars - Car - Diesel
- Motorcars - Car - Diesel-Hybrid
- Motorcars - SUV - Petrol
- Motorcars - SUV - Diesel-Hybrid
- Trucks - HCV - Diesel
- Trucks - LCV - Diesel
- Trucks - MCV - Diesel
- Trucks - MCV - Petrol
- Motorcars - Car - Petrol
- Motorcars - SUV - Diesel
- Motorcars - SUV - Petrol-Hybrid
- Trucks - LCV - Petrol
- XHCV - XHCV - Diesel
Projected Vehicle Residuals

Historical trend vs. projected trend

Vehicle Residuals (x1,000,000)

Years: 1984 to 2050
Projected Vehicle Kilometers

Kilometers Traveled (Billions)

- Buses  - Bus - Diesel
- Motorcars  - Car - Diesel
- Motorcars  - SUV - Diesel
- Motorcars  - SUV - Petrol
- Trucks  - LCV - Diesel
- Trucks  - LCV - Petrol
- Trucks  - MCV - Petrol
- Trucks  - HCV - Diesel
- Trucks  - MCV - Petrol
- XHCV  - XHCV - Diesel

Historical Trend

Projected Trend
Projected Passenger Kilometers

Billion Passenger Kilometers

<table>
<thead>
<tr>
<th>Year</th>
<th>Greenshoots</th>
<th>Moderate GDP Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2025</td>
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<td>2030</td>
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<td>2035</td>
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<td>2040</td>
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<tr>
<td>2045</td>
<td></td>
<td></td>
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<tr>
<td>2050</td>
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<td></td>
</tr>
</tbody>
</table>

- Motorcycles
- Motorcars
- Minibuses
- LDV's - Bakkies
- Buses
Projected Tonne Kilometers

Billion Tonnies Kilometers

- MCV Btkm
- LCV Btkm
- HCV Btkm

Years: 2015 to 2050

Scenarios:
- Greenshoots
- Moderate GDP Growth

Visual representation of projected tonne kilometers for different years and scenarios.
Projected Fuel Economy
FINAL ENERGY DEMAND PROJECTIONS
THANK YOU
SCENARIOS FOR LIQUID FUELS SUPPLY
Variables Analysed

1. Total Capacity
2. Production
3. Emissions
4. Water Consumption
5. Feedstock Consumption
6. Costs
7. Jobs
8 KEY OBJECTIVES

- Minimise Cost of Energy
- Promote Job Creation and Localisation
- Minimise Environmental Impacts
- Minimise Water Consumption
- Diversify Supply Sources
- Promote Energy Efficiency
- Promote Energy Access
- Ensure Security of Supply
- Total Capacity, Production
- Costs
- Jobs
- Emissions
- Water Intensity
- Total Capacity
- Minimise Water Consumption
Existing Refining Capacity

- Sasol – End of Life
- PetroSA – End of Life

Key: SAPREF, ENREF, CHEVRON, NATREF, SASOL, PETROSA

Year: 2015 to 2050
New Refining Capacity

- **Base Case**
- **Cleaner Pastures**
- **Green Shoots**
- **Resource Constrained**
- **Security of Supply**

The chart illustrates new refining capacity from 2026 to 2045, with scenarios for different energy sources:
- **CTL** (black bars)
- **GTL** (grey bars)
- **Crude** (yellow bar)

The vertical axis represents the capacity in bbl/day.
Total Capacity

- Base Case
- Cleaner Pastures
- Green Shoots
- Resource Constrained
- Security of Supply

Existing Refineries: Blue
New Refineries: Green

bbl/day

2015-2047

Existing Refineries
New Refineries
Domestic Production – Existing Refineries

- Base Case
- Cleaner Pastures
- Green Shoots
- Resource Constrained
- Security of Supply

Units: billion litres

Years: 2015 to 2047
Imports and Port Capacity Requirements

- **Base Case**
- **Cleaner Pastures**
- **Green Shoots**
- **Resource Constrained**
- **Security of Supply**

**Fuels:**
- **DIESEL**
- **PETROL**
- **LPG**
- **AVIFUEL**
- **PARAFFIN**

**Port Capacity**

**Time Frame:**
- 2015 to 2047
### Total Imports

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Base Case</th>
<th>Cleaner Pastures</th>
<th>Green Shoots</th>
<th>Resource Constrained</th>
<th>Security of Supply</th>
</tr>
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<tbody>
<tr>
<td>Paraffin</td>
<td>17</td>
<td>8</td>
<td>10</td>
<td>16</td>
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<td>Aviation Fuel</td>
<td>59</td>
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<td>77</td>
<td>58</td>
<td>42</td>
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<tr>
<td>LPG</td>
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<td>20</td>
<td>27</td>
<td>19</td>
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<tr>
<td>Petrol</td>
<td>129</td>
<td>44</td>
<td>95</td>
<td>28</td>
<td>49</td>
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<tr>
<td>Diesel</td>
<td>484</td>
<td>460</td>
<td>657</td>
<td>451</td>
<td>330</td>
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<tr>
<td>Crude</td>
<td>710</td>
<td>717</td>
<td>710</td>
<td>710</td>
<td>968</td>
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</table>

The diagram shows the total imports in billion litres for different fuel types across various scenarios.
Total Domestic Production - Crude Oil Refineries

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>Cleaner Pastures</th>
<th>Green Shoots</th>
<th>Resource Constrained</th>
<th>Security of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraffin</td>
<td>7</td>
<td>20</td>
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<td>Aviation Fuel</td>
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<td>LPG</td>
<td>15</td>
<td>14</td>
<td>15</td>
<td>15</td>
<td>21</td>
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<tr>
<td>Residual Fuel Oil</td>
<td>111</td>
<td>110</td>
<td>135</td>
<td>135</td>
<td>110</td>
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<tr>
<td>Petrol</td>
<td>247</td>
<td>270</td>
<td>247</td>
<td>247</td>
<td>356</td>
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<tr>
<td>Diesel</td>
<td>254</td>
<td>263</td>
<td>254</td>
<td>254</td>
<td>391</td>
</tr>
</tbody>
</table>

- **Diesel**
- **Petrol**
- **Residual Fuel Oil**
- **LPG**
- **Aviation Fuel**
- **Paraffin**
Carbon Dioxide Emissions from Liquid Fuel Production

- **Base Case**
- **Cleaner Pastures**
- **Green Shoots**
- **Resource Constrained**
- **Security of Supply**

Legend:
- **EXISTING REFINERIES**
- **NEWGTL**
- **NEWCTL**
- **NEWCRUDE**
- **PPD - LOWER**
- **PPD - UPPER**
Water Consumption by Refinery Type

EXISTING REFINERIES
NEWCTL
NEWCRUDE
LIQUID FUELS SENSITIVITY SCENARIO ANALYSIS
## SENSITIVITY SCENARIOS

<table>
<thead>
<tr>
<th>Key Assumptions</th>
<th>CF2 – No Cost Recovery (CF2_2C)</th>
<th>CF2 – No Cost Recovery (CF2_3C)</th>
<th>Low crude price (LCP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CF2 implemented</td>
<td>1. CF2 implemented</td>
<td>1. No CF2 implementation.</td>
<td>1. No CF2 implementation.</td>
</tr>
<tr>
<td>2. No cost recovery mechanism leading to closure of 2 existing crude refineries</td>
<td>2. No cost recovery mechanism leading to closure of 3 existing refineries</td>
<td>2. Low global crude oil prices</td>
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</tr>
<tr>
<td>3. No new build commitments</td>
<td>3. No new build commitments</td>
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</tbody>
</table>

### Reference Scenario

<table>
<thead>
<tr>
<th>Base Case</th>
<th>Base Case</th>
<th>Base Case</th>
<th>Base Case</th>
<th>Base Case</th>
</tr>
</thead>
</table>

**INTEGRATED ENERGY PLAN**
Moderate and Low Crude Prices

Source: IEA World Energy Outlook 2015
<table>
<thead>
<tr>
<th>Sensitivity Scenario</th>
<th>Total Capacity</th>
<th>Production</th>
<th>Discounted Costs</th>
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</thead>
<tbody>
<tr>
<td><strong>Base Case</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low Crude Price</td>
<td>New Capacity ↓</td>
<td>Imports ↑</td>
<td>Costs ↓</td>
</tr>
<tr>
<td>CF2_2C</td>
<td>Imports ↑</td>
<td></td>
<td>Costs ↓</td>
</tr>
<tr>
<td>CF2_3C</td>
<td>Imports ↑</td>
<td></td>
<td>Costs ↓</td>
</tr>
</tbody>
</table>
New Refining Capacity

- **Base Case**
  - 2026: 60,000 bbl/day
  - 2027: 65,000 bbl/day
  - 2040: 70,000 bbl/day
  - 2041: 80,000 bbl/day
  - 2045: 140,000 bbl/day

- **Low Crude Price**
  - 2026: 60,000 bbl/day
  - 2027: 65,000 bbl/day
  - 2040: 70,000 bbl/day
  - 2041: 80,000 bbl/day
  - 2045: 140,000 bbl/day

Legend:
- **GTL**
- **CTL**
Liquid Fuel Supply

- Base Case
- CF2 Crude Oil Refinery Closures (CF2_2C)
- CF2 Crude Oil Refinery Closures (CF2_3C)
- Low Crude Price

Graph showing billion litres of liquid fuel supply from 2015 to 2048, with categories for base case, CF2 closures, and low crude price, distinguished by Existing Refineries, Imports, and New Refineries.
## Sensitivity Scenario

<table>
<thead>
<tr>
<th>Sensitivity Scenario</th>
<th>Emissions</th>
<th>Water</th>
<th>Feedstock</th>
</tr>
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<tbody>
<tr>
<td><strong>Base Case</strong></td>
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<td></td>
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</tr>
<tr>
<td>Low Crude Price</td>
<td></td>
<td>Consumption ↑</td>
<td>Coal ↑</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas ↓</td>
<td></td>
</tr>
<tr>
<td>CF2_2C</td>
<td>CO₂ ↓</td>
<td>Consumption ↓</td>
<td>Crude ↓</td>
</tr>
<tr>
<td></td>
<td>SOₓ ↓</td>
<td>Intensity ↑</td>
<td>Coal ↓</td>
</tr>
<tr>
<td></td>
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<td>Gas ↓</td>
<td></td>
</tr>
<tr>
<td>CF2_3C</td>
<td>CO₂ ↓</td>
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<td></td>
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<td>Gas ↓</td>
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</tbody>
</table>
THANK YOU