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INTEGRATED ENERGY PLAN (IEP)

22 November 2016

PROBLEM STATEMENT



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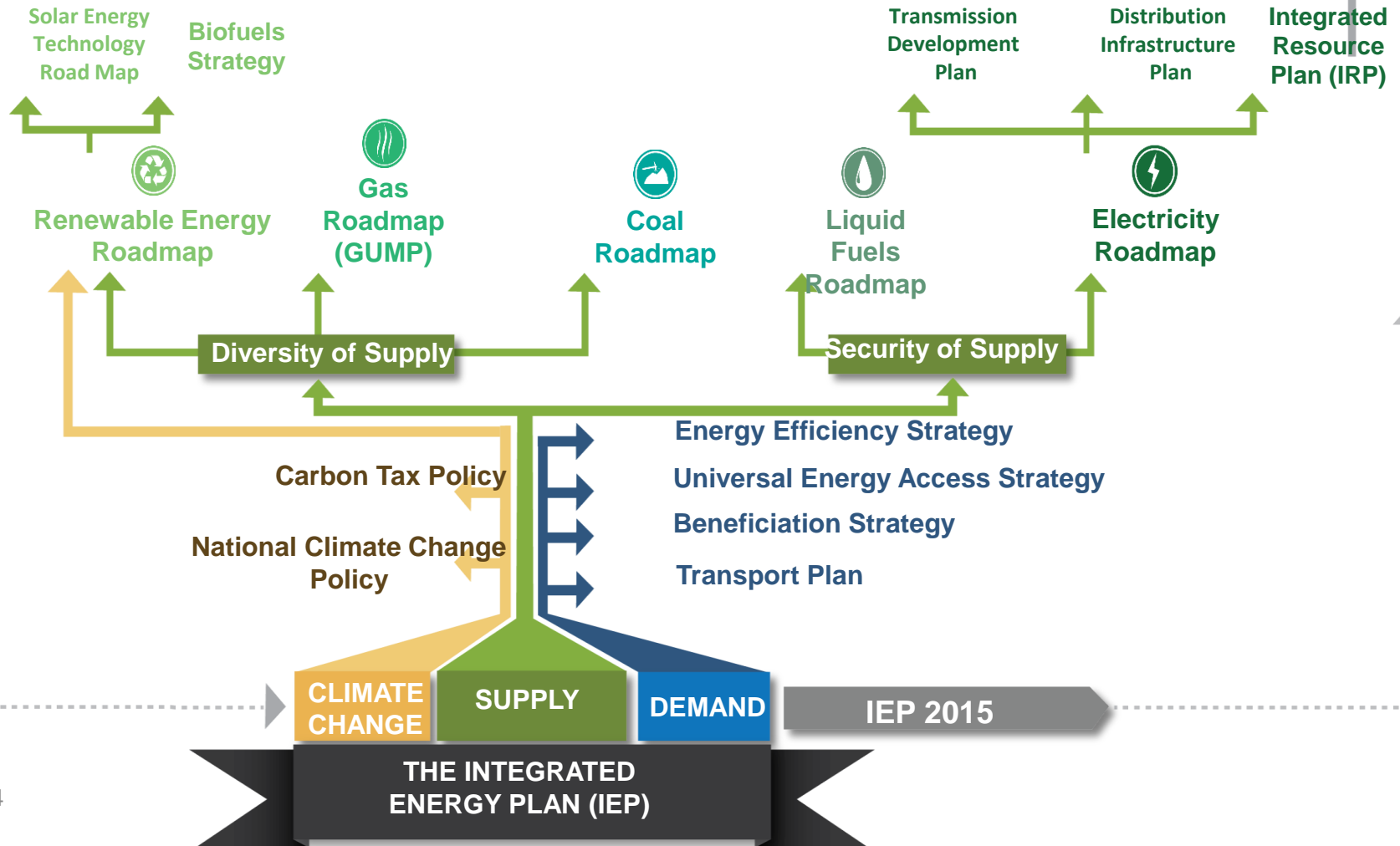
- Energy is the life blood of the economy which impacts on all sectors as well as individual livelihoods. Integrated energy planning is required to ensure that current and future energy service needs can be met in the most cost effective, efficient and socially beneficial manner while also taking into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

IEP AND SECTOR PLANS



The IEP takes into consideration existing policies

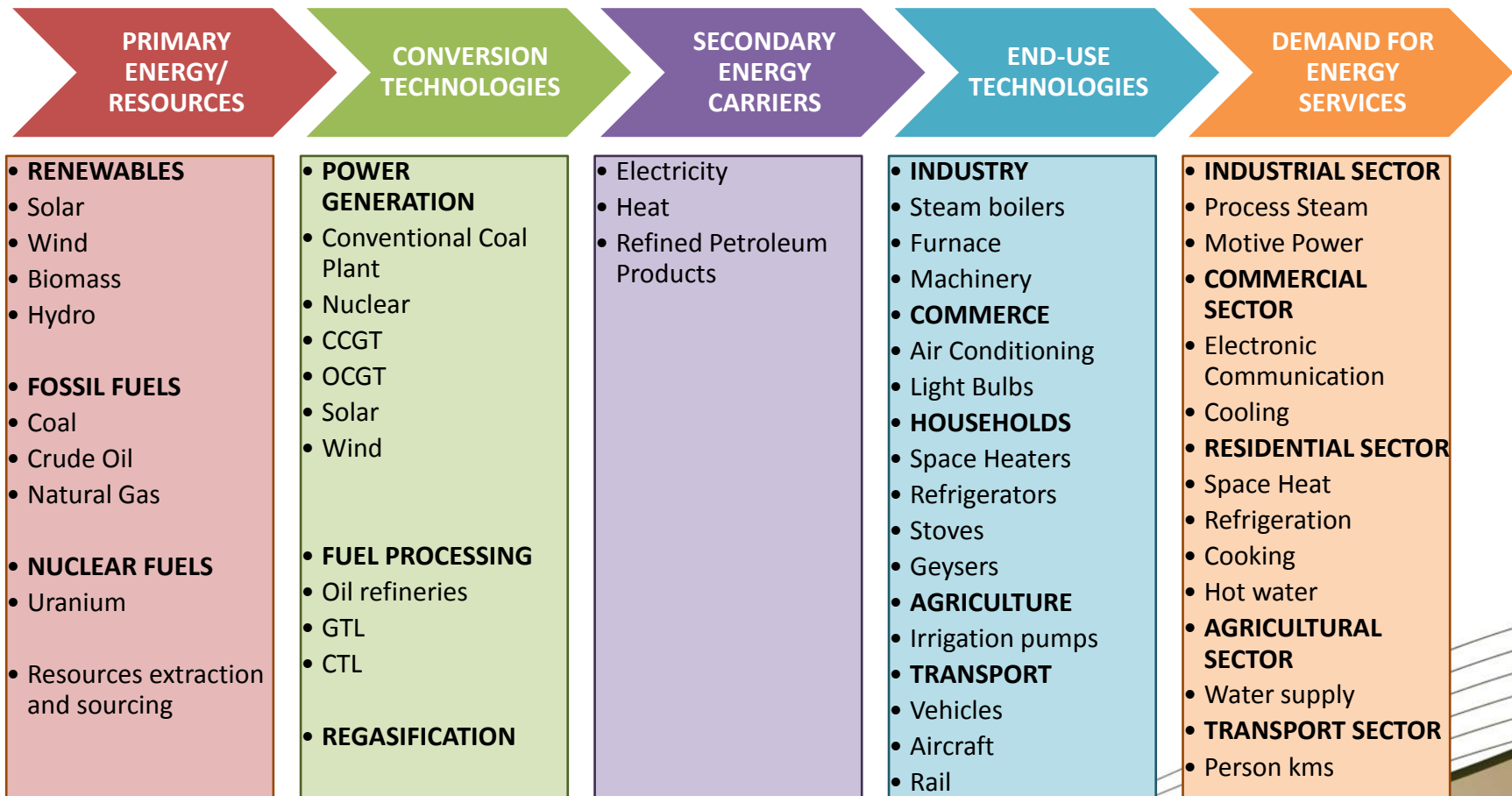
- Informs development of future energy sector roadmaps
- Provides feedback to development & review of external policies





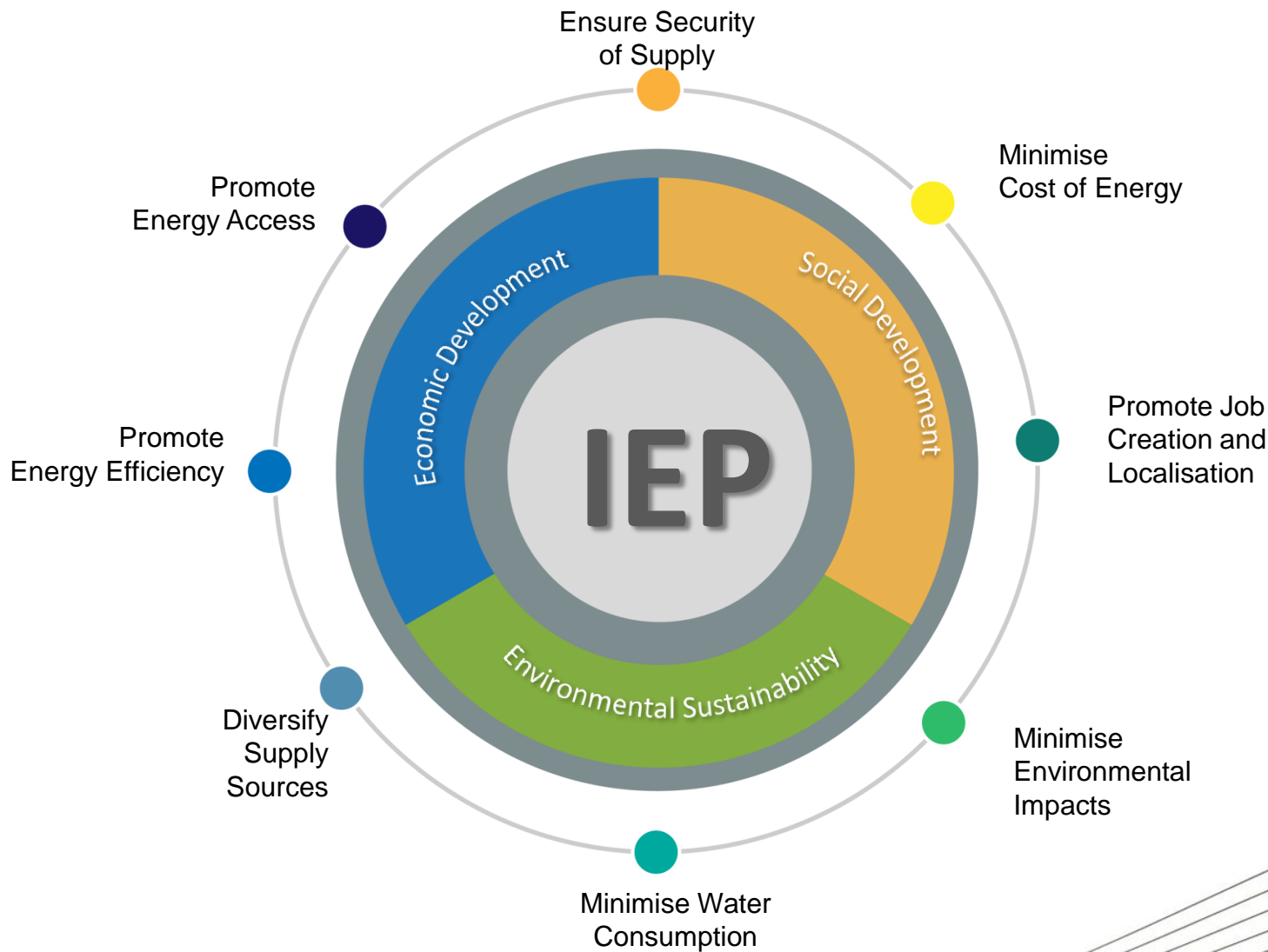
ENERGY PLANNING FRAMEWORK

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.





8 KEY ENERGY PLANNING OBJECTIVES



ENERGY PLANNING FRAMEWORK



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| | IEP | IRP | LFRM | GUMP |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SCOPE | <p>Entire energy sector</p> <ul style="list-style-type: none"> All energy carriers Cross-cutting issues that span entire energy sector | <ul style="list-style-type: none"> Electricity generation build plan Transmission build plan System Adequacy Electricity Price Path | <p>Liquid Fuel Supply Infrastructure</p> <ul style="list-style-type: none"> - Location and logistics | <p>Gas supply and infrastructure</p> |
| ENERGY CARRIERS CONSIDERED | <ul style="list-style-type: none"> All primary fuels <ul style="list-style-type: none"> - Coal - Natural Gas (Imported LNG and indigenous sources) - Crude oil - Renewables (Solar, Wind, Hydro, Biomass, etc.) All secondary fuels <ul style="list-style-type: none"> - Electricity - Petroleum Products | <ul style="list-style-type: none"> Primary fuels <ul style="list-style-type: none"> - Coal - Natural Gas (Imported LNG and indigenous sources) - Renewables (Solar, Wind, Hydro, Biomass, etc.) Secondary fuels <ul style="list-style-type: none"> - Electricity - Petroleum Products | <ul style="list-style-type: none"> Primary fuels <ul style="list-style-type: none"> - Coal - Natural Gas (Imported LNG and indigenous sources) - Renewables (Biomass, Crops) - Crude Oil Secondary fuels <ul style="list-style-type: none"> - Petroleum Products | <ul style="list-style-type: none"> Primary fuels <ul style="list-style-type: none"> - Imported Natural Gas - Indigenous gas (Shale gas, CBM, other natural gas) |

ENERGY PLANNING FRAMEWORK



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|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| ENABLING LEGISLATION | National Energy Act | Regulations for New electricity Generation (Under Electricity Regulation Act) | No explicit legislation | No explicit legislation |
| METHODOLOGY | Optimise least cost energy mix based on certain assumptions (policy objectives, economic conditions, technology costs, etc.) | Optimise least cost electricity generation mix based on certain assumptions (policy objectives, economic conditions, technology costs, etc.) | Optimise least cost liquid fuel supply mix based on certain assumptions (policy objectives, economic conditions, technology costs, etc.) | Simulations of possible gas scenarios |
| INTENDED USE OF PLAN | <p>Descriptive: Guiding policy which sets framework for:</p> <ul style="list-style-type: none"> - Development of Electricity, Gas and Liquid Fuel “infrastructure” Plans - Selection of appropriate technologies to meet energy demand - Development of policies and targets | <p>Prescriptive: - Informs implementation of the electricity expansion build plan</p> <p>INTEGRATED ENERGY PLAN</p> | <p>Descriptive: - Informs investments and implementation of liquid fuel infrastructure</p> | <p>Descriptive: - Guide for future investments in gas infrastructure</p> |



ENERGY PLANNING FRAMEWORK

| | IEP | IRP | LFRM | GUMP |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| DEMAND | <ul style="list-style-type: none">• Demand-side driven• Estimate demand for meeting an energy need (“energy end-use”) and the factors that may drive switching between different fuels in the future• Impact of vehicle technology improvements and fuel specifications considered | Focuses on electricity demand and takes into account peak demand | Focuses on the projected demand for petroleum products taking into account historical factors | <ul style="list-style-type: none">• Projects different scenarios of natural gas consumption sectors and the impact of this on demand |
| FUEL-SWITCHING | Considers fuel-switching options (i.e. electricity to gas, fuel-powered vehicles to electric vehicles) | No fuel switching considered | No fuel switching considered | No fuel switching considered |

ENERGY PLANNING FRAMEWORK



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|---------------------------------------------------------|----------------------|-----|------|------|
| Macroeconomic Impact Assessment | Yes | No | No | No |
| Jobs and Localisation Impact | Yes | No | No | No |
| Externalities | Yes | Yes | No | No |
| Location of new plants | No | Yes | Yes | Yes |
| Transmission and Distribution costs | High-level estimates | Yes | N/A | N/A |
| Pipeline Capacity Requirements and Location | No | N/A | Yes | Yes |
| Storage Infrastructure Requirements and Location | No | N/A | Yes | Yes |

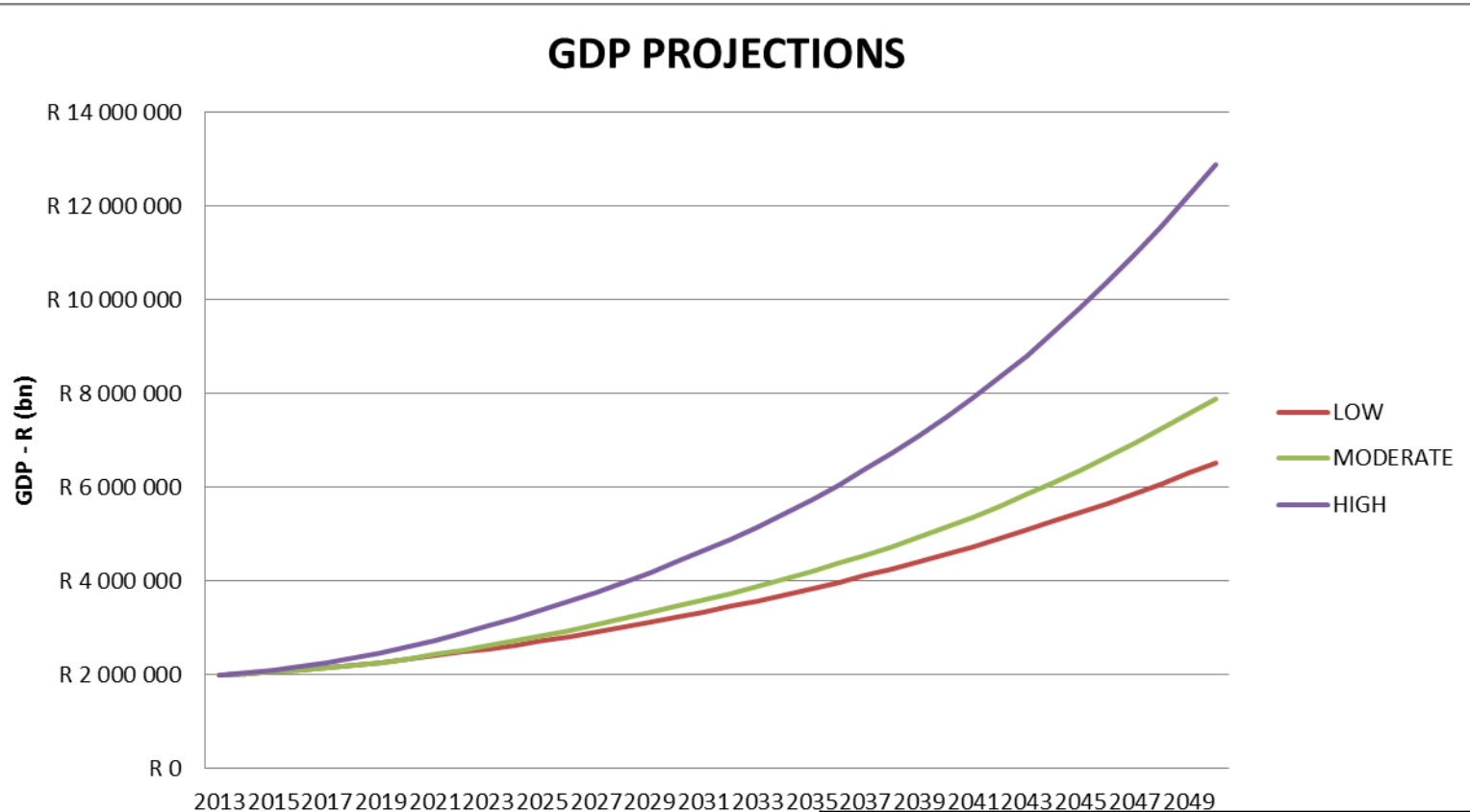


SUMMARY OF MACROECONOMIC ASSUMPTIONS

| PARAMETER | ASSUMPTION |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Discount Rate | 8.4% (unchanged) |
| GDP projections | Revised to 2016 Budget Vote |
| Commodity Prices (Crude Oil and Natural Gas) | Revised to International Energy Agency (IEA) World Energy Outlook 2015 projections |
| Coal price | Revised – instead of a fixed price, future price path derived from IEA World Energy Outlook 2015 projections |



GDP PROJECTIONS



| | ST | | | | MT | LT |
|-----------------|------|------|------|------|-----------|-----------|
| | 2015 | 2016 | 2017 | 2018 | 2019-2025 | 2025-2050 |
| Low | 1.3 | 0.9 | 1.7 | 2.4 | 2.8 | 3.0 |
| Moderate | 1.3 | 0.9 | 1.7 | 2.4 | 3.7 | 4.2 |
| High | 2.0 | 3.3 | 3.7 | 4.0 | 4.9 | 5.5 |



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SCENARIOS

DRAFT BASE CASE*



| INDICATORS | BASE CASE |
|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Technology Constraints | <ul style="list-style-type: none"> All electricity generation determinations up to and including 31 December 2015 included Minimum Production constraints on crude oil refineries No CF2 compensation mechanism for existing refineries |
| GDP | Treasury moderate GDP growth |
| DEMAND-SIDE INTERVENTIONS | |
| DSM | 1 million SWH |
| Energy efficiency | Business As Usual |
| VEHICLE EFFICIENCY (new vehicle improvement per annum) | |
| Cars and SUVs | 1.1% |
| Trucks and buses | 0.8% |
| Electric vehicle penetration | 20% annual rate |
| Prices of Energy Commodities | Moderate |
| CLIMATE CHANGE | |
| CO ₂ emissions limits | Upper bound “Peak-Plateau-Decline” (PPD) emission limit trajectory from the National Climate Change Response White Paper |
| Externality costs | See previous slide |

SCENARIOS



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| INDICATORS | GREEN SHOOTS | CLEANER PASTURES | RESOURCES CONSTRAINED | SECURITY OF SUPPLY |
|---------------------------------------------------------------|-----------------------------------------|----------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Technology Constraints | | •Clean Fuels 2 compensation/ recovery mechanism | | •Clean Fuels 2 compensation •New crude oil refinery enforced (200 000 bbl/day) |
| GDP | National Development High GDP Growth | | | |
| DEMAND-SIDE INTERVENTIONS | | | | |
| DSM | 10 million SWH | 5 million SWH | | |
| Energy efficiency | High Energy Efficiency | | | |
| VEHICLE EFFICIENCY (new vehicle improvement per annum) | | | | |
| Cars and SUVs | 2.50% | | | |
| Trucks and buses | 1.00% | | | |
| Electric vehicle penetration | 40% annual rate | | | |
| Prices of Energy Commodities | | | •High commodity prices •Extraction of shale gas uneconomical | |
| CLIMATE CHANGE | | | | |
| CO ₂ emissions limits | | PPD lower limit | | |



ADDITIONAL SCENARIOS

- Additional scenarios and sensitivity analyses will also be conducted
 - Carbon Tax
 - Low oil price
 - Gas price volatility (Low and High prices)
 - Big Gas (Significant development of SA Gas Market – with import options and shale gas)
 - No Shale Gas (Uneconomical/unviable shale gas development)
 - No Clean Fuels 2 recovery mechanism with 2 refinery closures
 - No CF2 recovery mechanism with 3 refinery closures
 - CF2 with recovery mechanisms and different crude oil refinery sizes (300k bbl/day and 360k bbl/day)



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DEMAND SECTORS CONSIDERED



CATEGORISATION OF DEMAND SECTORS (1)

| Economic grouping | Economic sector | Energy demand sector | Sub-sectors | Subsectors included | Energy carriers considered | Activity variable |
|-------------------|-----------------------------------|----------------------|-------------|---------------------|----------------------------|----------------------------------|
| Primary | Agriculture, forestry and fishing | Agricultural Sector | N/A | N/A | Electricity, coal, diesel | GDP |
| | Mining and quarrying | Mining Sector | N/A | N/A | Electricity, coal, diesel | Value-added in the Mining Sector |



CATEGORISATION OF DEMAND SECTORS (2)

| Economic grouping | Economic sector | Energy demand sector | Sub-sectors | Subsectors included | Energy carriers considered | Activity variable |
|-------------------|-----------------|----------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-----------------------------------------|
| Secondary | Manufacturing | Industrial Sector (excl. mining) or Manufacturing Sector | Chemicals | N/A | Electricity, coal, natural gas | Value-added in the Manufacturing Sector |
| | | | Iron and steel | N/A | Electricity, coal, natural gas | Value-added in the Manufacturing Sector |
| | | | Non-ferrous metals | N/A | Electricity, coal, natural gas | Value-added in the Manufacturing Sector |
| | Construction | Electricity, gas and water | Other manufacturing | Non-metallic minerals, food and tobacco, paper and pulp, construction, machinery, textile, wood and wood products, transport equipment | Electricity, coal, natural gas | Value-added in the Manufacturing Sector |



CATEGORISATION OF DEMAND SECTORS (3)

| Economic grouping | Economic sector | Energy demand sector | Sub-sectors | Subsectors included | Energy carriers considered | Activity variable | | |
|-------------------|----------------------------------------------------|----------------------|-----------------------------|---------------------|--------------------------------------------|-------------------|----------------------------|--------------------------------------------|
| Tertiary | Wholesale and retail trade; hotels and restaurants | Commercial Sector | N/A | N/A | Electricity, coal, LPG, residual fuel oil | GDP | | |
| | Finance, real estate and business services | | | | | | | |
| | General government services | | | | | | | |
| | Personal services | | | | | | | |
| | Storage and communication | | | | | | | |
| | Transport | Transport Sector | Private passenger transport | N/A | Diesel, petrol, electricity, aviation fuel | GDP/capita | | |
| | | | | | | | Public passenger transport | Diesel, petrol, electricity, aviation fuel |
| | Freight transport | | | | | | Diesel, petrol, | GDP/capita |



CATEGORISATION OF DEMAND SECTORS (4)

| Economic grouping | Economic sector | Energy demand sector | Sub-sectors | Subsectors included | Energy carriers considered | Activity variable |
|-------------------|-----------------|----------------------|-------------|---------------------|----------------------------------------|---------------------------------------------------------------------------------------------|
| Households | N/A | Residential Sector | N/A | N/A | Electricity, coal, LPG, paraffin, wood | Population growth, number of households, electrification, urbanisation and household income |



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Thank You



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ANNEXURE: MODEL OUTPUTS



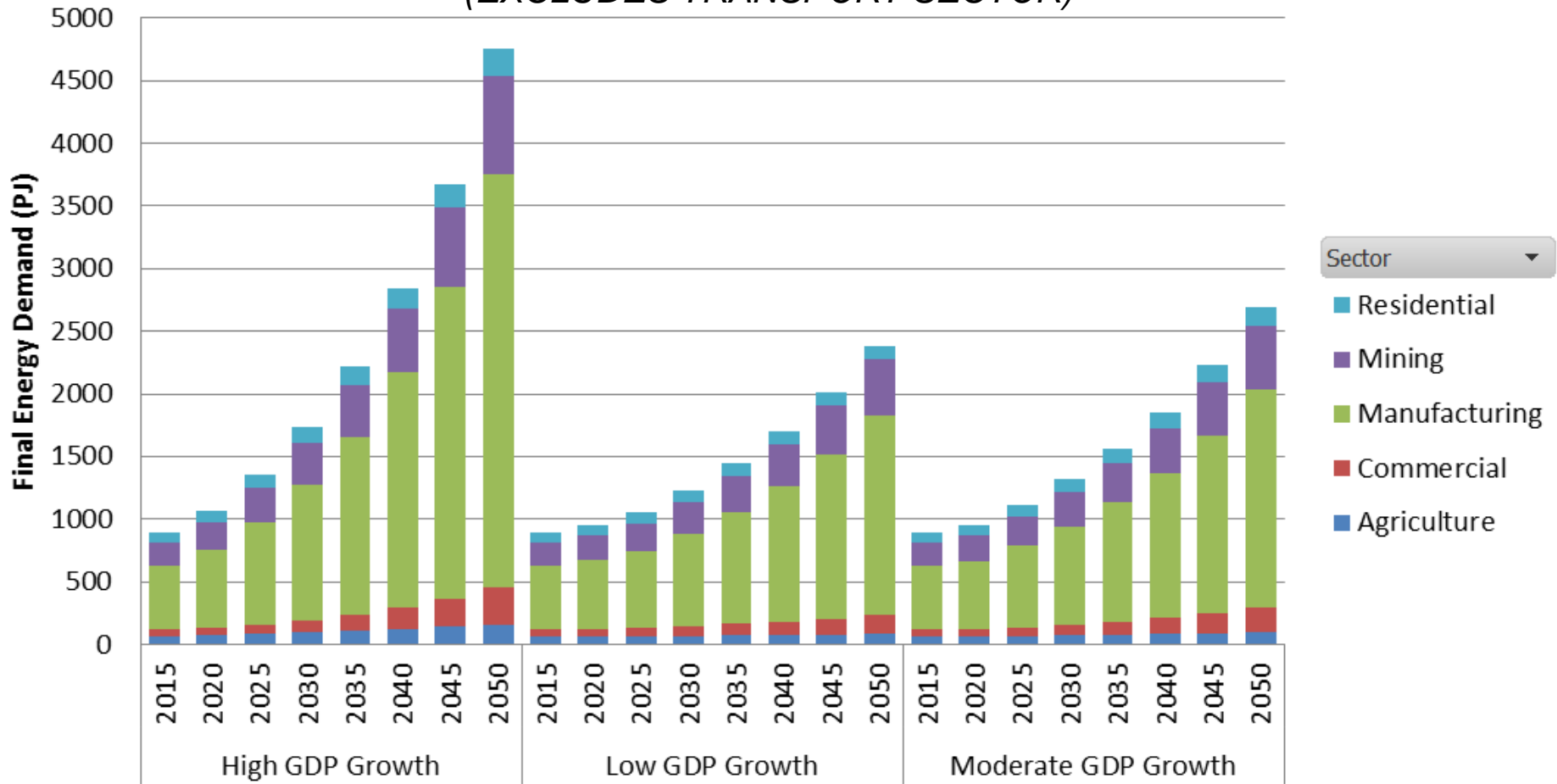
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PRELIMINARY DEMAND PROJECTIONS BY SECTOR



TOTAL ENERGY DEMAND ACROSS ALL SECTORS (EXCLUDES TRANSPORT SECTOR)



Sum of V...

Sector

- Residential
- Mining
- Manufacturing
- Commercial
- Agriculture

G... Year

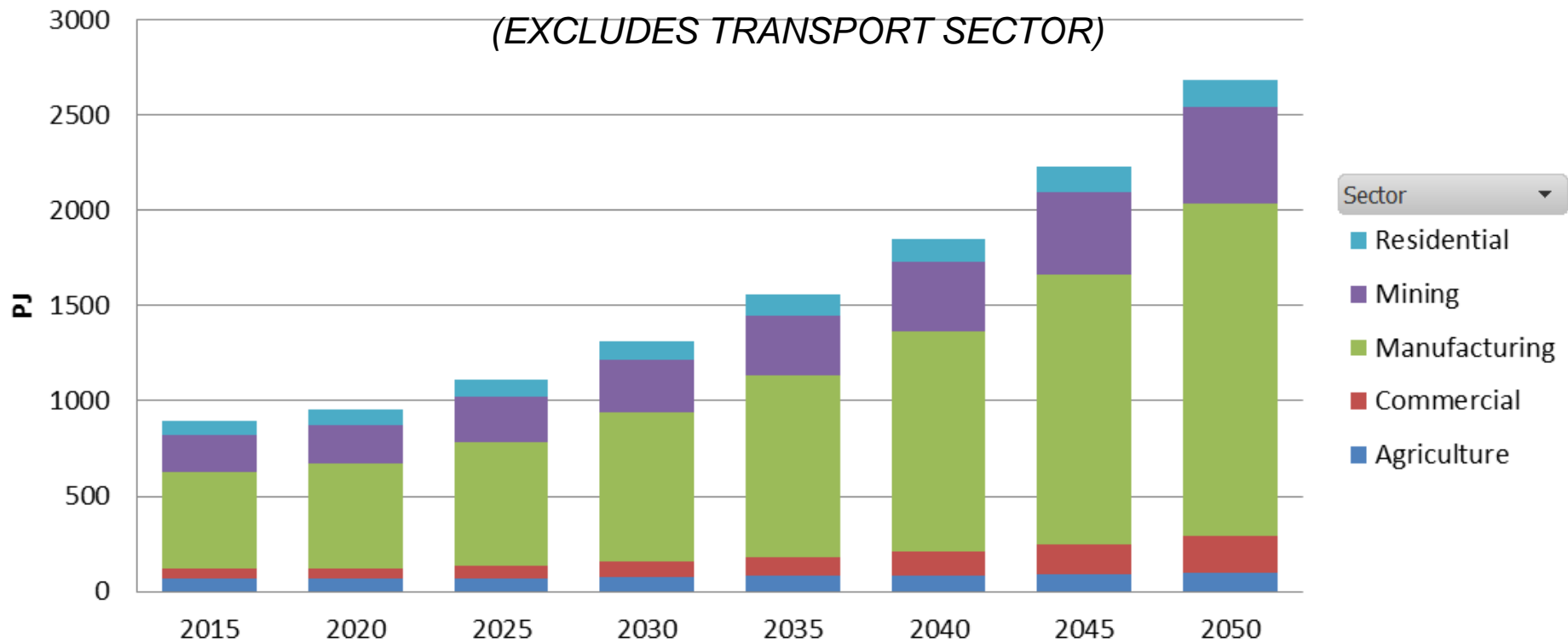


GDP

Sum of V...

TOTAL ENERGY DEMAND ACROSS ALL SECTORS (BASE CASE)

(EXCLUDES TRANSPORT SECTOR)



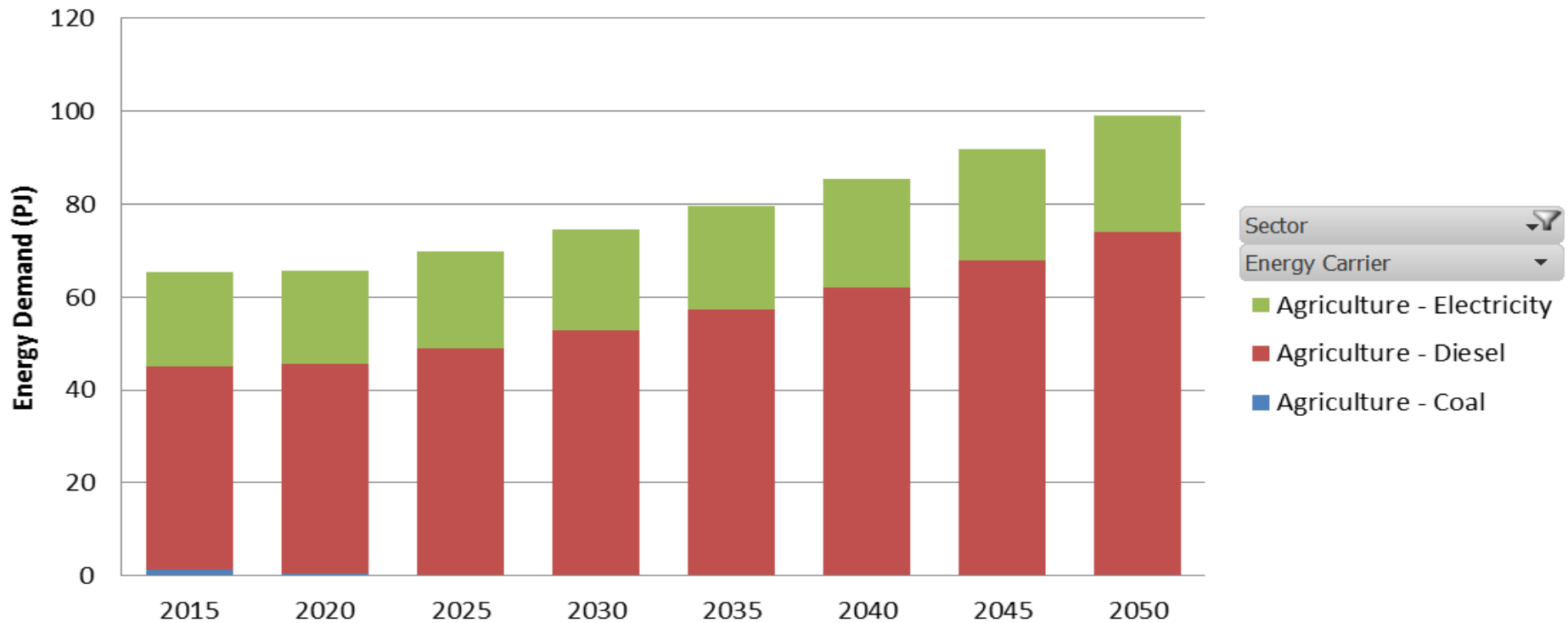
Year 26



GDP ↕

Sum of V...

ENERGY DEMAND - AGRICULTURE SECTOR (BASE CASE)

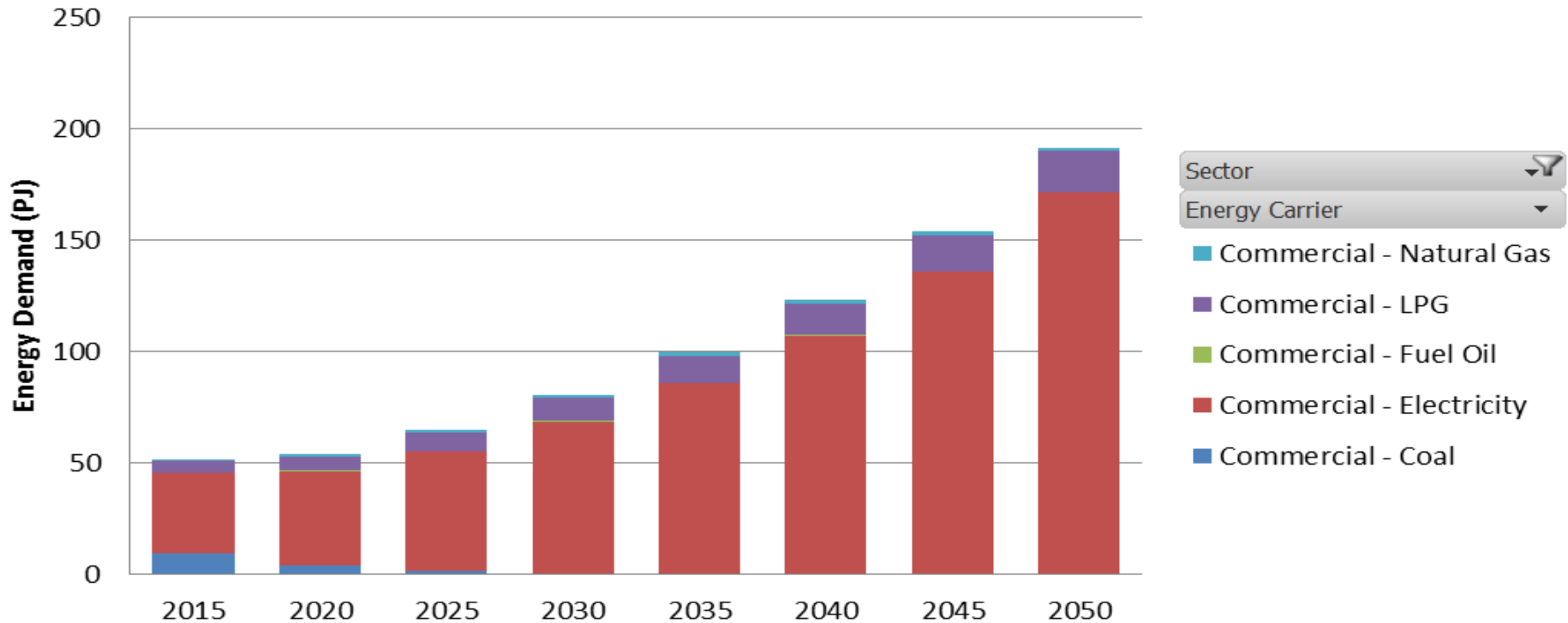




GDP

Sum of V...

ENERGY DEMAND - COMMERCE (BASE CASE)



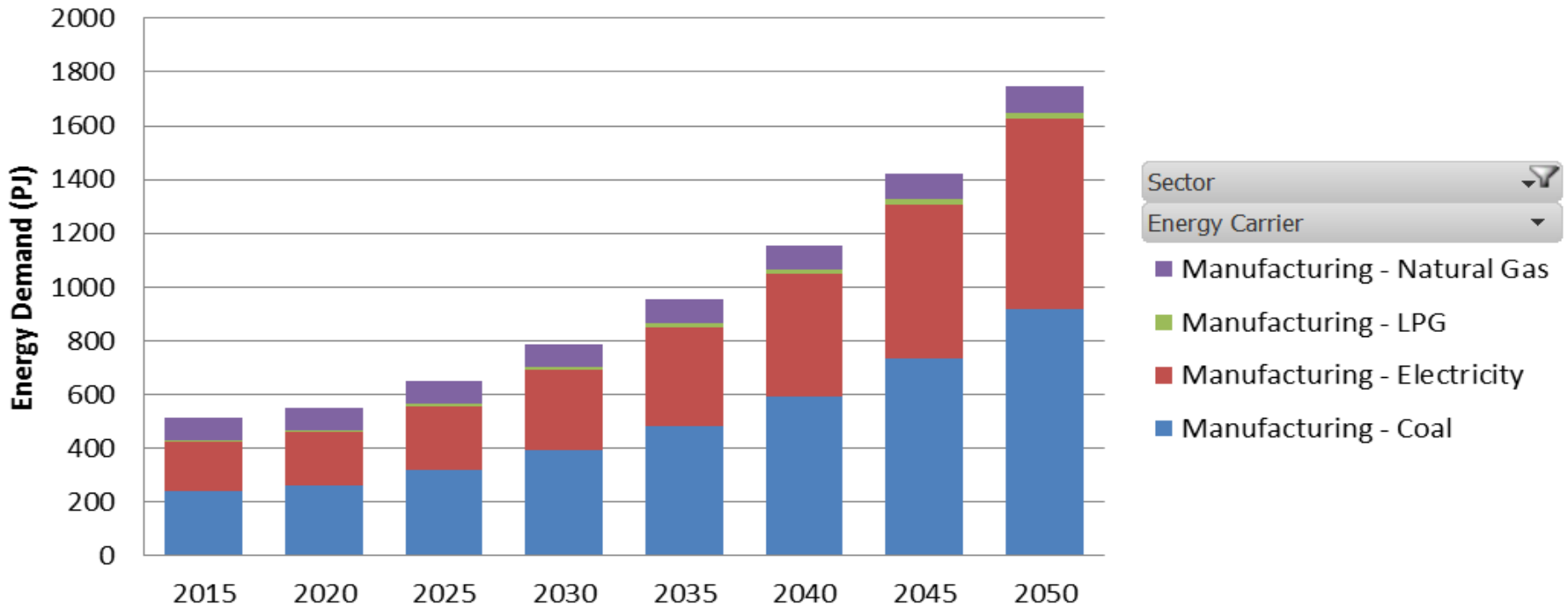
Year



GDP

Sum of V...

ENERGY DEMAND - INDUSTRY (BASE CASE)

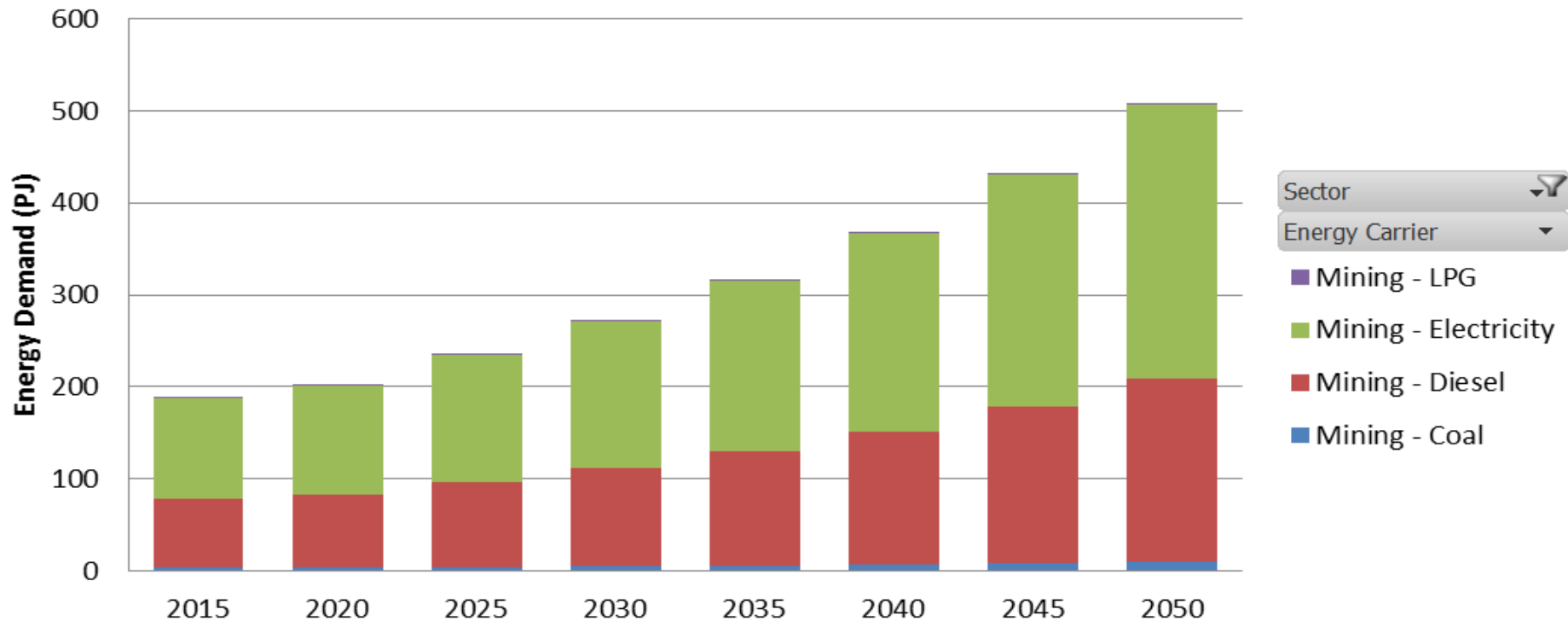




GDP

Sum of V...

ENERGY DEMAND - MINING (BASE CASE)



Sector

Energy Carrier

- Mining - LPG
- Mining - Electricity
- Mining - Diesel
- Mining - Coal

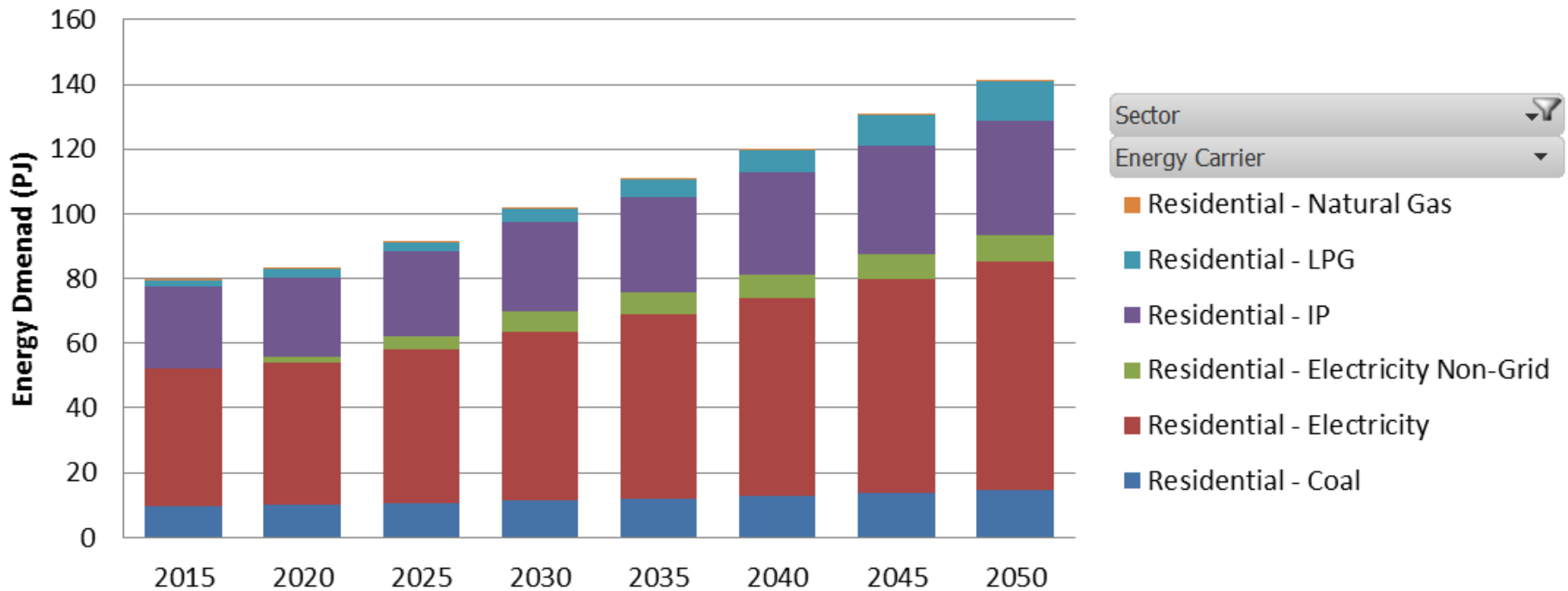
Year



GDP

Sum of V...

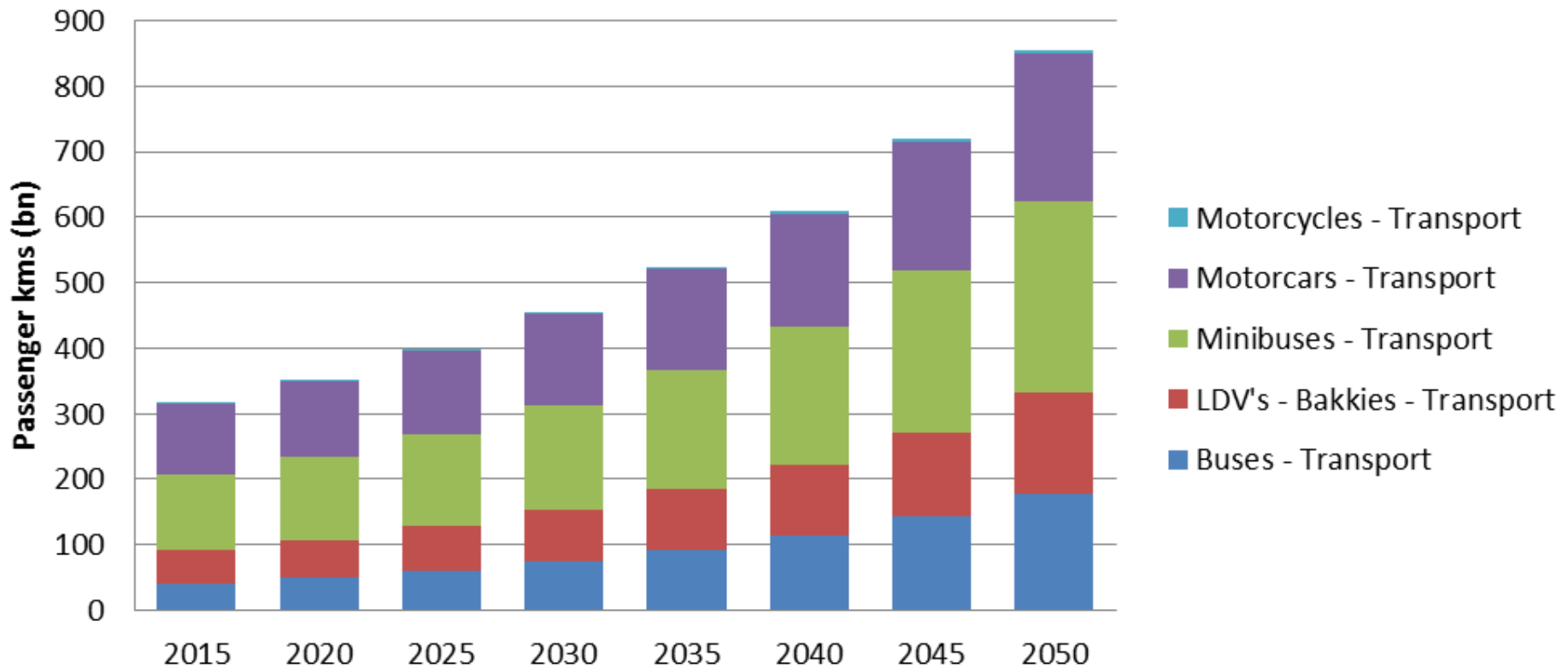
ENERGY DEMAND - RESIDENTIAL SECTOR (BASE CASE)



Year

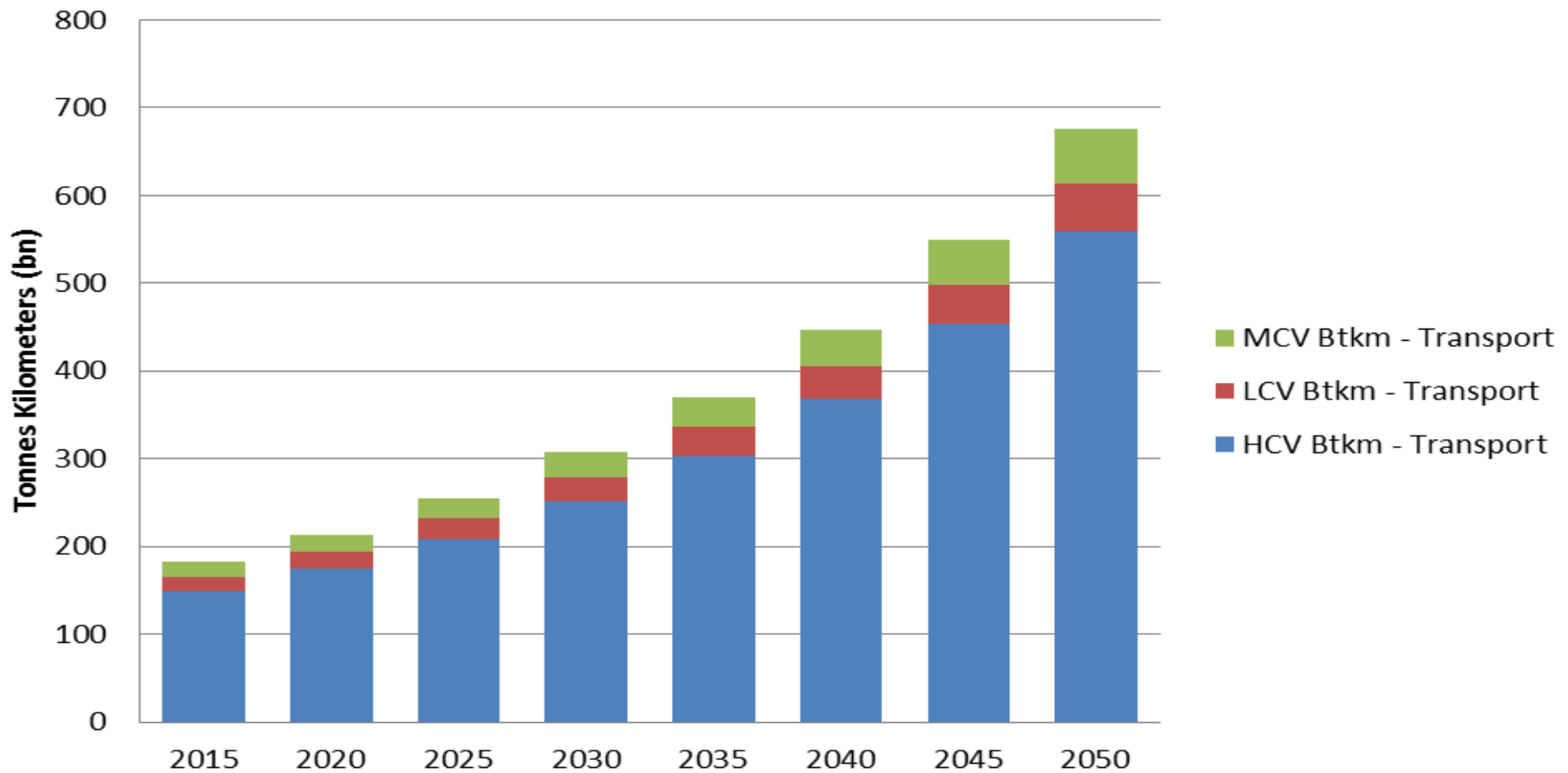


TRANSPORATION DEMAND (PASSENGER KILOMETERS)



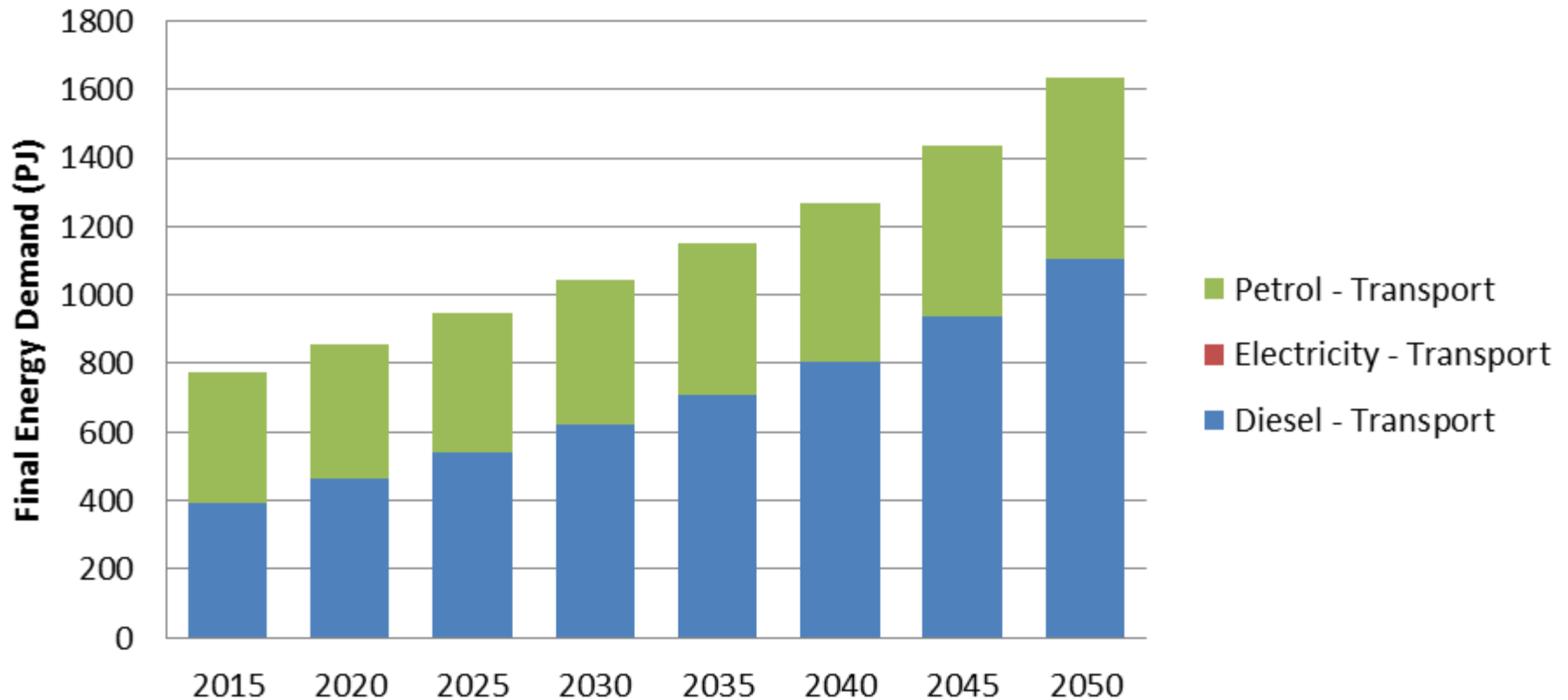


TRANSPORTATION DEMAND (TONNE KILOMETERS)





ENERGY DEMAND - TRANSPORT SECTOR (BASE CASE)





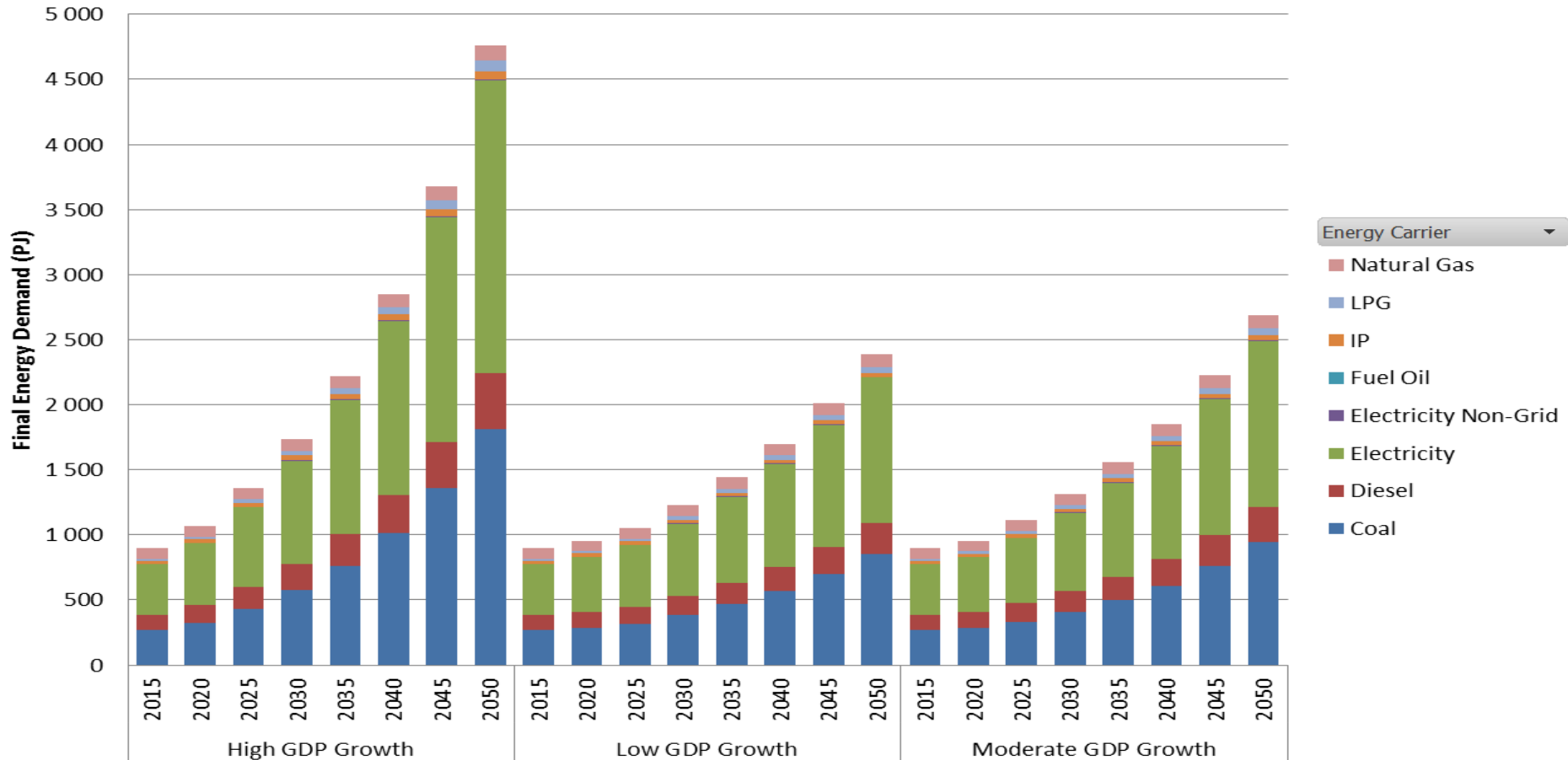
PRELIMINARY DEMAND PROJECTIONS BY ENERGY CARRIER

**EXCLUDES TRANSPORT SECTOR
DEMAND**



Sum of V...

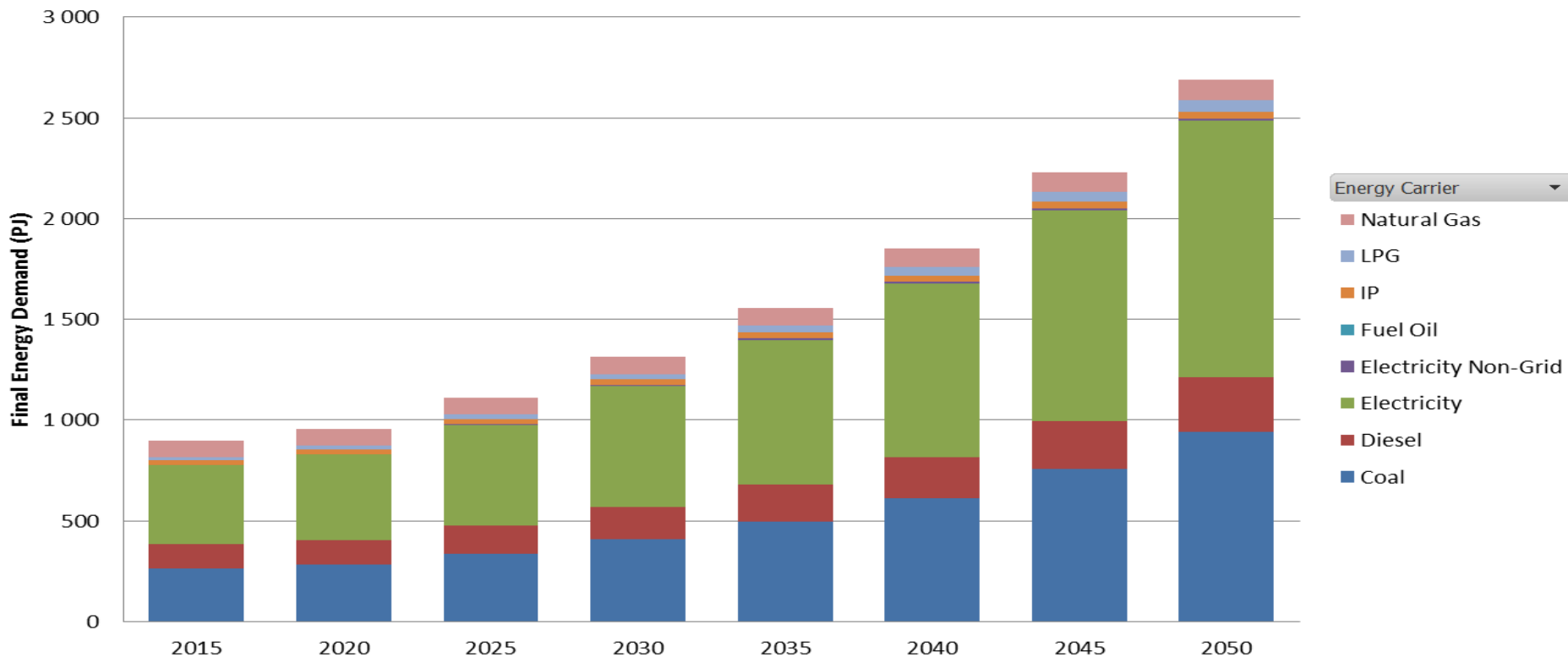
FINAL ENERGY DEMAND - ALL SECTORS



G... Year



FINAL ENERGY DEMAND - ALL SECTORS (BASE CASE)

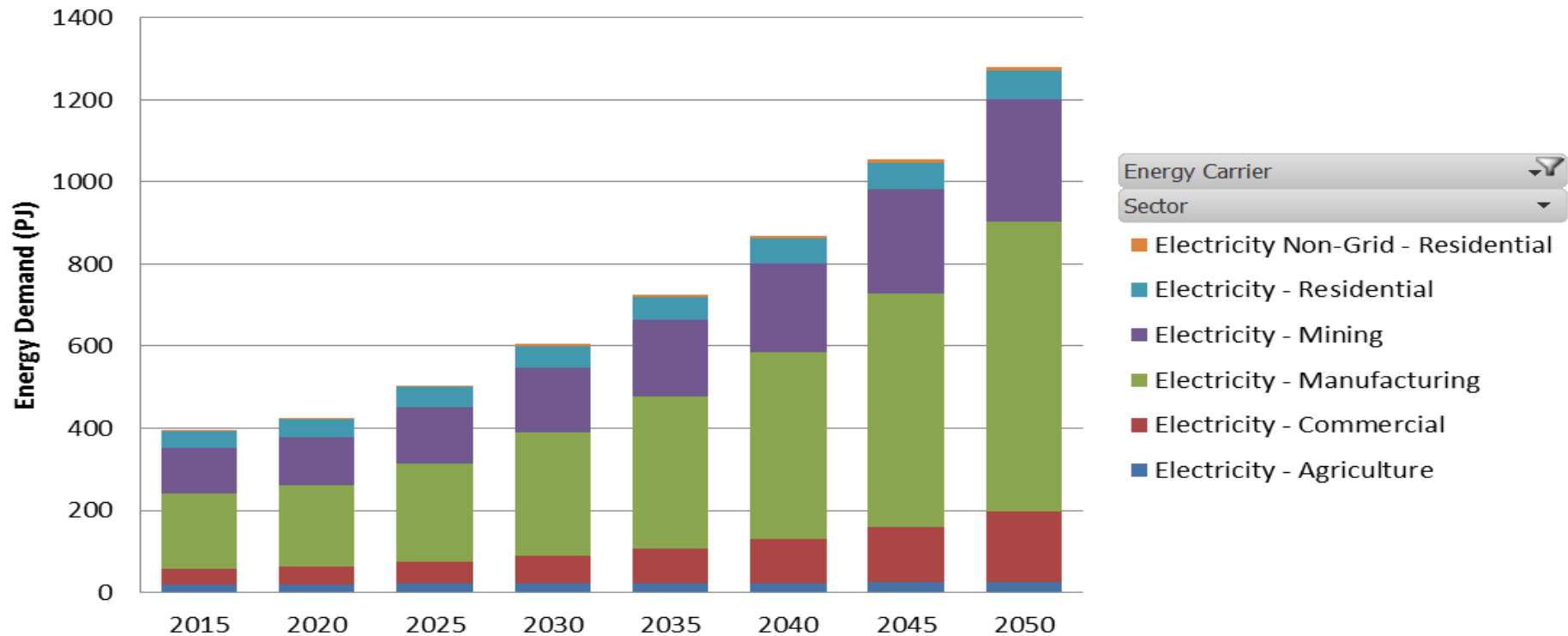




GDP

Sum of V...

ELECTRICITY DEMAND (BASE CASE)

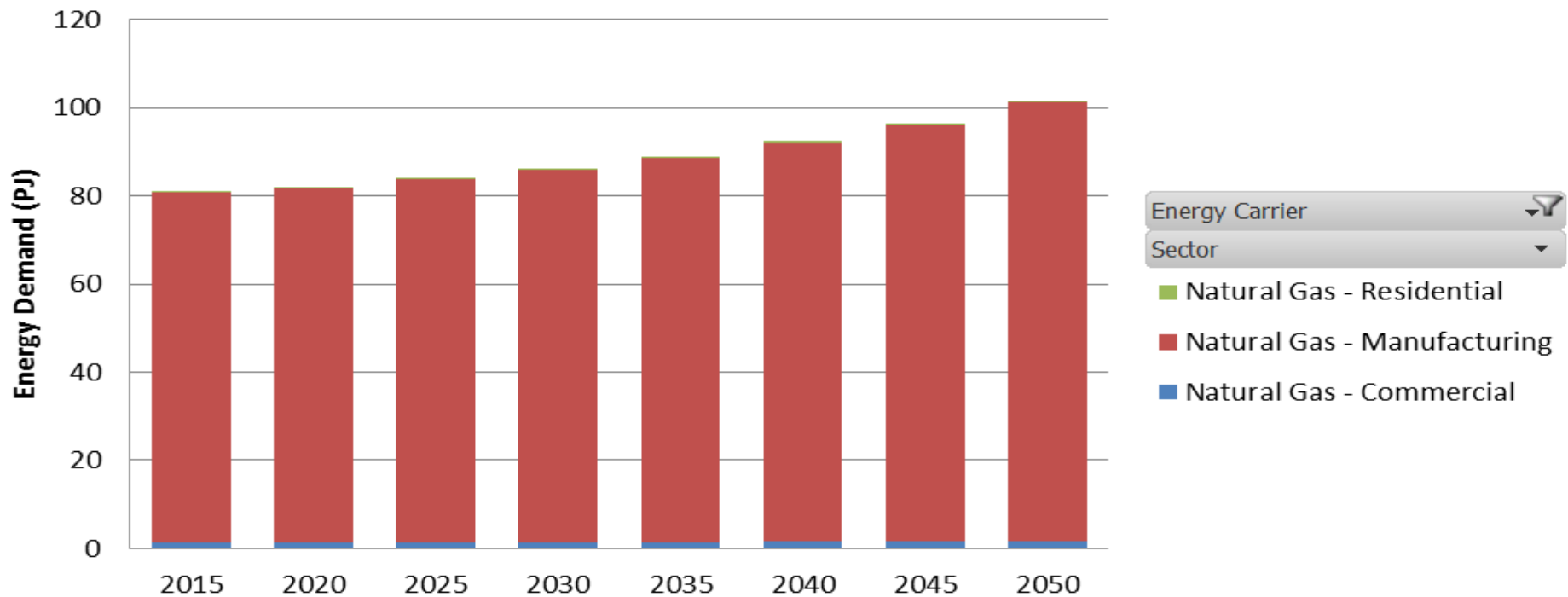




GDP ↕

Sum of V...

NATURAL GAS DEMAND (BASE CASE)

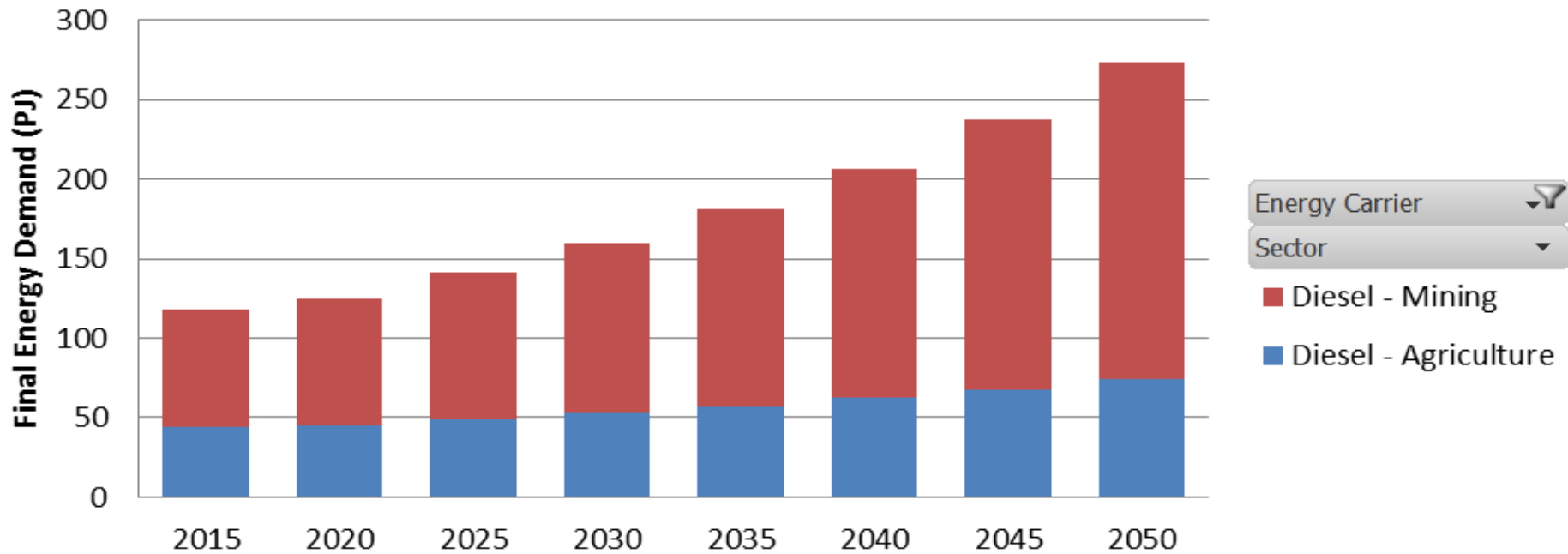




GDP

Sum of V...

DIESEL DEMAND (BASE CASE)



Energy Carrier

Sector

■ Diesel - Mining

■ Diesel - Agriculture

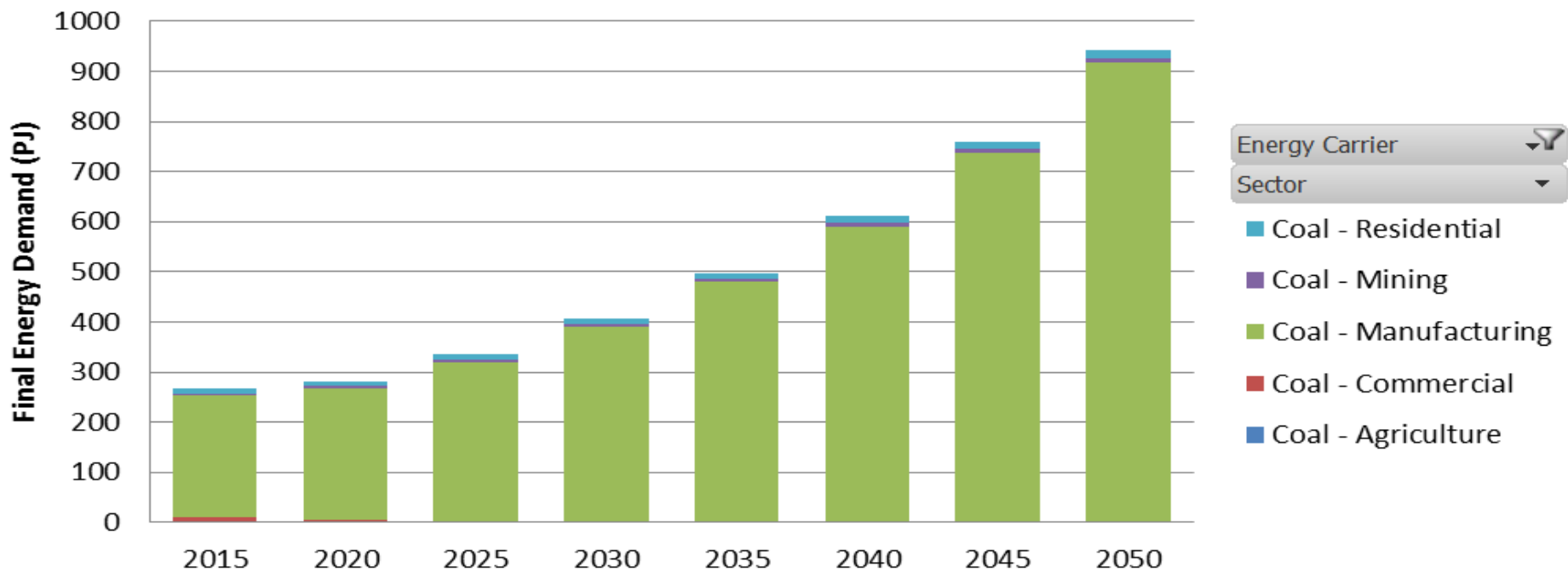
Year



GDP

Sum of V...

ENERGY DEMAND - COAL (BASE CASE)



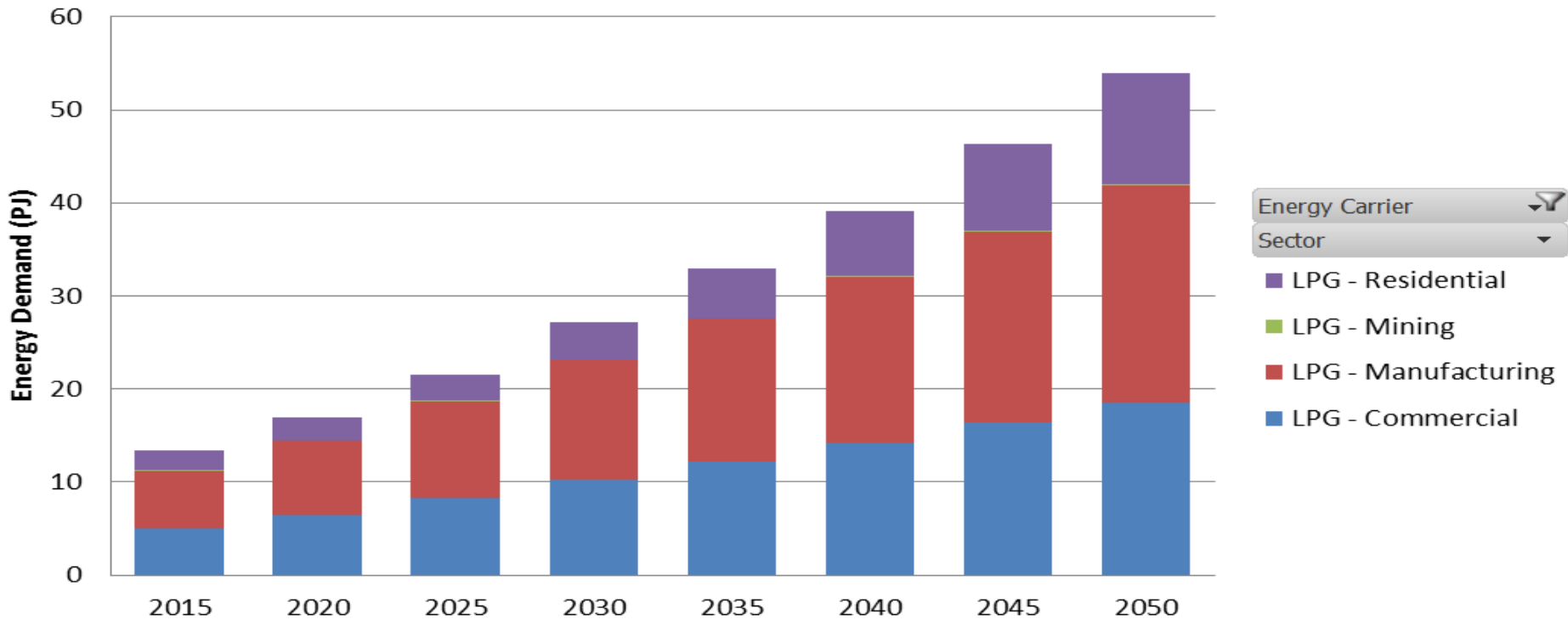
Year



GDP

Sum of V...

LPG DEMAND (BASE CASE)



Energy Carrier

Sector

- LPG - Residential
- LPG - Mining
- LPG - Manufacturing
- LPG - Commercial

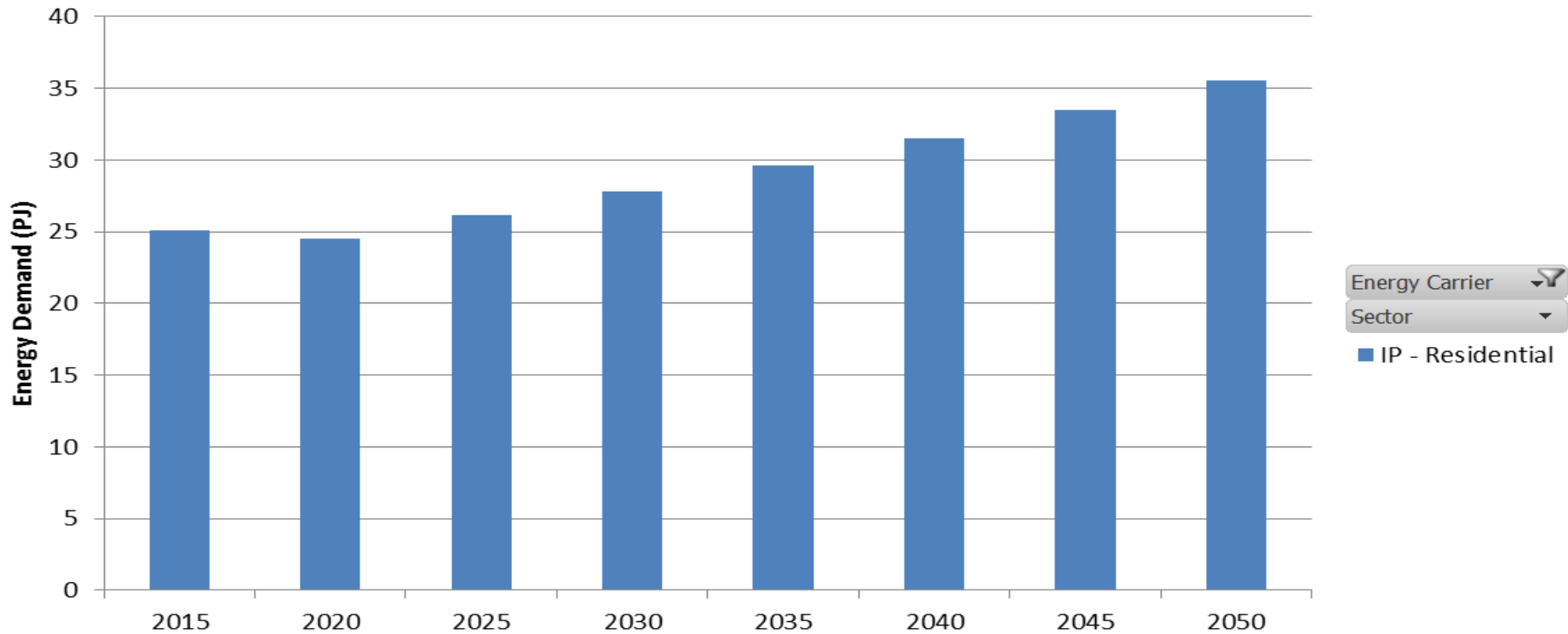
Year



GDP

Sum of V...

ILLUMINATING PARAFFIN DEMAND (BASE CASE)



Year



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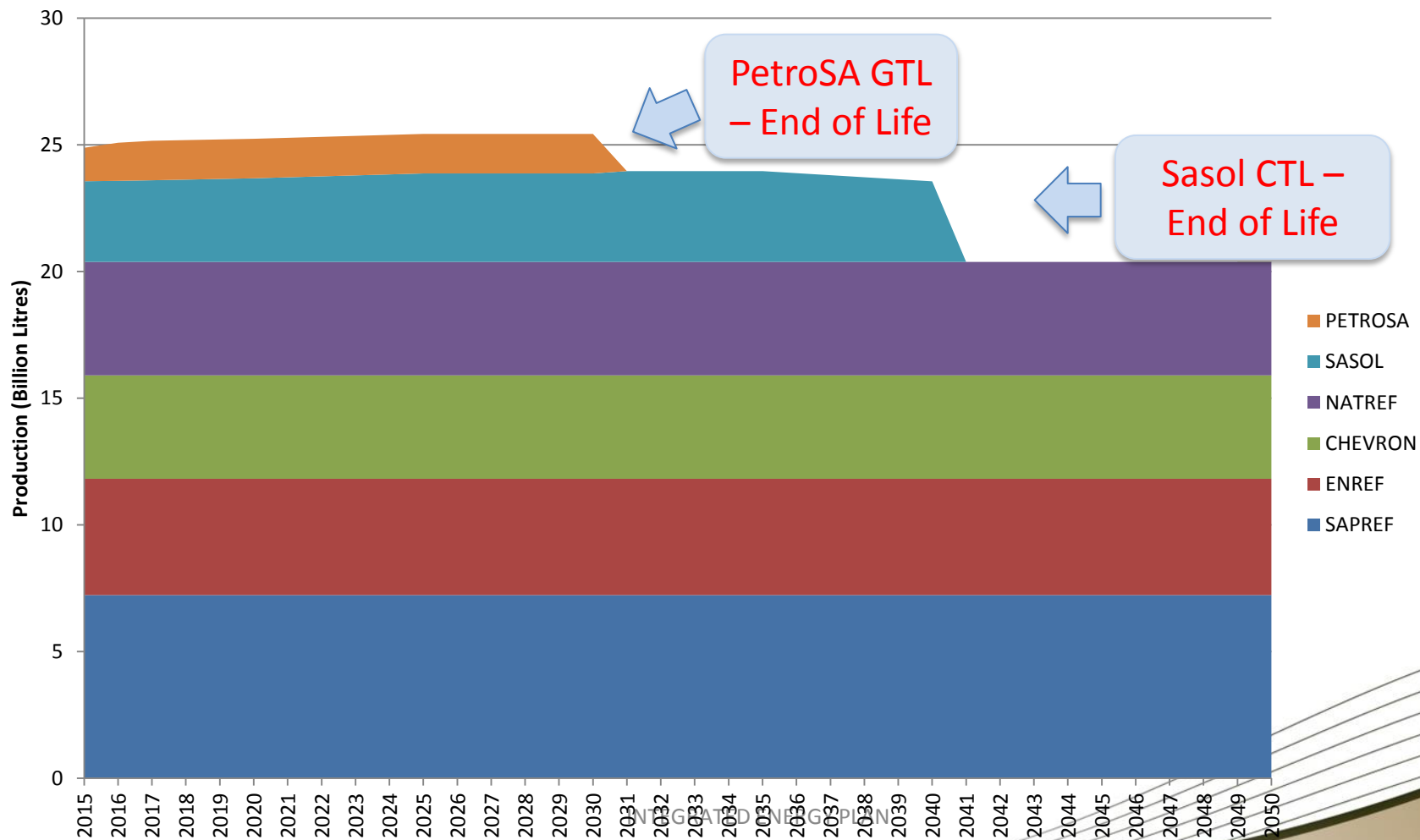
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LIQUID FUELS SUPPLY OPTIONS

PRELIMINARY MODELLING OUTPUT



EXISTING PRODUCTION CAPACITY





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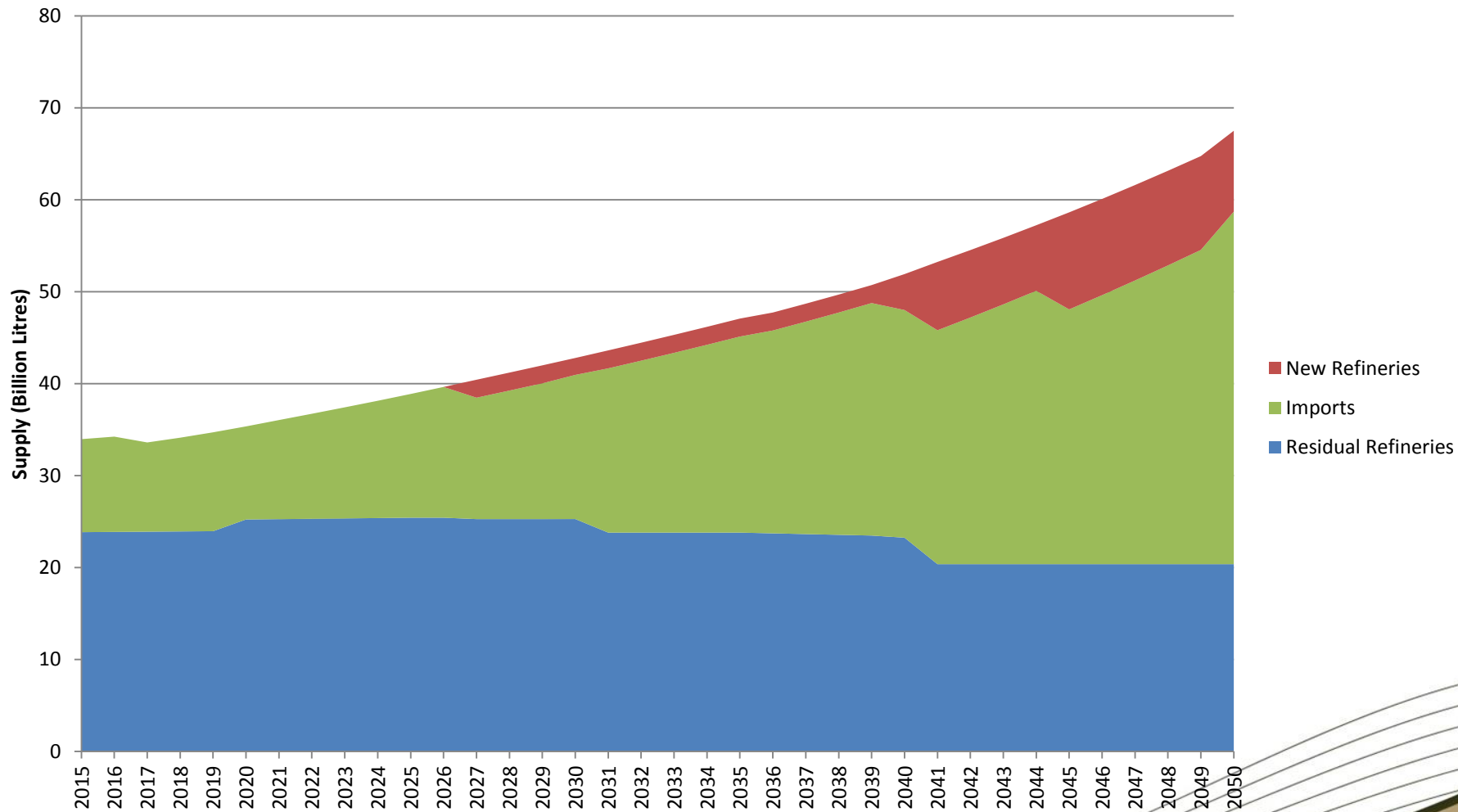
LIQUID FUEL SUPPLY OPTIONS



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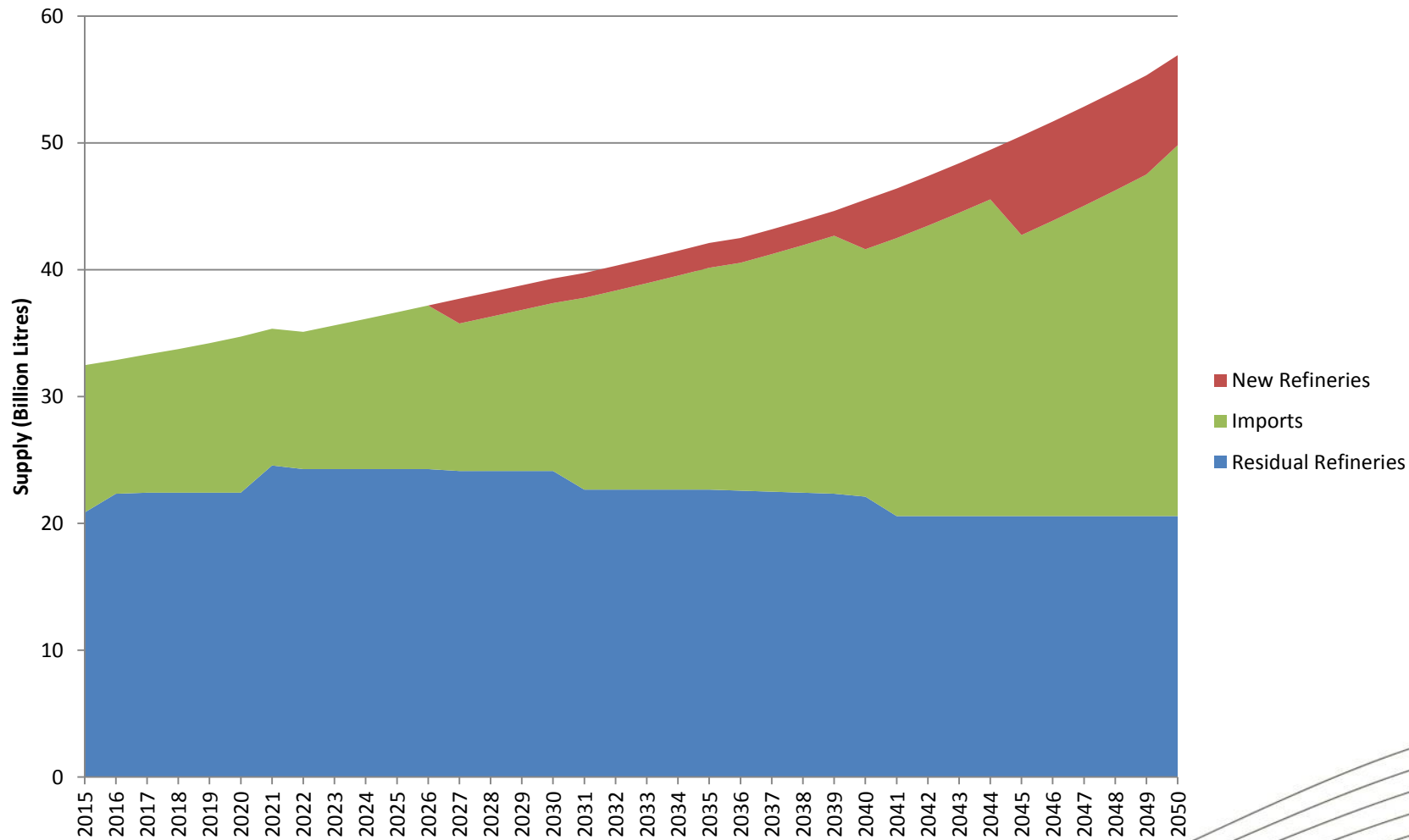
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Total Supply (BASE CASE)



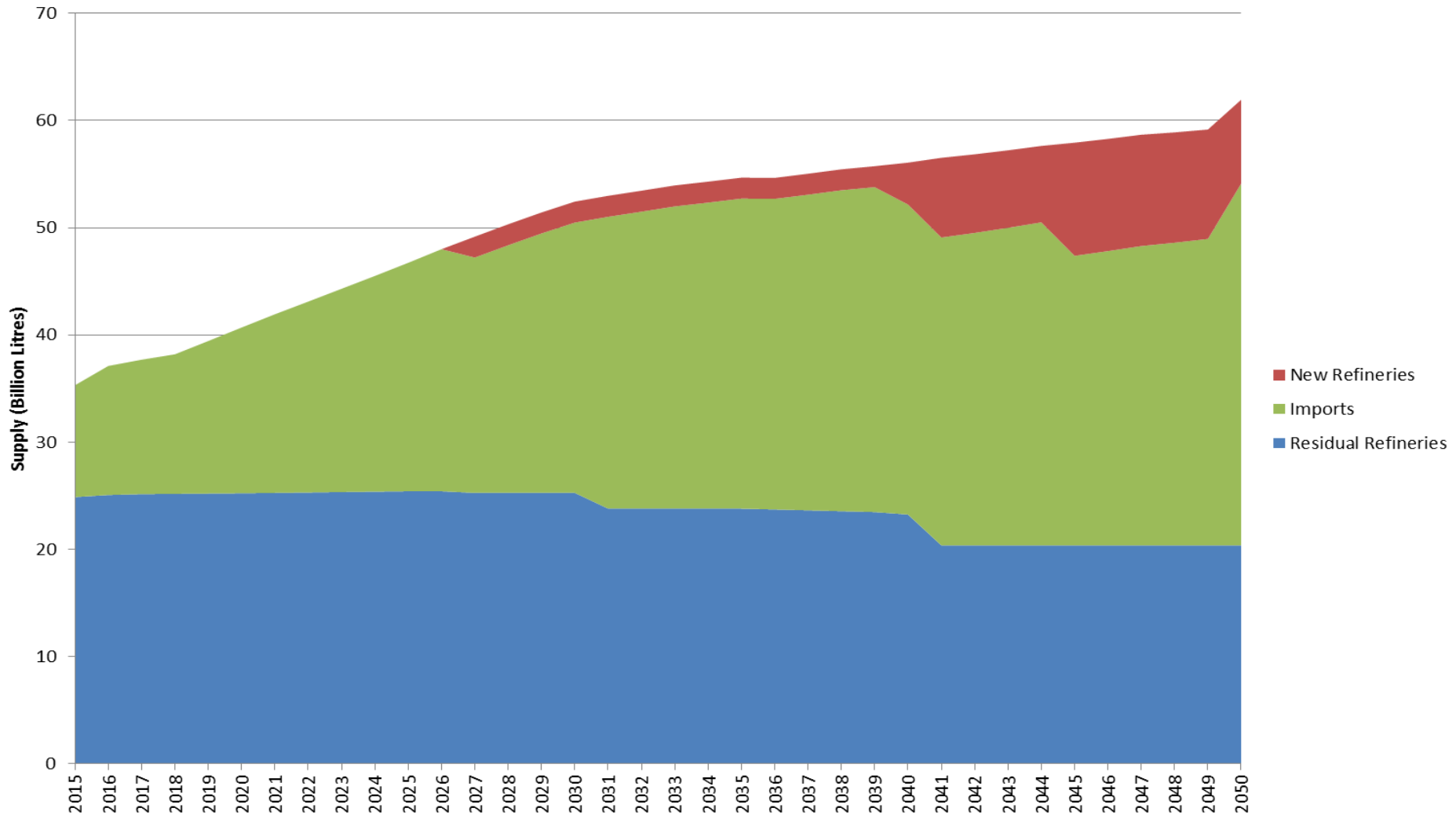


Total Supply (CLEANER PASTURES)





Total Supply (GS)

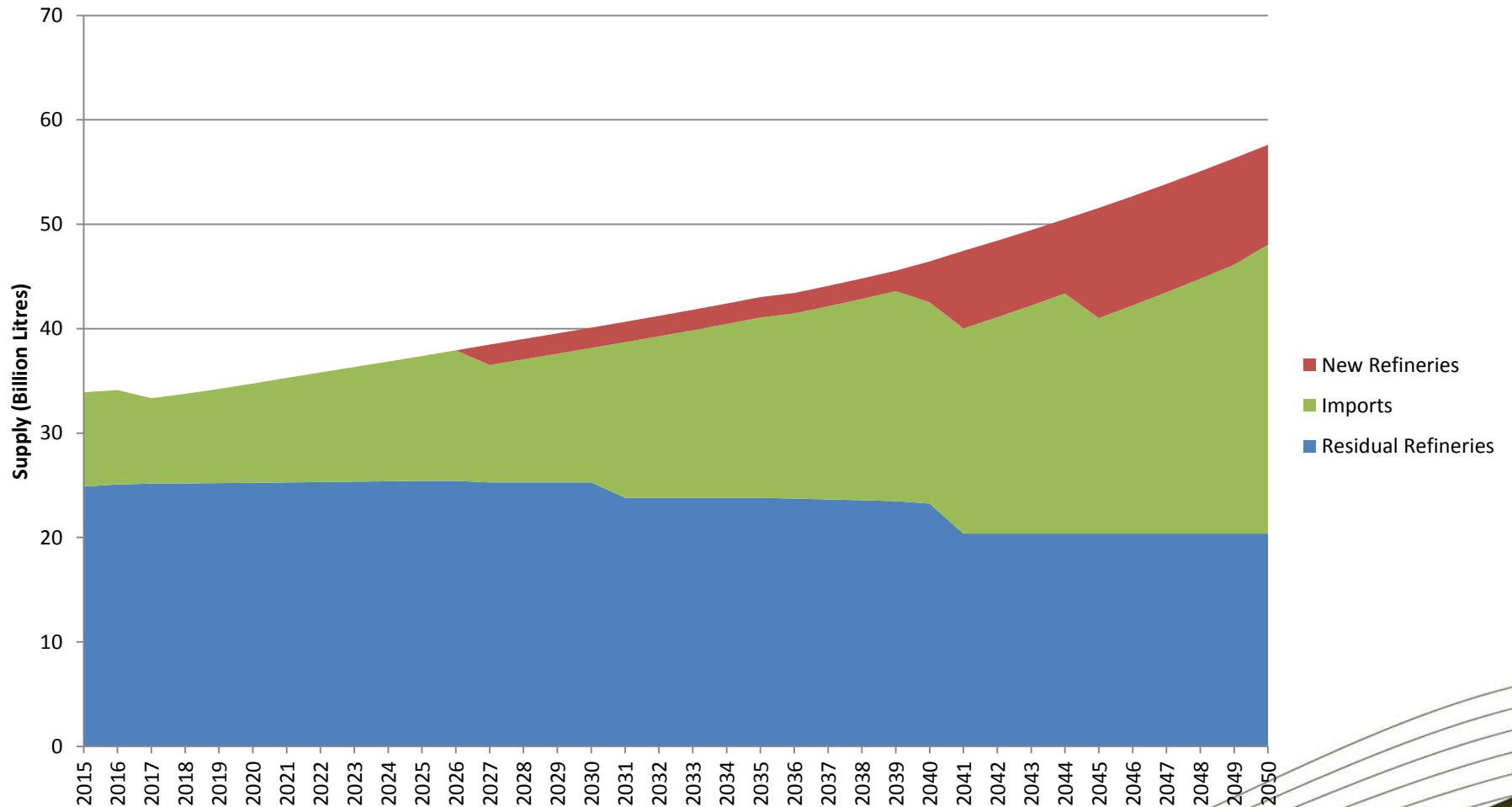




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Total Supply (RESOURCES CONSTRAINED)

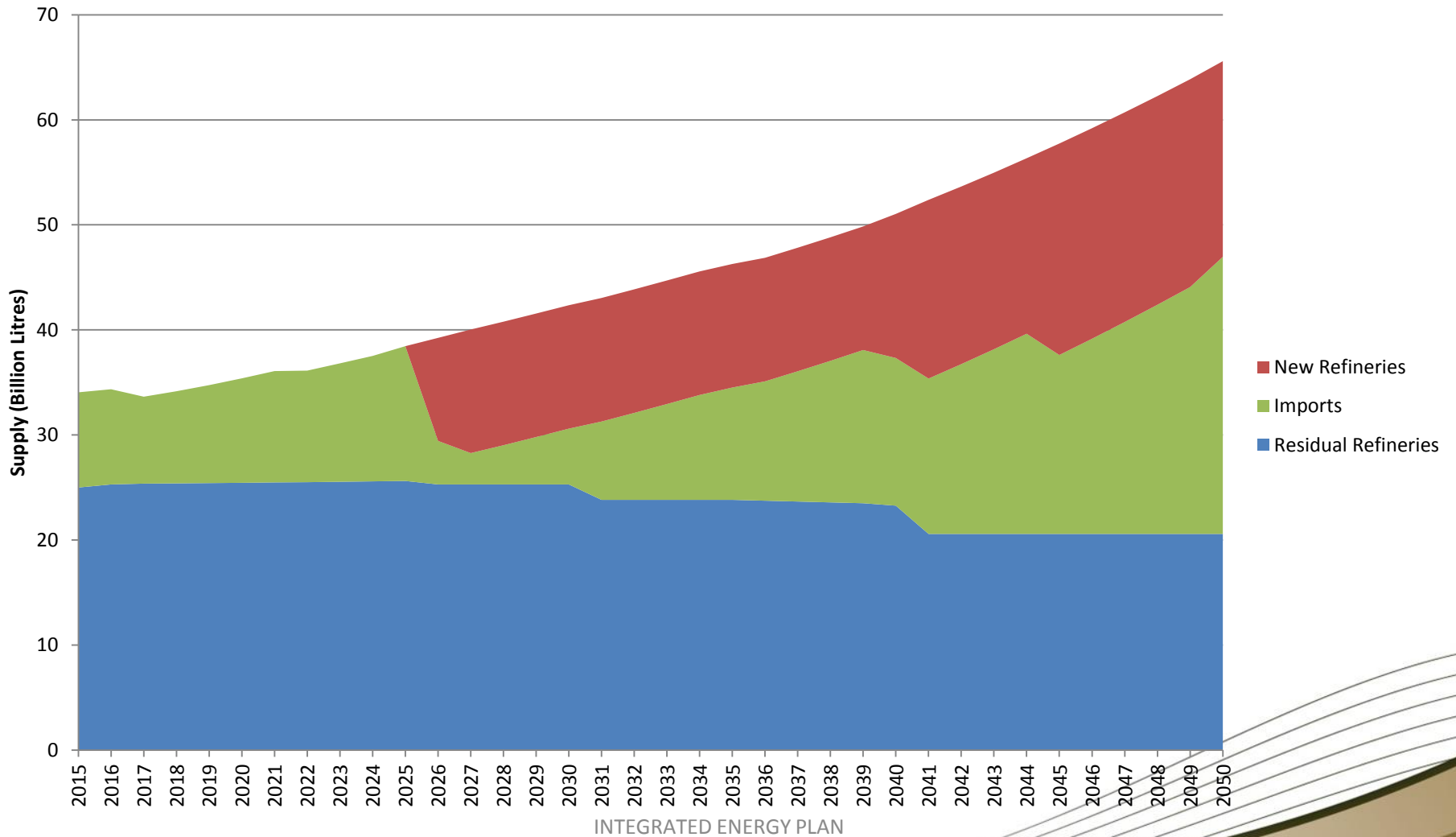




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Total Supply (SECURITY OF SUPPLY)



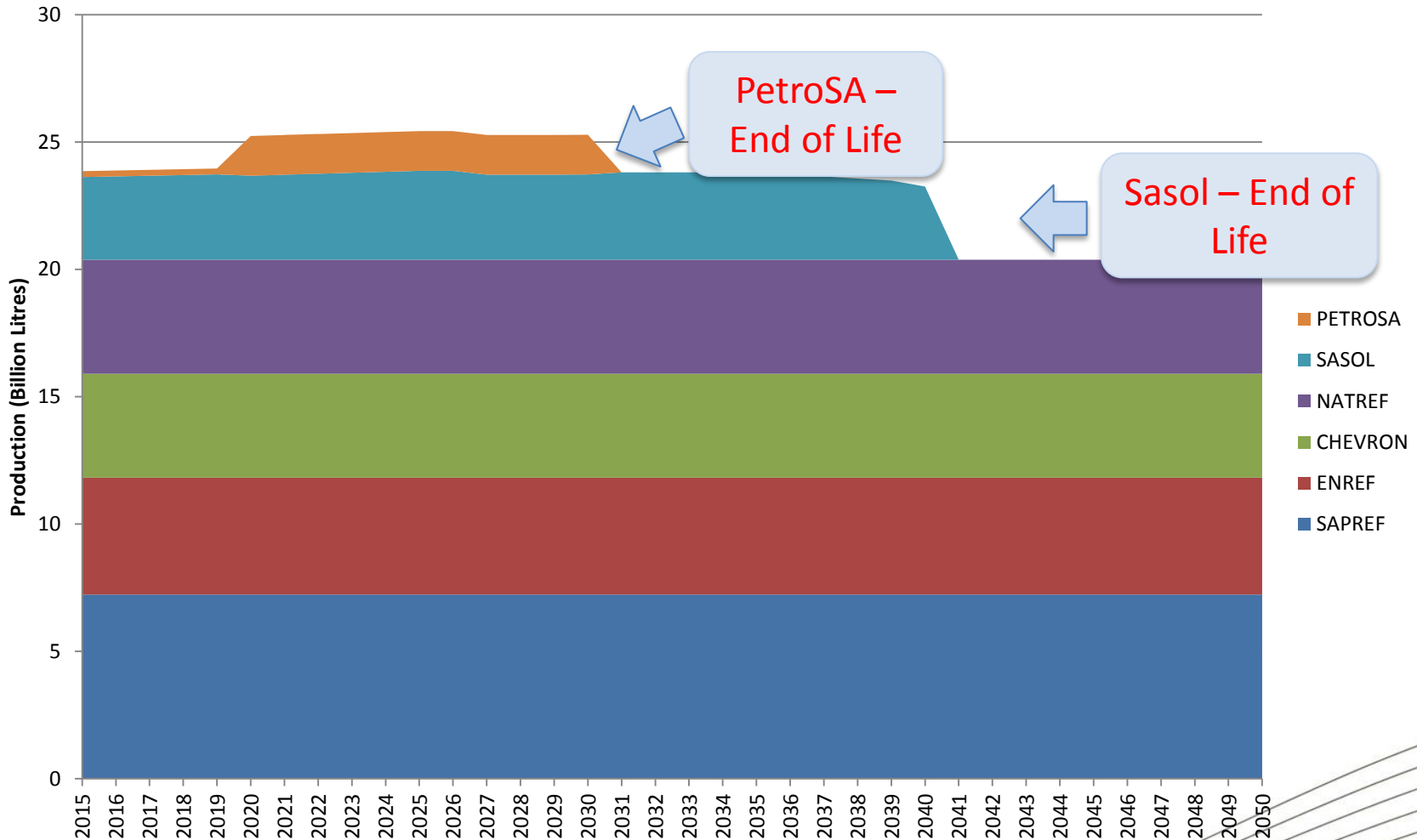


LIQUID FUEL SUPPLY OPTIONS

- There are significant similarities between the liquid fuel supply options of the different scenarios
- The Base Case, Cleaner Pastures and Resources Constrained have the same demand profile and exhibit the same liquid fuel supply mix (model chooses more imports and builds less new refining capacity). This is despite the more stringent emission constraints of the Cleaner Pastures and the higher crude oil price of the Resources Constrained scenarios
- The model starts choosing more new refining capacity towards 2039 and incrementally thereafter
- The model output from the Greenshoots scenario (which has the higher demand profile) shows a similar trend except with slightly more new refining capacity
- The Security of Supply scenario, which forces a new refinery (capacity of 200 000bbl/day) has the highest supply from local refineries with fewer imports



Domestic Production (BASE CASE)





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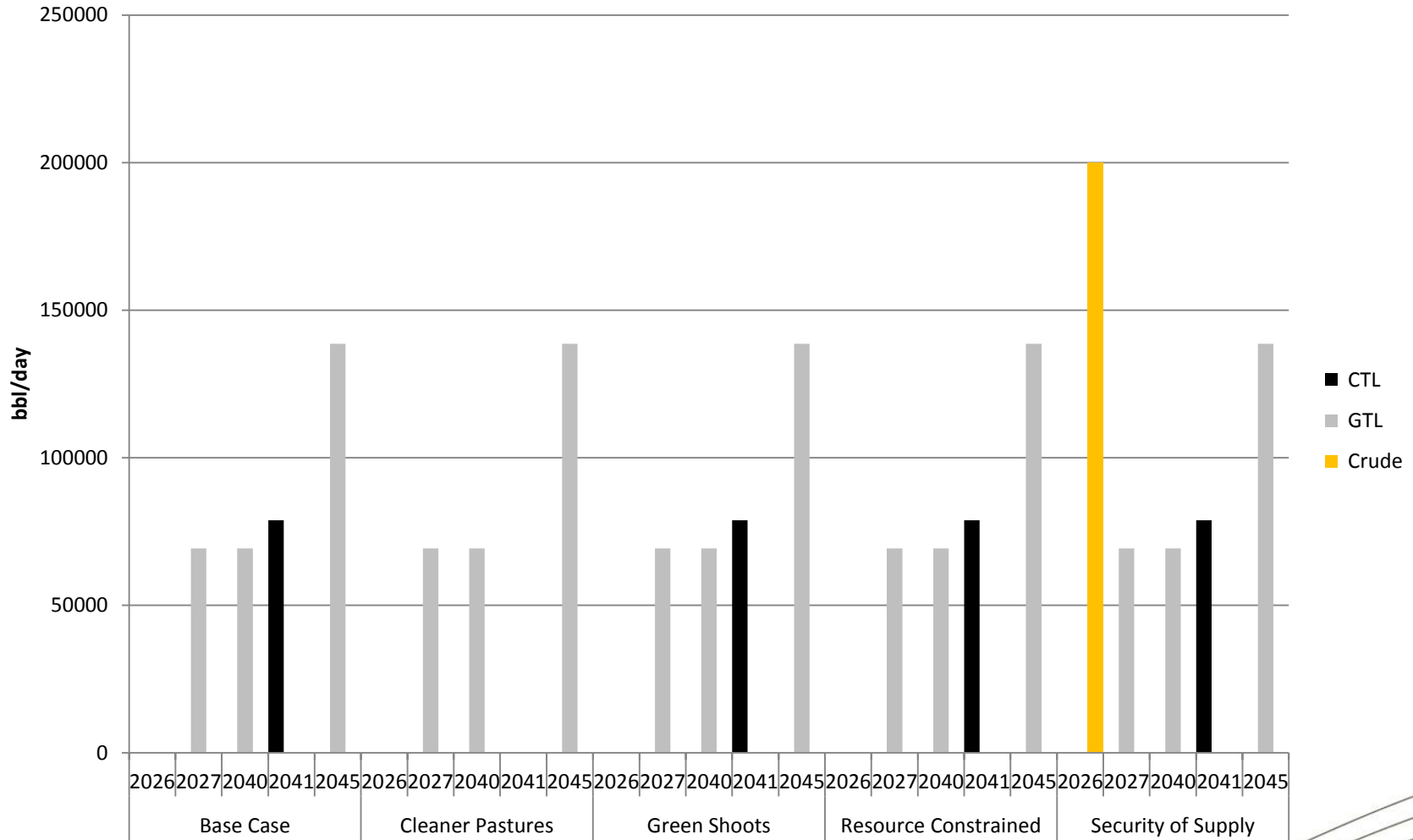
NEW REFINING CAPACITY



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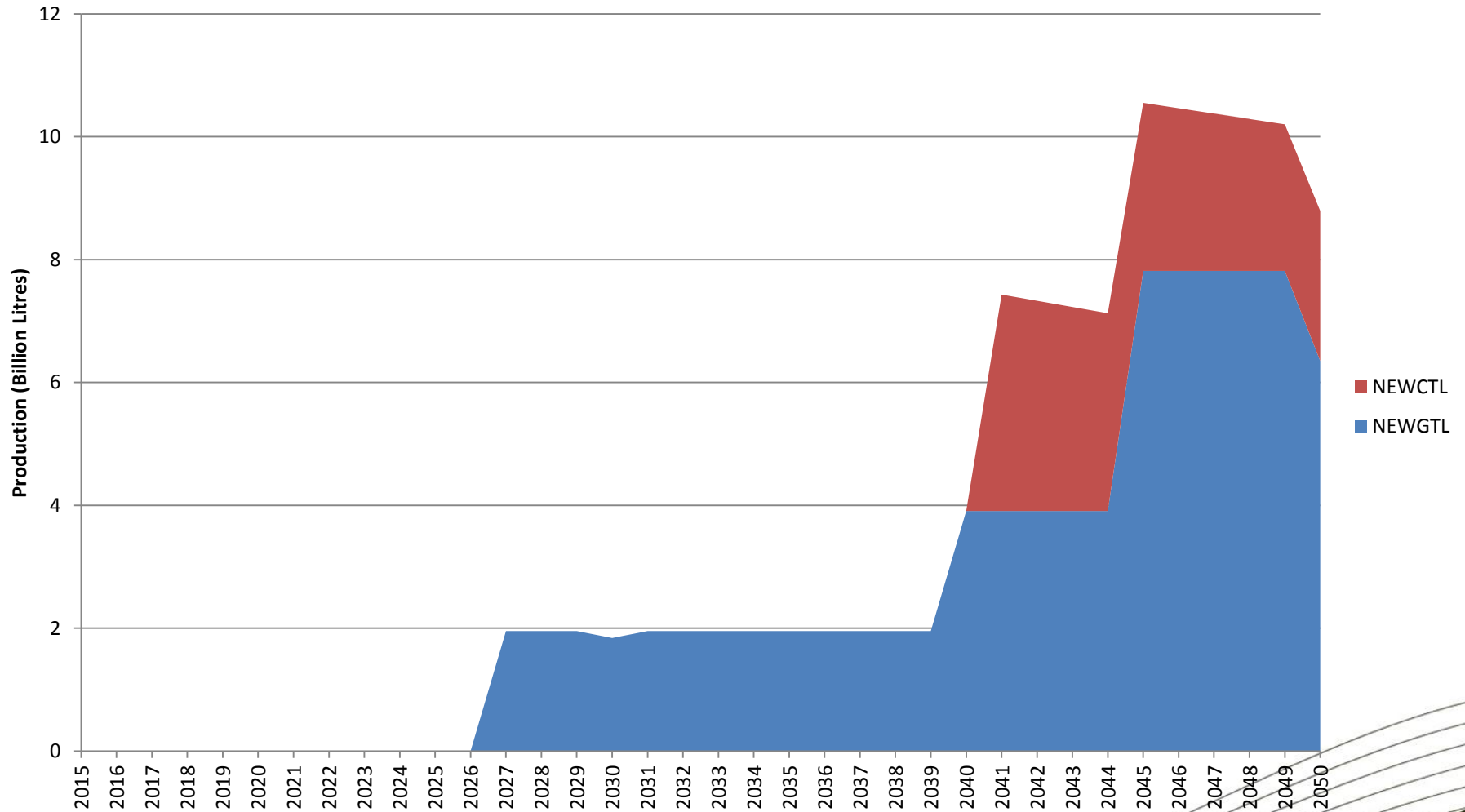
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New Refining Capacity



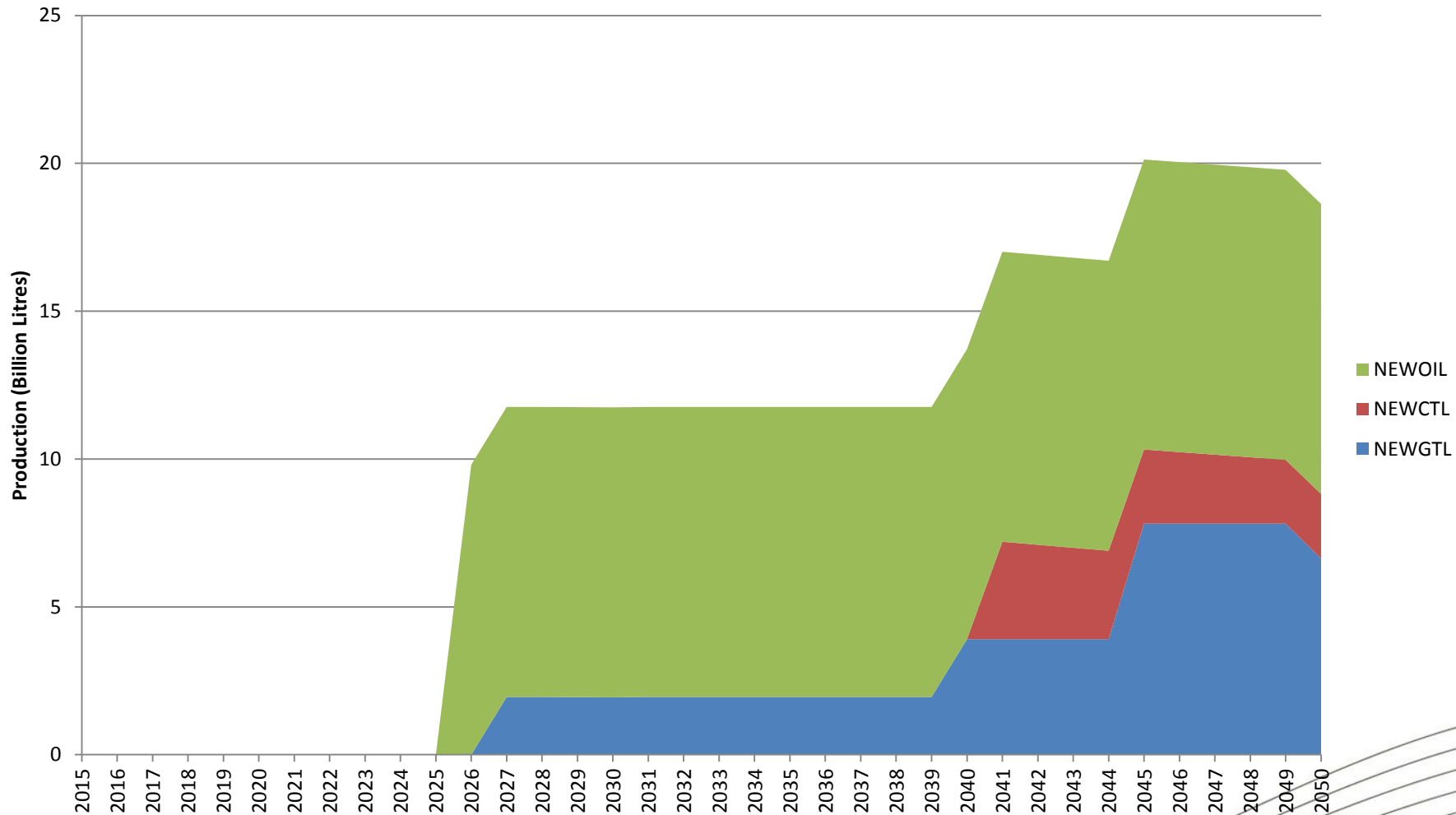


New Refinery Production (BASE CASE)





New Refinery Production (SECURITY OF SUPPLY)





NEW REFINING CAPACITY

- The new refining capacity technology options are also similar for the Base Case and Resources Constrained scenarios
- New GTL dominates new refining capacity throughout the planning horizon with some CTL also coming on-stream after 2040
- The Greenshoots scenario is also dominated by GTL, with CTL also coming on-stream after 2040. The
- The exception is the Cleaner Pasturers scenario, which, with more stringent emission constrained the model does not choose a new CTL refinery
- In the Security of Supply scenario, the model builds the additional crude oil refinery (capacity of 200 000bbl/day) over and above the new GTL and CTL in other scenarios



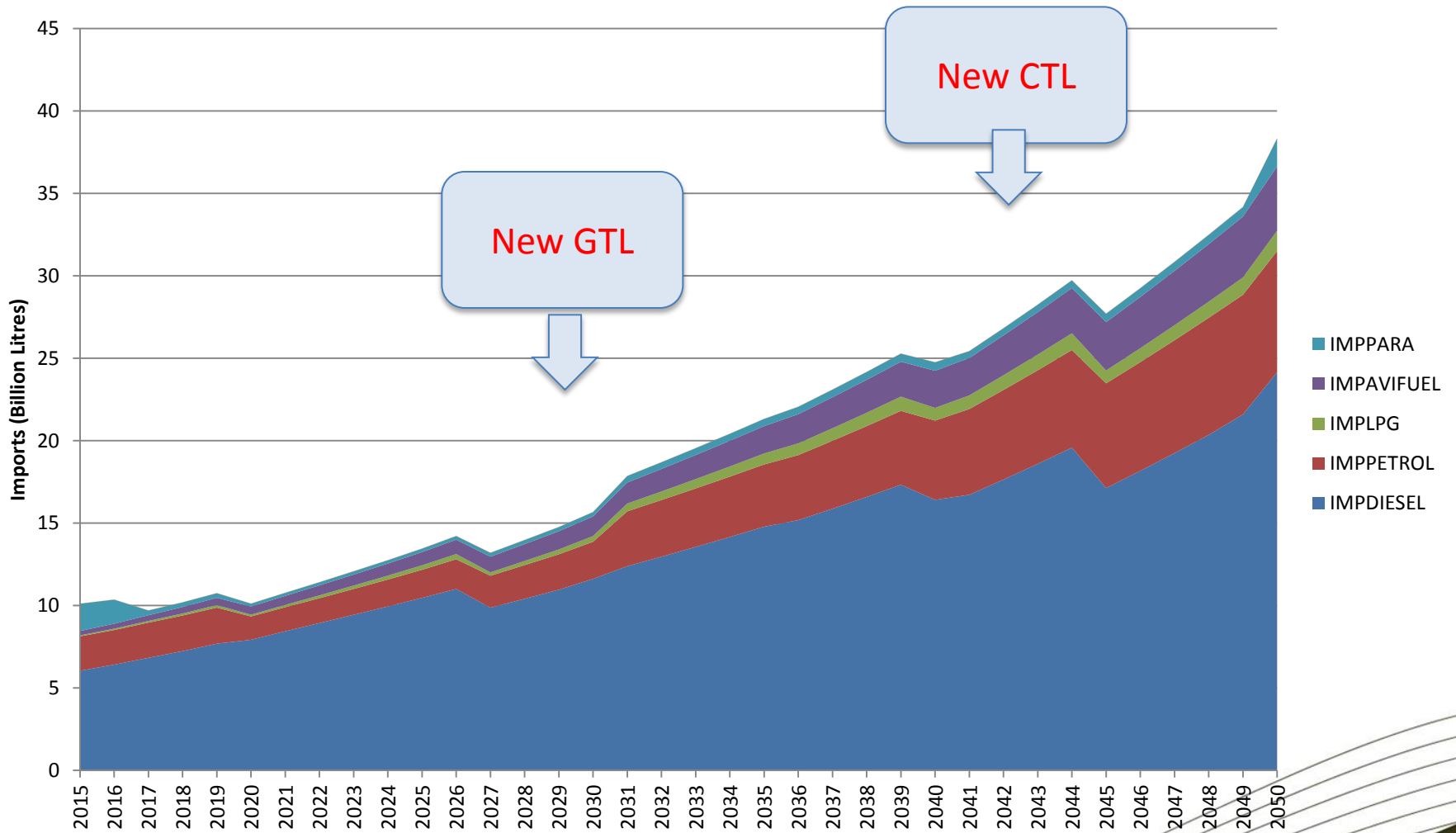
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IMPORTS

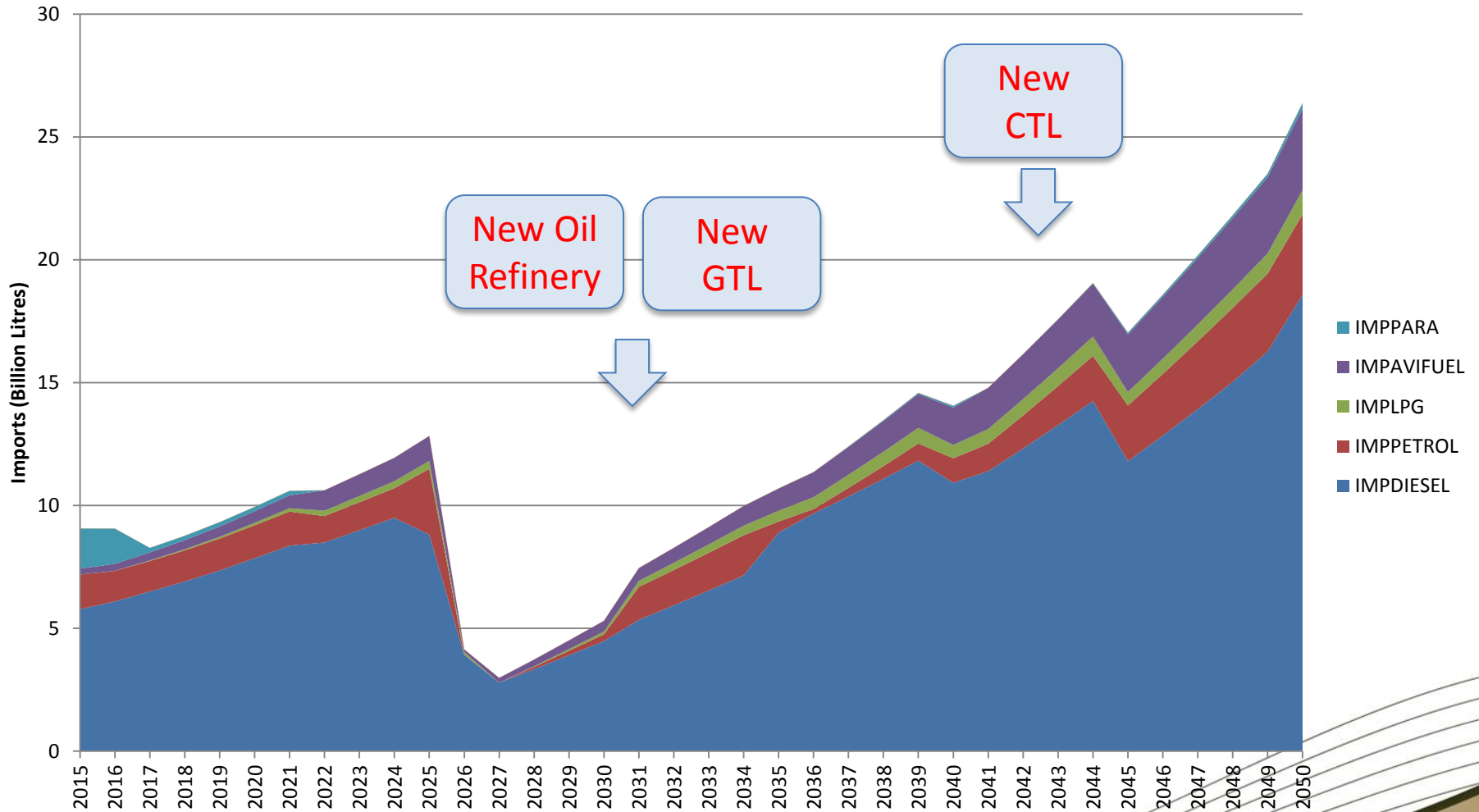


Liquid Fuel Imports (BASE CASE)





Liquid Fuel Imports (SECURITY OF SUPPLY)



IMPORTS



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- All scenarios exhibit a similar mix of final product
- This is dominated by diesel, which has the highest projected demand, followed by petrol
- A significant amount of jet fuel is also imported
- While proportionally the quantity of LPG imported is significantly lower than for the major fuel products, this is quite a significant increase to current imports
- The construction of a new 200 000bb/day refinery reduces the level of imports quite significantly, however this increases steadily as demand grows



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COSTS



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TOTAL DISCOUNTED COSTS (R'bn 2015)

| | Base Case | Cleaner Pastures | Green Shoots | Resource Constrained | Security of Supply |
|-----------------------------------|----------------|------------------|----------------|----------------------|--------------------|
| Imports - Refined Products | 1 015.5 | 930.2 | 1 367 | 949.7 | 656.5 |
| Imports - Crude Oil | 1 493.7 | 1 512.5 | 1 493.7 | 1 649.1 | 1 890.8 |
| Production - Existing Refineries | 154.6 | 218.9 | 200.3 | 200.3 | 199.4 |
| Production & Capital - New Builds | 44 | 36.9 | 48.9 | 49 | 121.7 |
| Fuel - Gas & Coal | 85.9 | 95.8 | 77.7 | 92.1 | 222.3 |
| Total | 2 793.7 | 2 794.3 | 3 187.5 | 2 940.2 | 3 090.7 |



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REPUBLIC OF SOUTH AFRICA

Discounted Costs

