

Petroleum Production under the two degree scenario (2DS)



MILJØVERNDEPARTEMENTET



Norge og veien mot lavutslippssamfunnet

Arendal, 8. August 2013

Presentasjon
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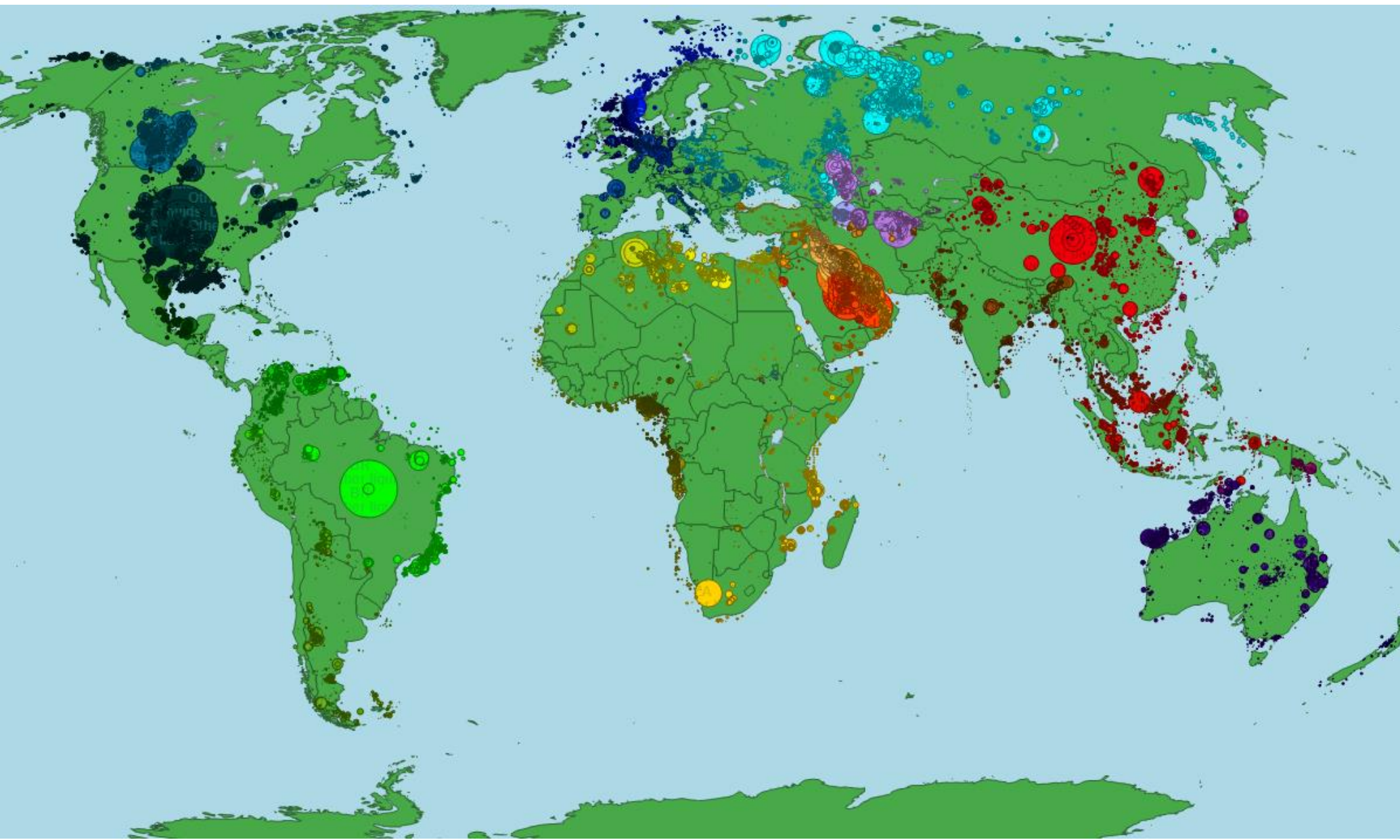
This is:

- Assessment of oil and gas resources that could be produced within 2DS carbon budget (as used by IEA) in a “static case” based on pure economical decisions
 - Globally
 - In Norway
 - Under various coal shares
 - With static cost base and frame conditions

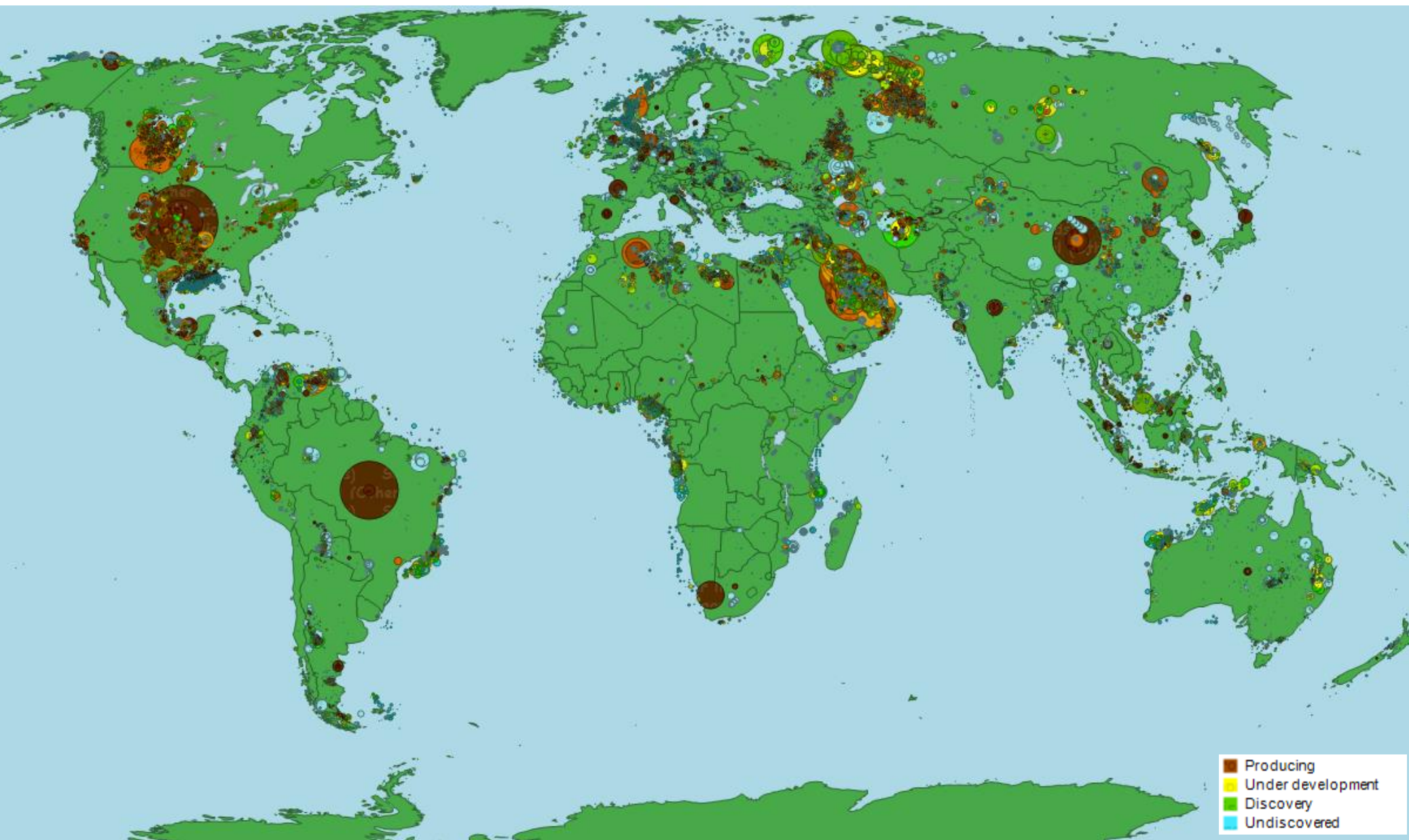
This is NOT:

- Assessment of relevance of carbon budget for 2DS
- Assessment of dynamic effects of carbon policies
- Assessment of effects of new technologies, cost changes or changes in fiscal regimes

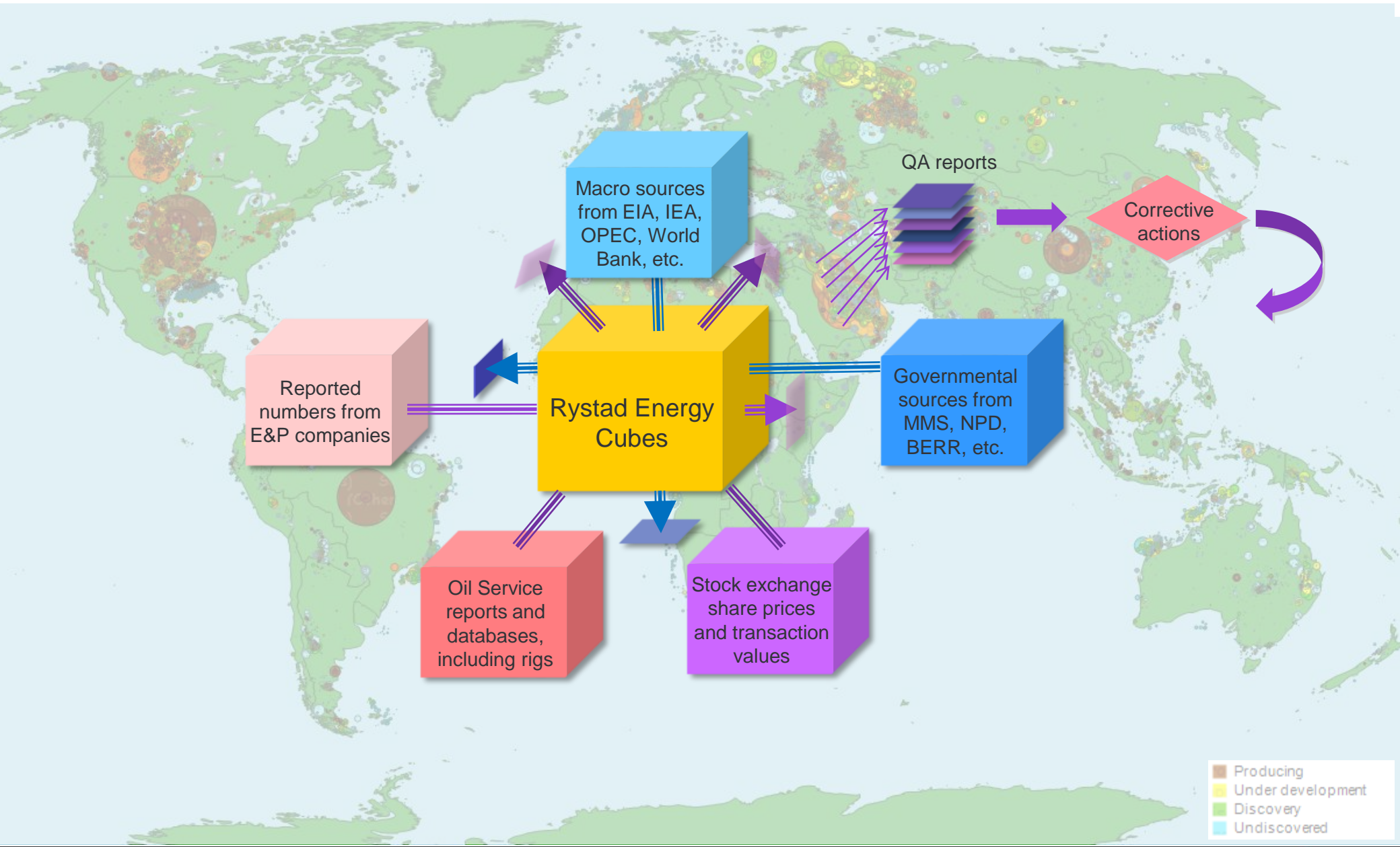
Based on CO2 emission potential from 68 000 fields and exploration areas to 2100



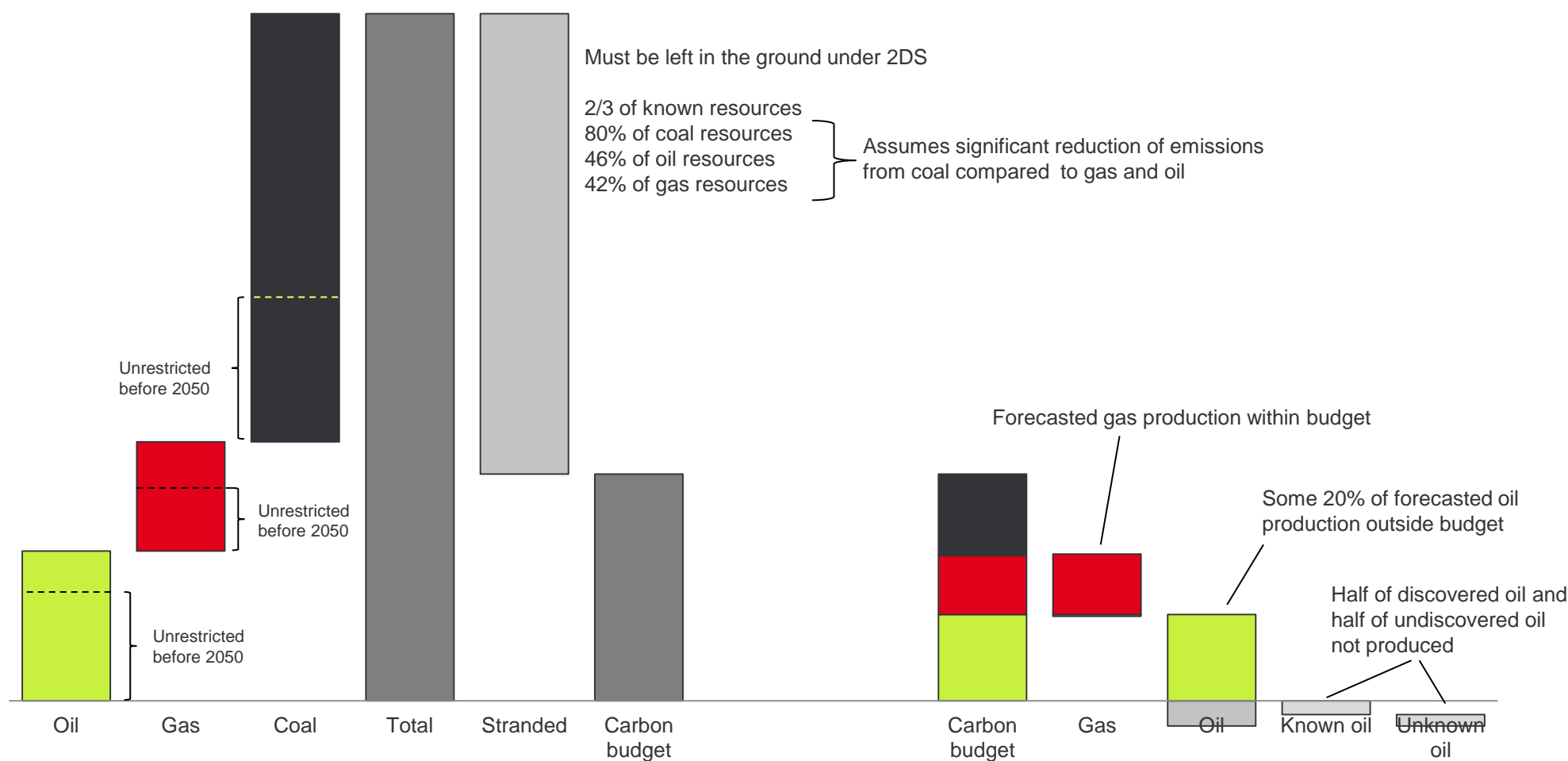
Based on CO2 emission potential from 68 000 fields and exploration areas to 2100 – by life cycle



Based on CO2 content in 68 000 fields and exploration areas to 2100



CO₂ emission balances under the two degree scenario



Known resources

The time horizon is potentially several hundred years into the future. While a large part of known oil and gas resources will be produced before 2050 in an unrestricted case, only around one third of coal resources are likely to be produced in the same period.

Unrestricted production 2013-2050

The time horizon is 2013-2050. Forecasted production not restricted by low demand and low oil price is compared to the 2DS carbon budget, assuming the emission mix between coal, oil and gas as proposed by IEA Energy Technology Perspectives

Carbon emission budget 2013-2050: ~1000 Gt

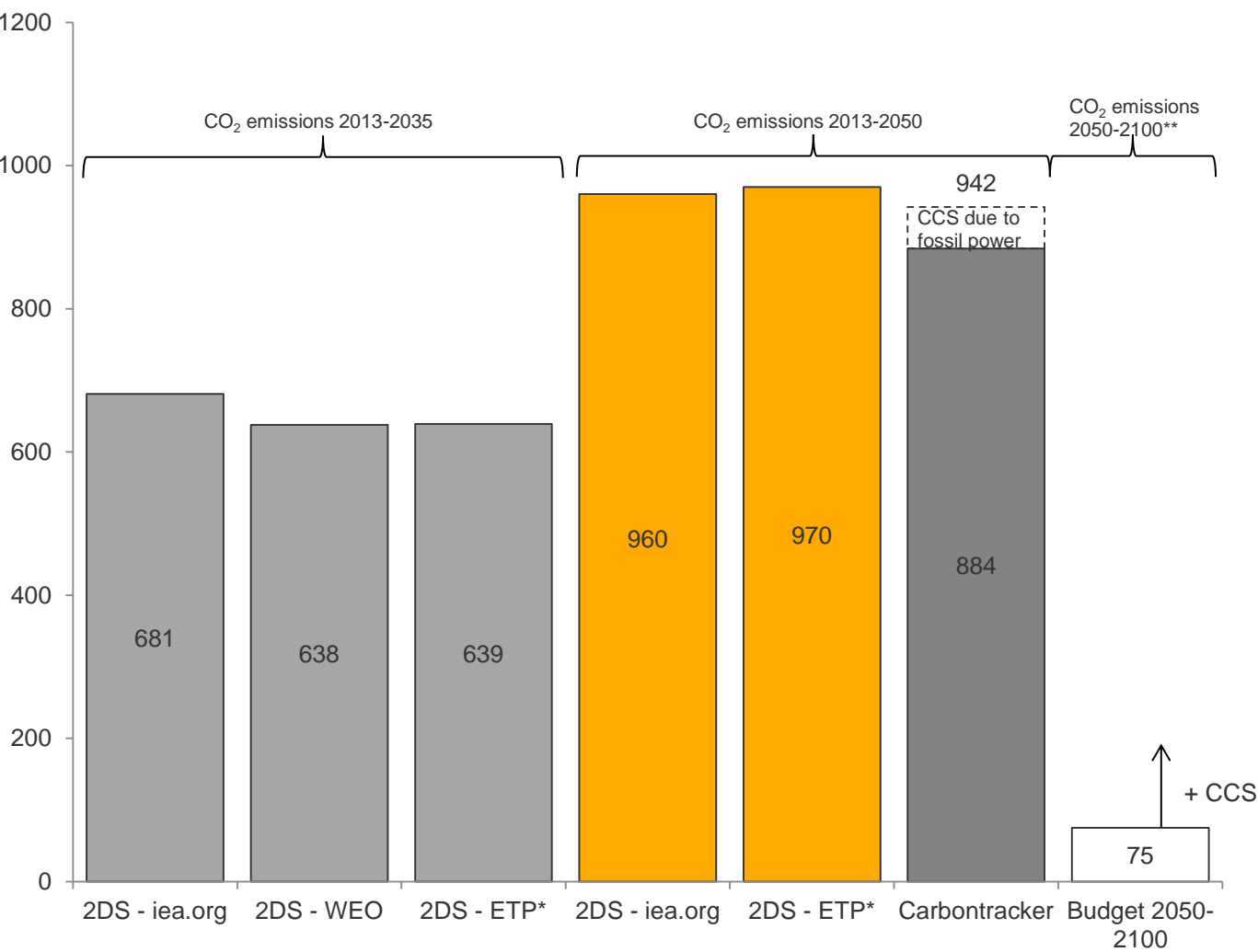
The chart compares the carbon budget from various sources. The carbon budget is the maximum cumulative CO₂ emissions that limits average global temperature increase to 2°C.

The IEA's carbon budget is higher than the one communicated by Carbon Tracker. This is due to the fact that carbon tracker doesn't account for potential increased emission potential due to carbon capture and storage (CCS). Carbon Tracker does, however, estimate that given a full investment in CCS, the carbon budget will increase by 12-14 %.

In total this leaves us with a carbon budget that allows for a total CO₂ emission of approximately 1000 Gt for the period 2012-2050.

Carbon Tracker has estimated the carbon budget *after* 2050 to be 75 Gt, not including a CCS upside that might be underutilized due to small demand.

The total carbon budget 2013-2050 (from combustion) given the 2DS scenario.
CO₂ Gt



*) CO₂ emissions are calculated based on ETP's hydrocarbon demand estimates for each year

**) Carbon budget after 2050 : Source Carbon Tracker, "Unburnable carbon 2013"

Source: Rystad Energy research and analysis; International Energy Agency (2012), Energy Technology Perspectives 2012, OECD/IEA, Paris; IEA Energy Technology Perspective (2012)



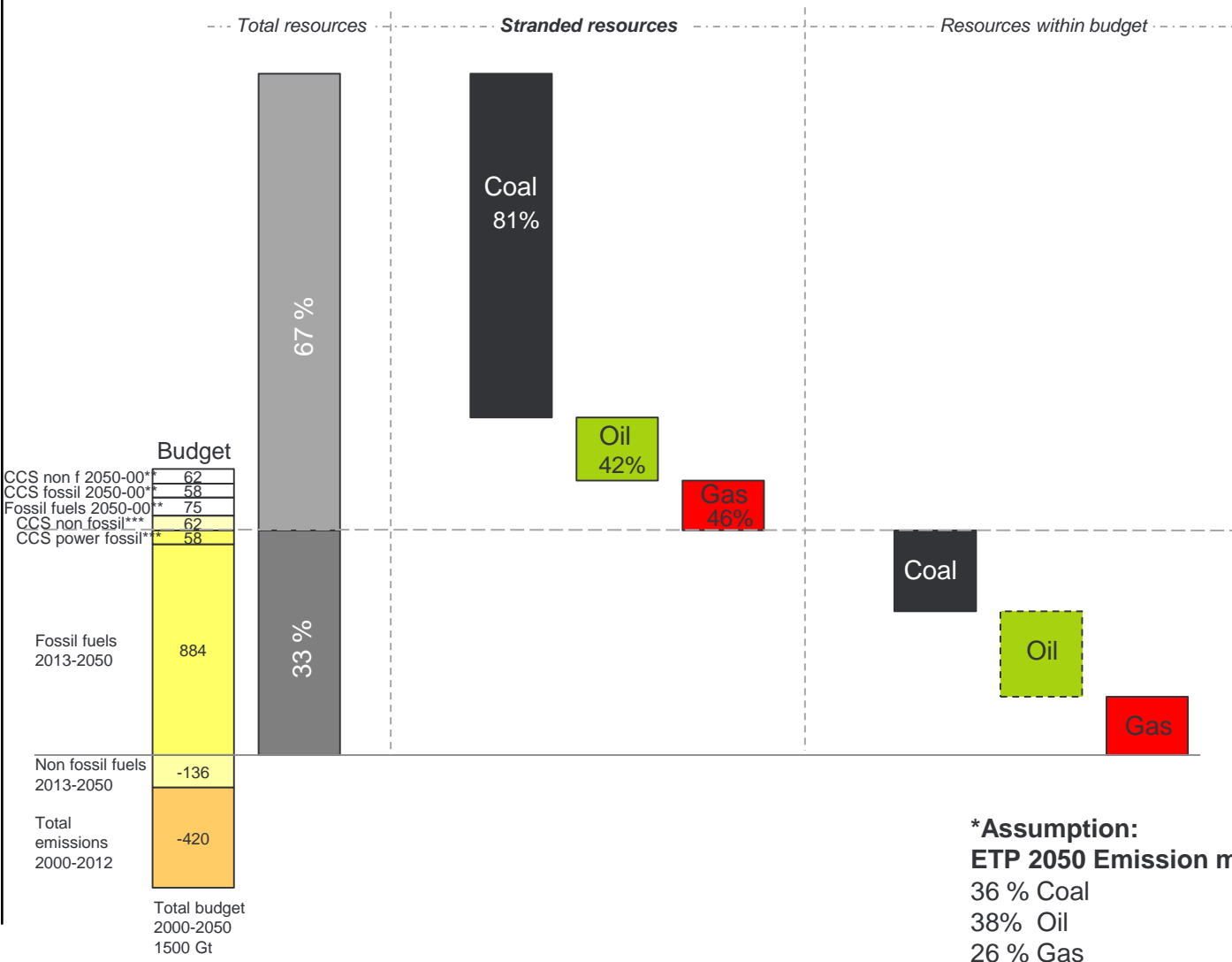
80% of the coal, but less than half of known oil and gas resources must be left in the ground*

Under the 2DS, maximum cumulative CO₂ emissions during first half of the 21st century is 1500 Gt CO₂*. Maximum emissions from fossil fuels during 2013-2050 around 950 Gt, including some 60 Gt removed from the atmosphere with CCS.

Measured in potential CO₂ emissions during combustion, 2/3 of known fossil resources must be left in the ground under 2DS. 63 % of these reserves are coal, and coal's share of CO₂ emissions is reduced from 45% to 36% under 2DS. This implies 81 % of known coal resources must be left in the ground.

Assuming ETP 2050 emission mix, 42% of known oil resources and 46% of known gas resources must be left in the ground under 2DS.

Known resources** versus 2DS carbon budget* 2012-2050**
Gt CO₂ emissions during combustion



*Source IEA World Energy Outlook 2012
**Source Carbon Tracker, Unburnable Carbon 2013
***Budget increase due to increased Carbon Capture and Storage(CCS). Source IEA
****Source: Rystad Energy UCube, Expected value (P-Mean)

Emission budget for oil and gas depends heavily on coal budget

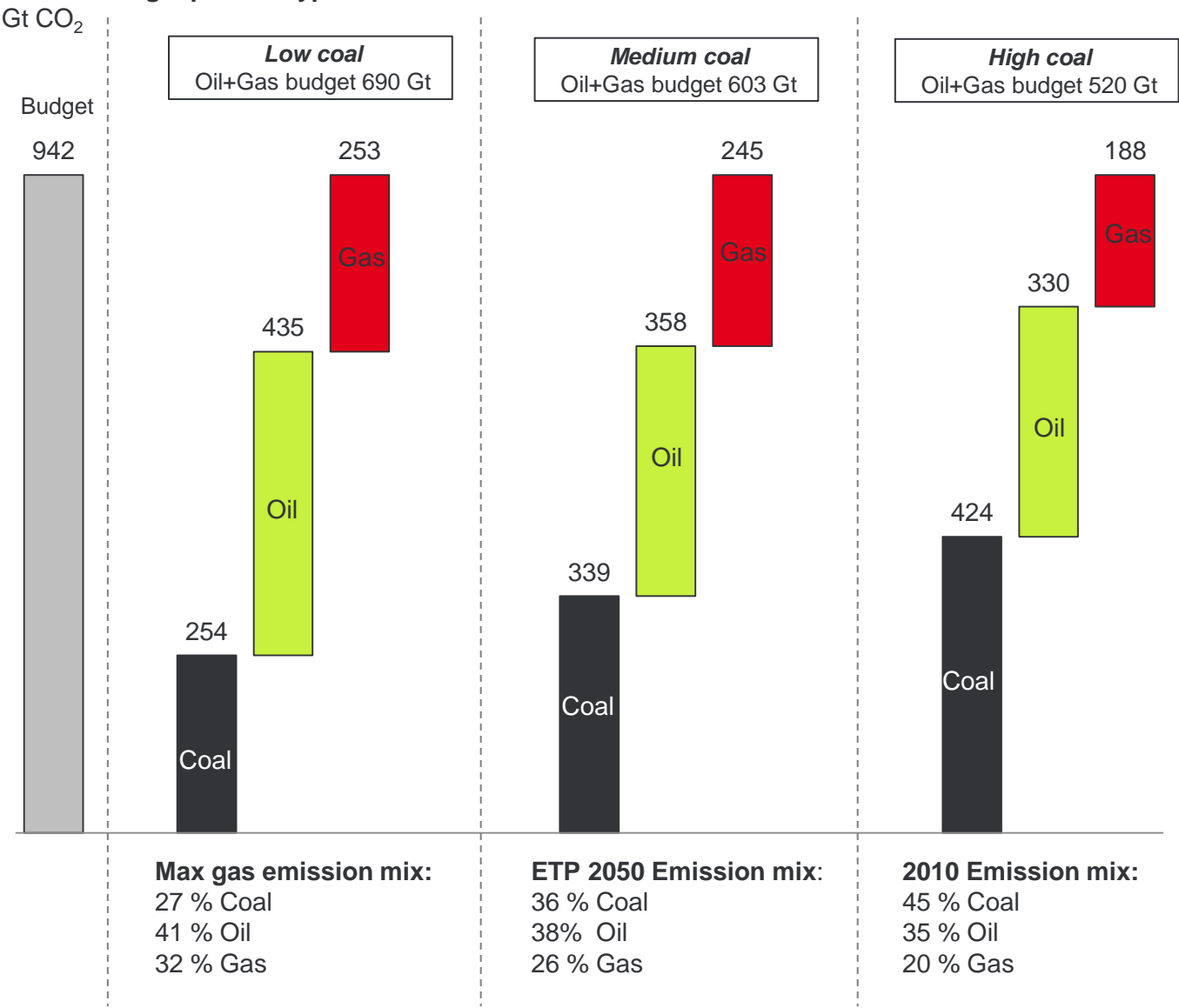
Right chart compares the carbon budget per fuel type for three scenarios for CO₂ emission mix.

The «Medium coal» scenario corresponds to the average emission mix under 2DS and is the case discussed in this study.

The «High coal» scenario corresponds to the current emission mix, while the «Low coal scenario» corresponds to producing all available gas combined with a reduction of coal's emission fraction to 27%.

The carbon budget of hydrocarbons is 30% higher in the low coal case than the high coal case, showing that coal's share of emission mix will heavily impact emission budget of hydrocarbons towards 2050.

Carbon budget per fuel type for three coal-fraction scenarios



Source: Rystad Energy research and analysis

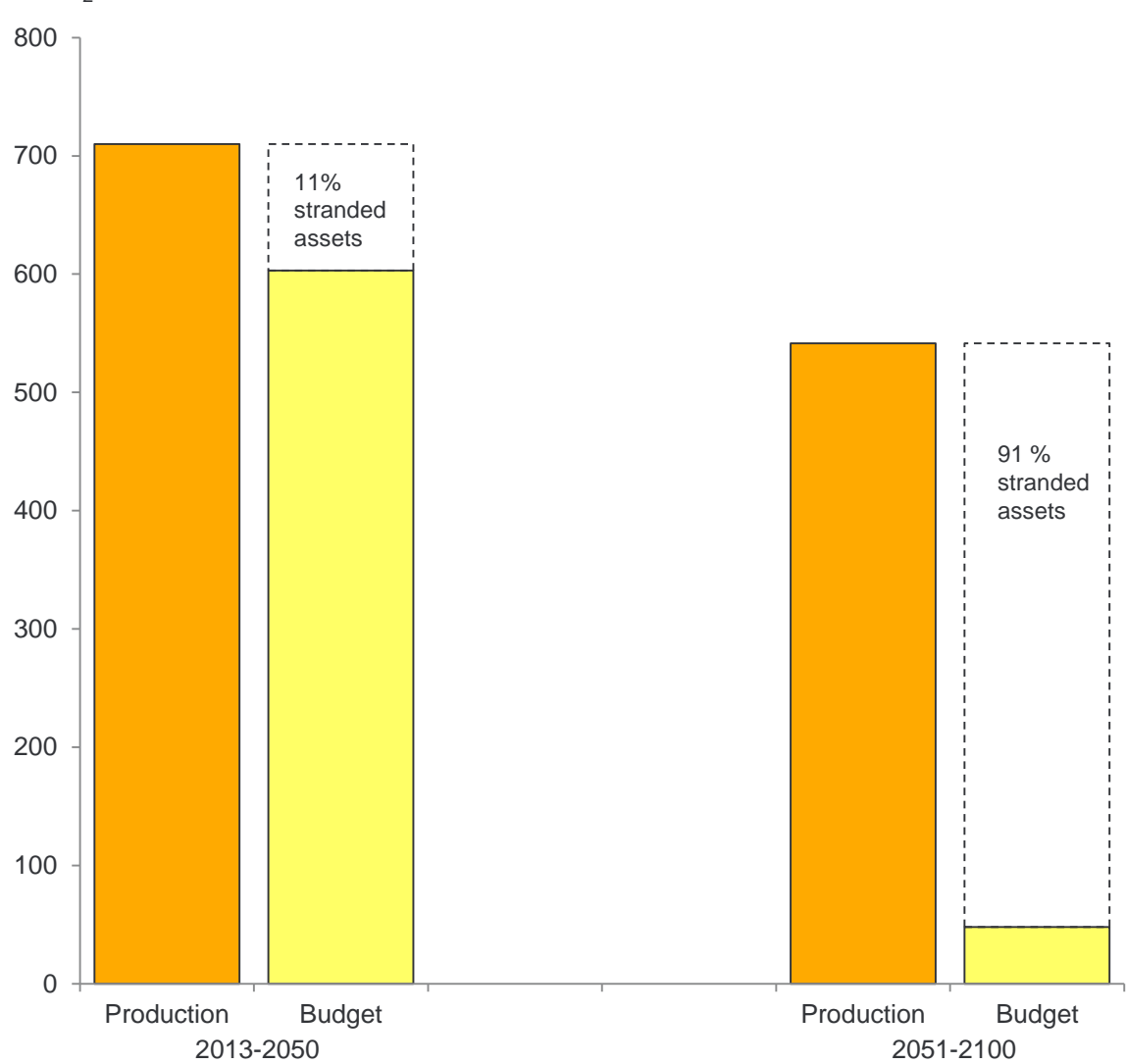
Most stranded oil and gas resources under 2DS are to be produced after 2050

Right chart compares forecasted CO₂ emissions in an unrestricted oil price scenario with the 2DS carbon budget before and after 2050.

CO₂ emissions are aggregated emissions from combustion of each field's production, taking different emission factors of different hydrocarbons into account. Forecasted production from not yet discovered fields is included in this forecast.

Only 11% of forecasted emissions in the unrestricted case are above the carbon budget before 2050. However, the 2DS scenario requires a drop to very low CO₂ emission levels post 2050 while forecasted emissions in the unrestricted case are still significant.

Forecasted unrestricted production compared to 2DS carbon budget before and after 2050
Gt CO₂



*Forecasted production in the unrestricted case, Source: Rystad Energy UCube

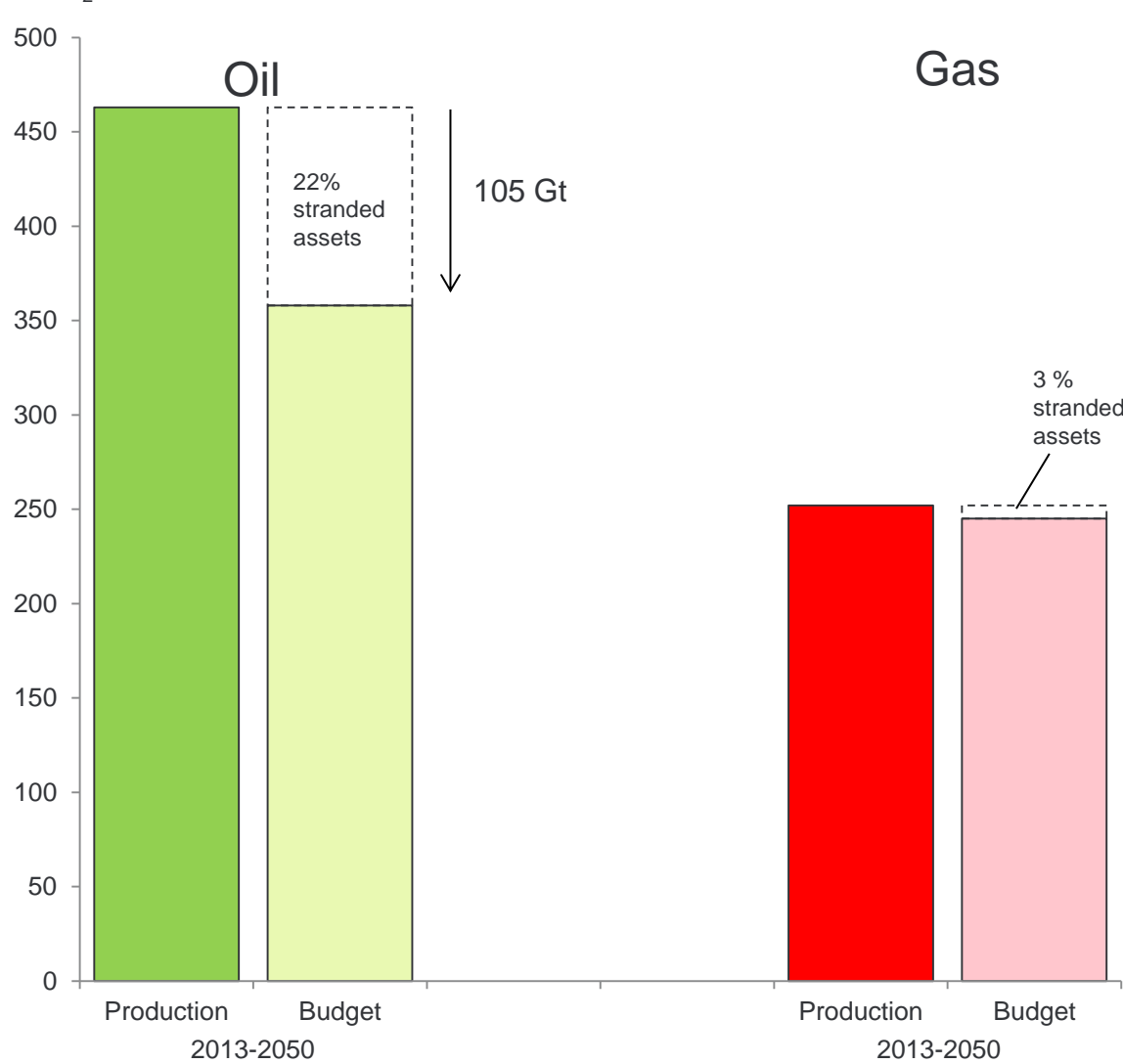
2013-2050: Gas production within carbon budget while around 20%* of the oil is stranded

The right chart compares forecasted CO₂ emissions in an unrestricted oil price scenario with the 2DS carbon budget before 2050 for oil and gas separately, assuming the “medium coal” energy mix scenario.

CO₂ emissions are aggregated emissions from combustion of each field’s production, taking different emission factors of different hydrocarbons into account.

Only 3% of forecasted emissions from produced gas in the unrestricted case are above the carbon budget, while 105 Gt or 22% of emissions from produced oil in the unrestricted case are above the carbon budget.

Forecasted unrestricted production potential compared to 2DS carbon budget before 2050
Gt CO₂



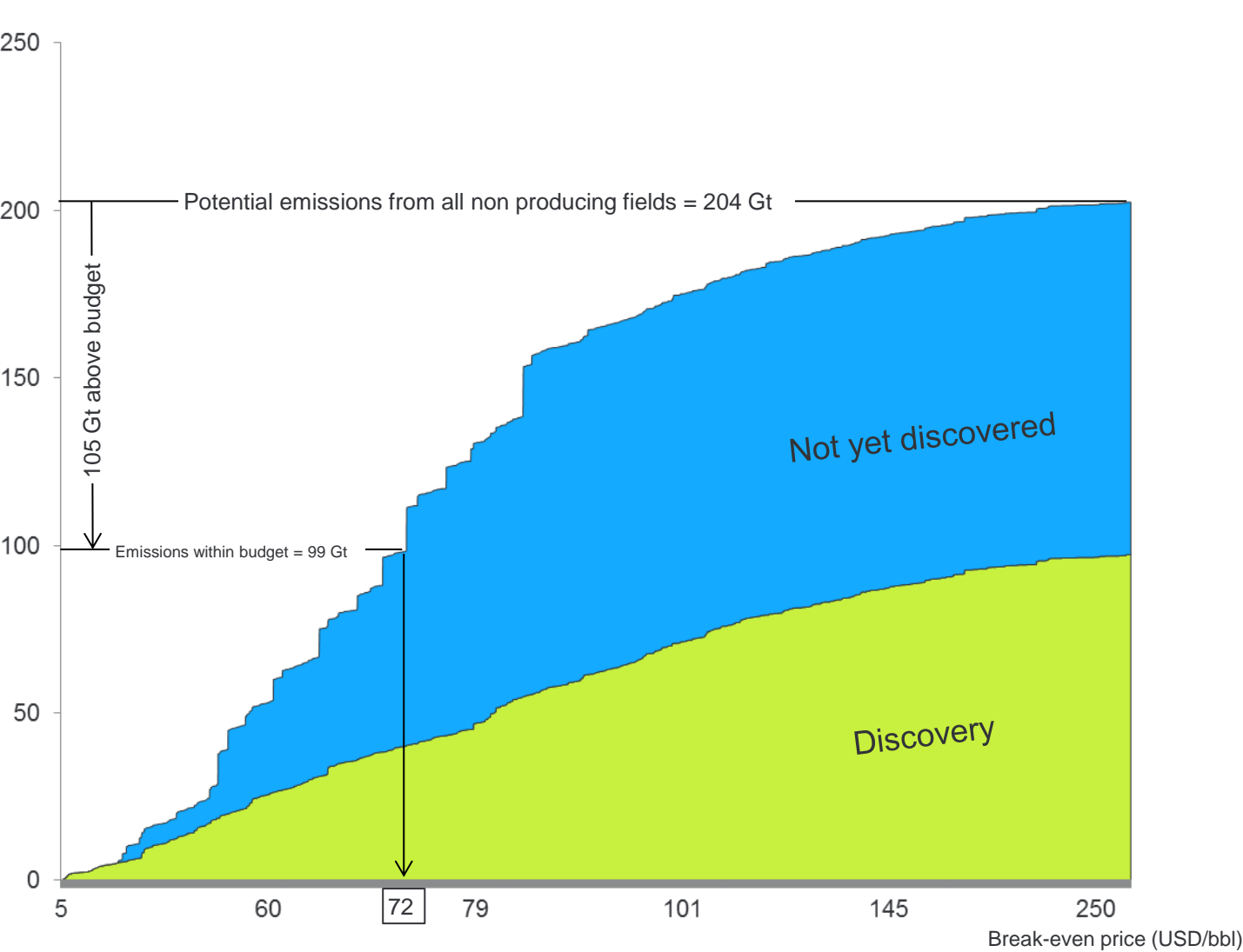
*Measured as emissions of CO₂ from combustion of produced hydrocarbons

Oil price that will “create” a 2DS: 85-90 USD per barrel

The chart shows potential cumulative CO₂ emissions during combustion of production from all currently non-producing fields between 2013 and 2050 split by discovered and not yet discovered fields.

The total 204 Gt potential emissions must be reduced with 105 Gt down to 99 Gt under 2DS, which implies that fields with break-even cost above 72 USD/bbl will not be developed. Adding an assumed 15 USD/bbl in contingency, an estimate of the oil price level under 2DS is around 87 USD/bbl.

Cumulative CO₂ emissions (2013 non producing fields) 2013-2050 versus break-even price

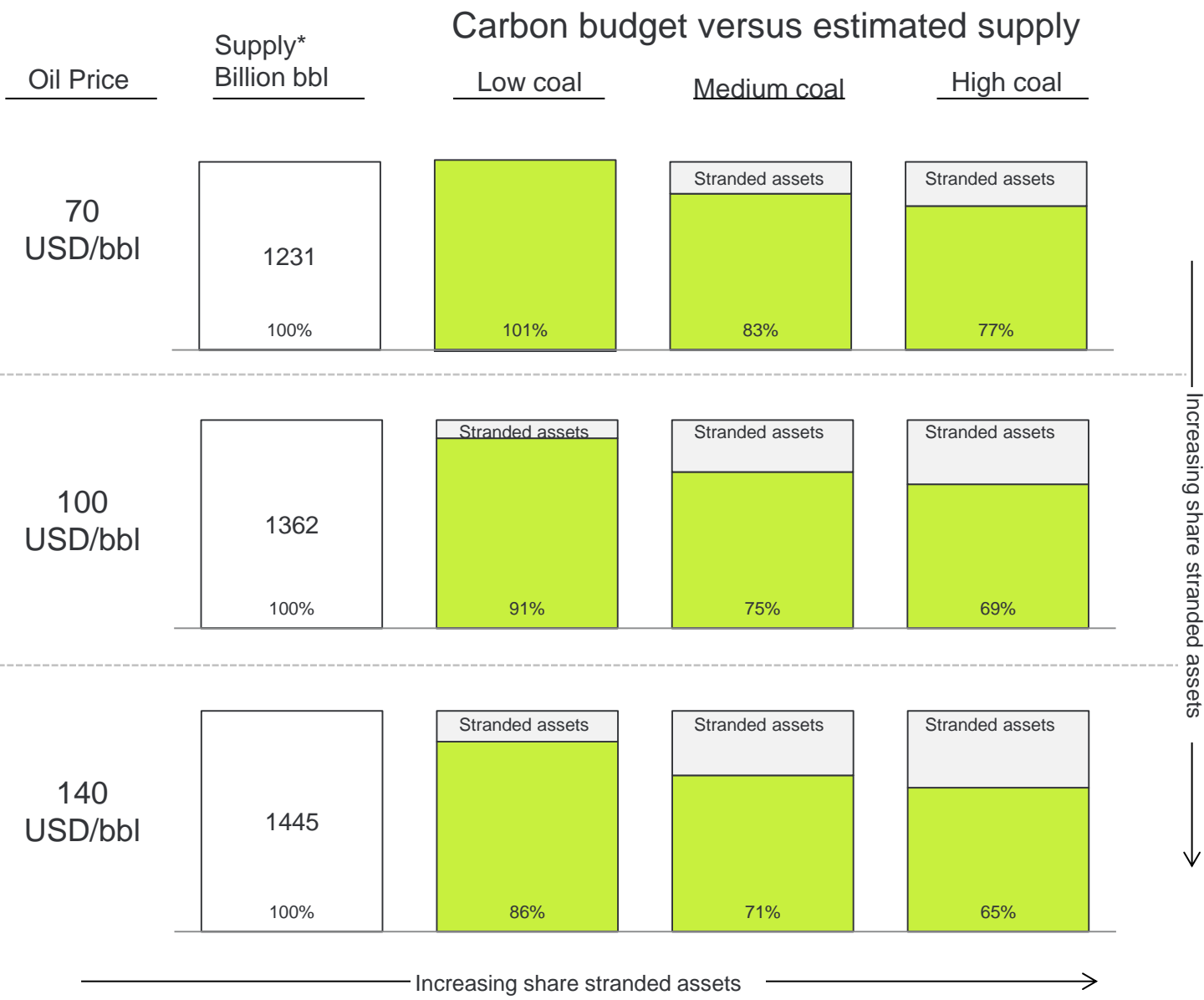


Stranded oil varies from 0-35% of max. supply, depending on oil price level and energy mix

Right table compares forecasted global unrestricted oil production 2013-2050, including resources not yet found, with oil carbon budget under the three coal fraction scenarios at three different oil price scenarios.

The share of production potential that is stranded increases both with increasing coal fraction in the energy mix and with increasing oil price level.

In a low coal and low oil price scenario, forecasted supply of oil is likely to match the carbon budget.



*Source: Rystad Energy UCube

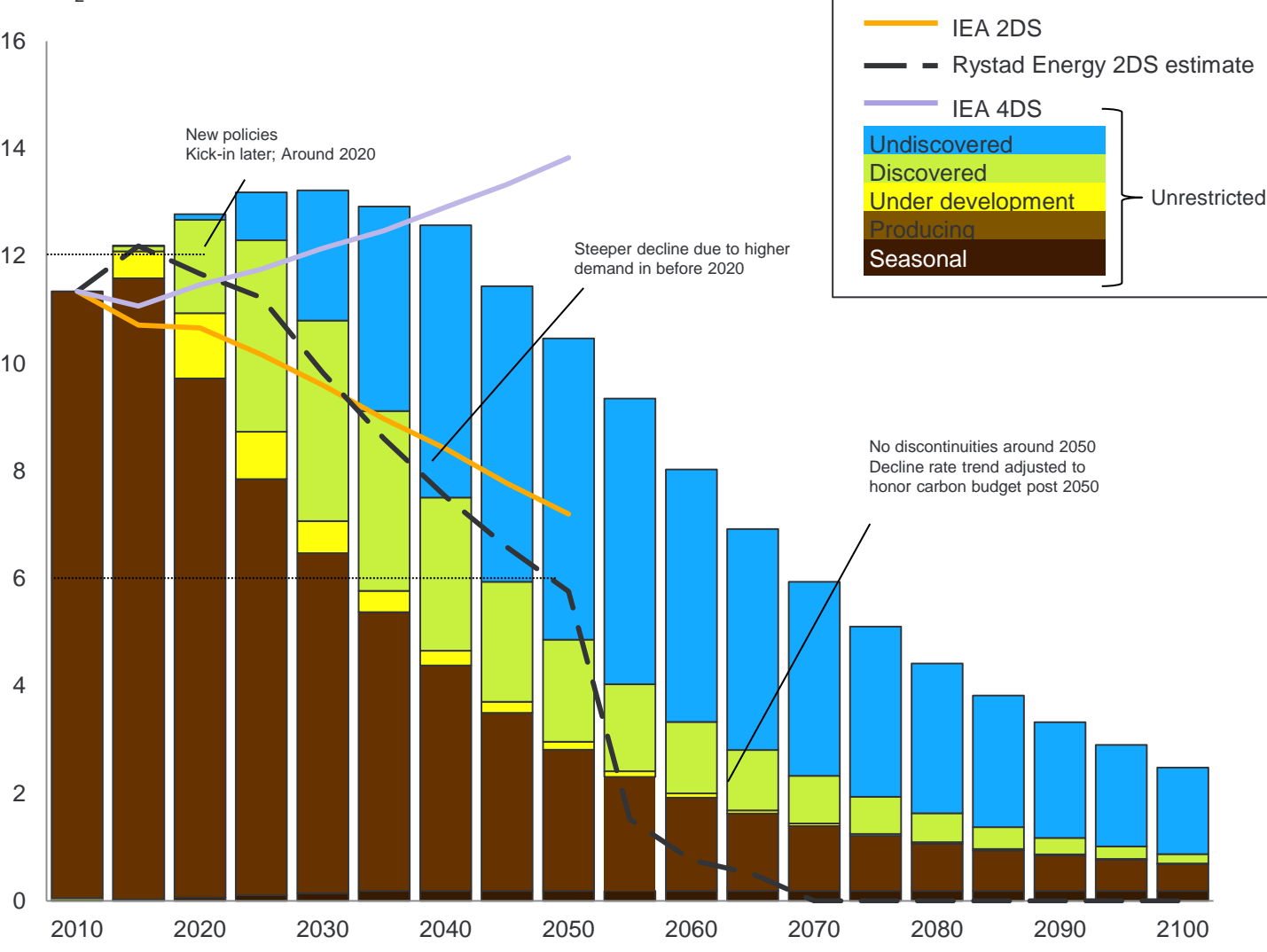
Global oil production to be reduced with 50% between 2020 and 2050 under 2DS

The right chart outlines CO₂ emissions from the global oil production towards 2050 spilt by current life cycle (fields in production, under development, discoveries not yet approved for development and undiscovered.)

The yearly CO₂ emissions are based on 68.000 fields assessed bottom-up by Rystad Energy. The emission factors used are estimated individual for each oil- and gas category, and are calibrated to best match the factors used by the IEA.

Taking into account a likely delay of the effect of new policies until 2020, Rystad Energy suggests a somewhat steeper demand curve than IEA. This curve suggests a necessary reduction of global oil production with 50% from 2020 to 2050 under 2DS.

Demand for oil 2010-2100 under 2DS versus unrestricted production potential
Gt CO₂ emissions



Source: Rystad Energy UCube, Rystad Energy research and analysis, IEA Energy Technology Perspectives 2012

Stranded oil assets under 2DS

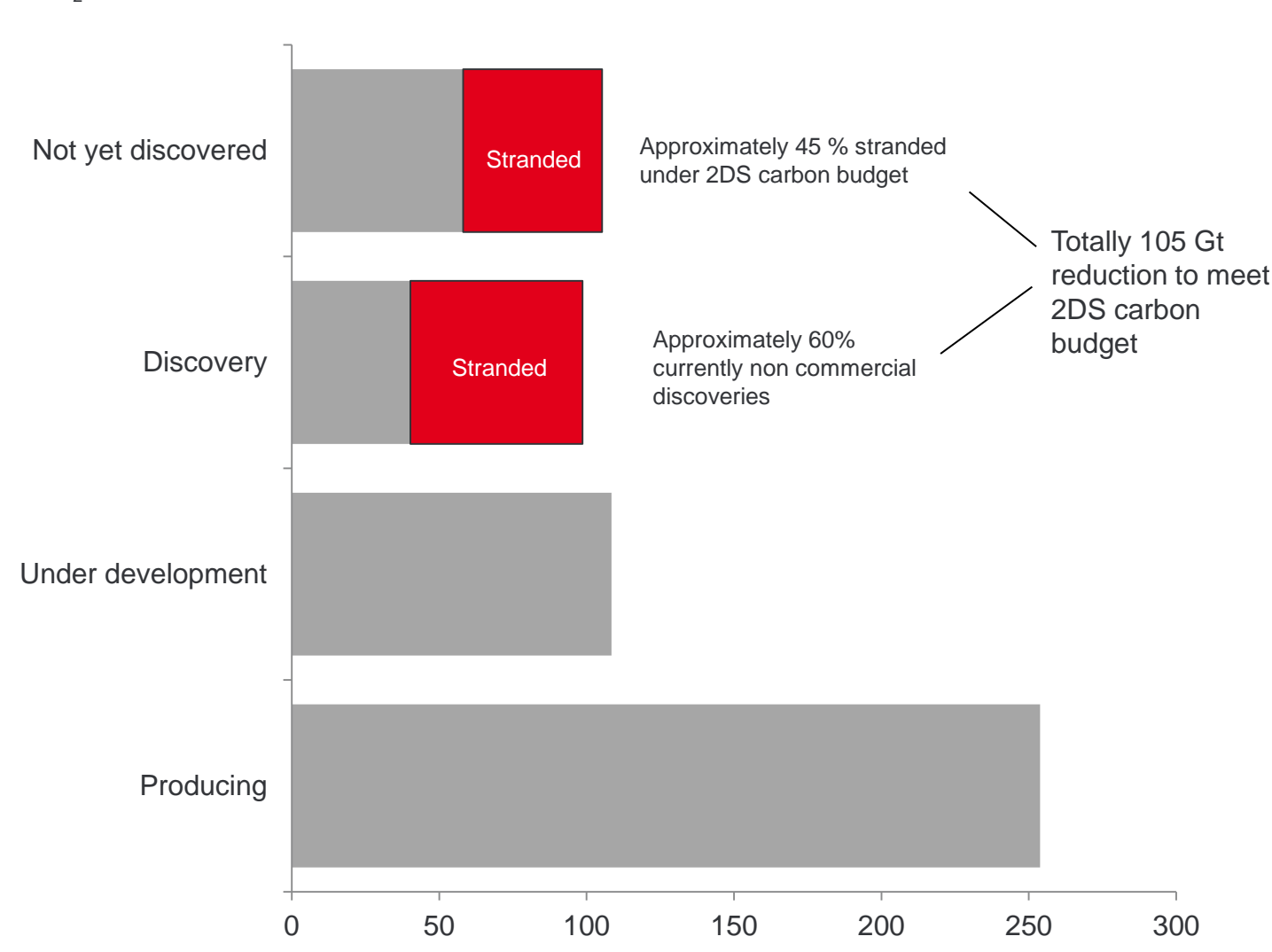
The right chart shows estimated global CO₂ emissions from combustion of produced oil per current life cycle of oil field.

To meet oil carbon budget, emissions must be reduced by 105 Gt. Since this is a relatively low share of total emissions, it makes economic sense that already producing field will continue producing under 2DS.

Furthermore, current non-economical discovered assets are unlikely to be developed under a reduced demand scenario. Potential production from this group of assets represent some 58 Gt.

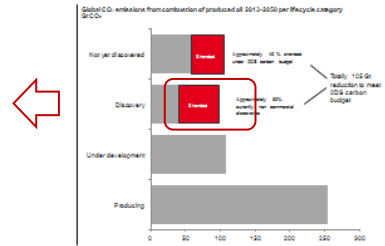
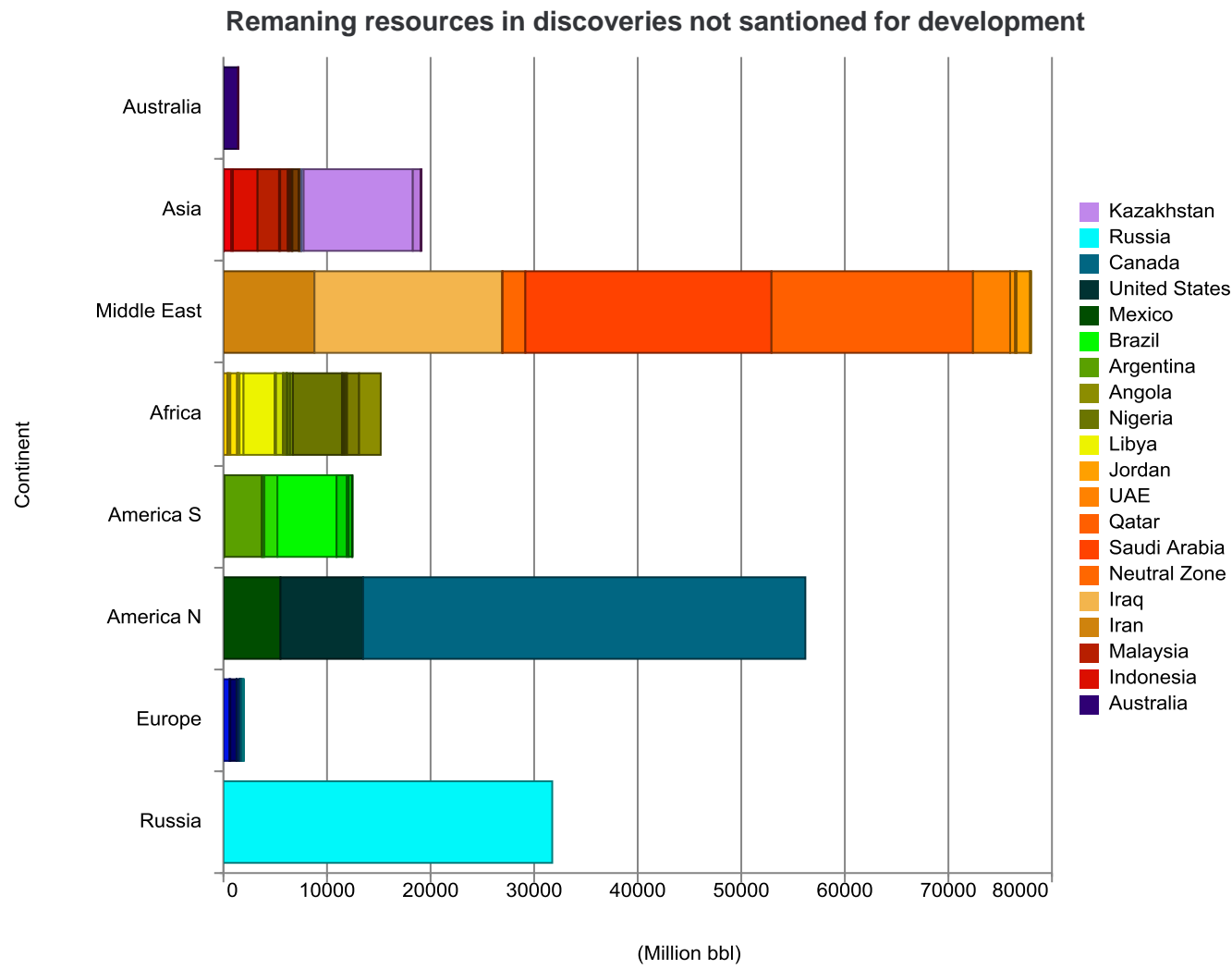
As a result, emissions from assets yet to be found must be reduced by 47 Gt, or 45% of total emissions.

Global CO₂ emissions from combustion of produced oil 2013-2050 per lifecycle category
Gt CO₂



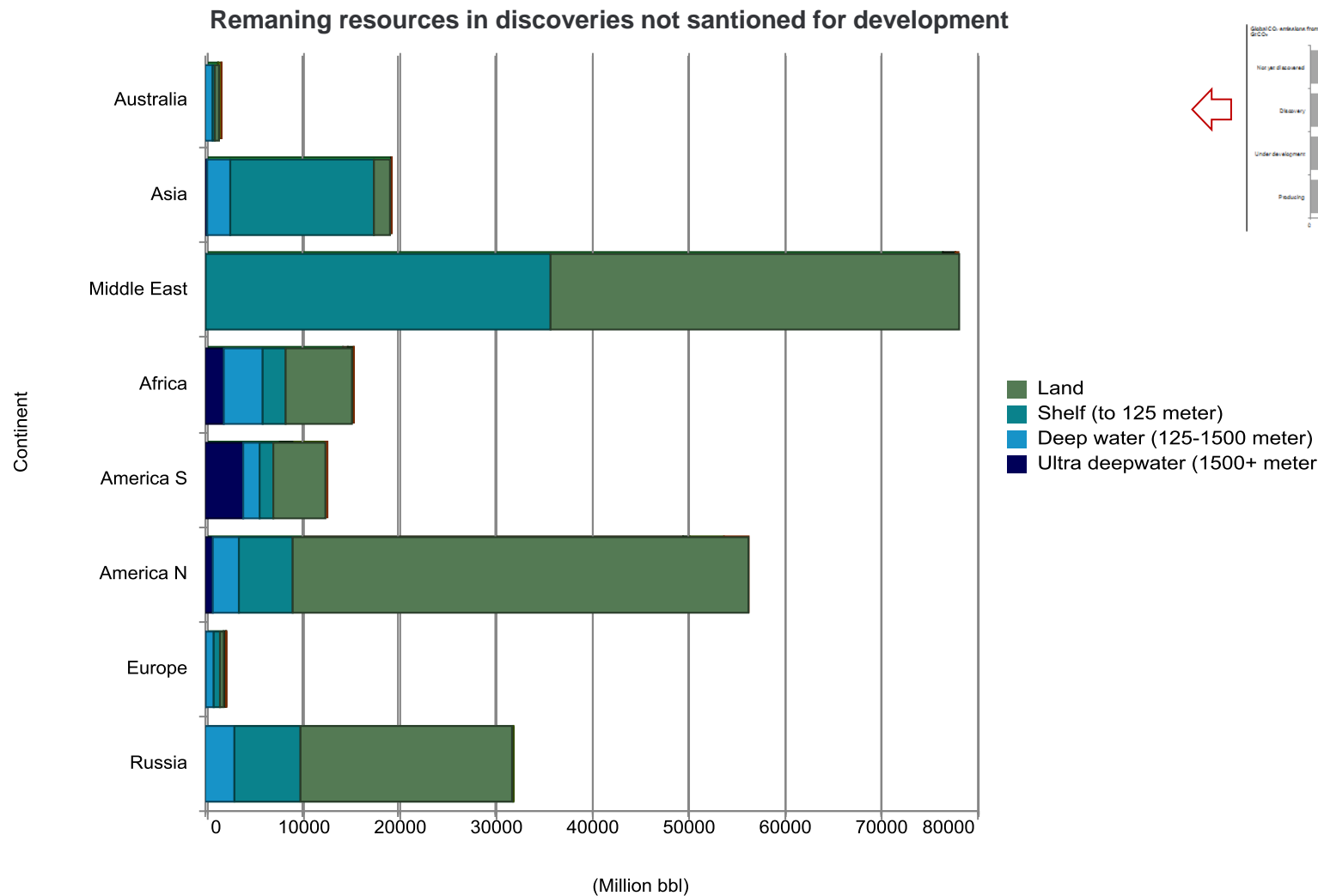
Source: Rystad Energy UCube, Rystad Energy research and analysis

Unsanctioned liquid resources with break even above USD 80, by contient and HC type

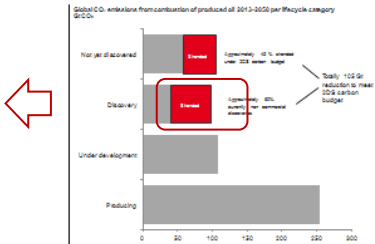


Source: Rystad Energy UCube

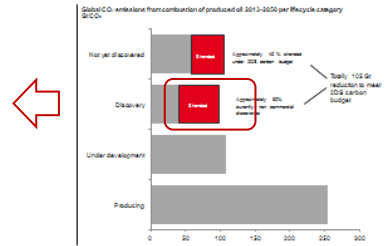
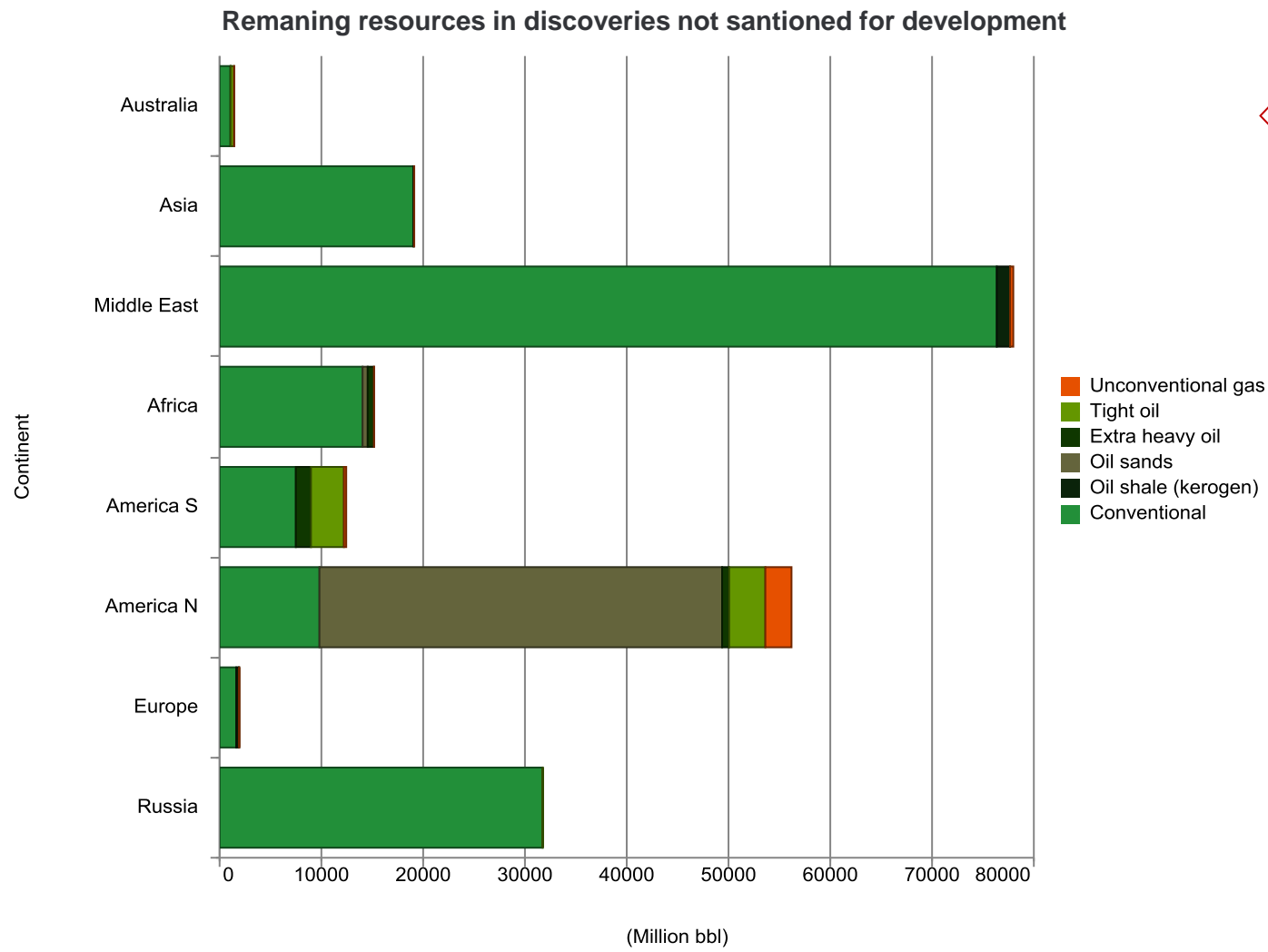
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Source: Rystad Energy UCube

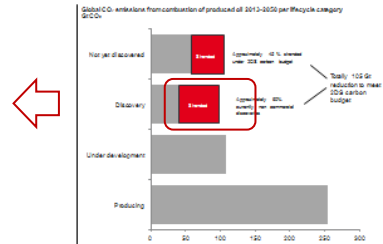
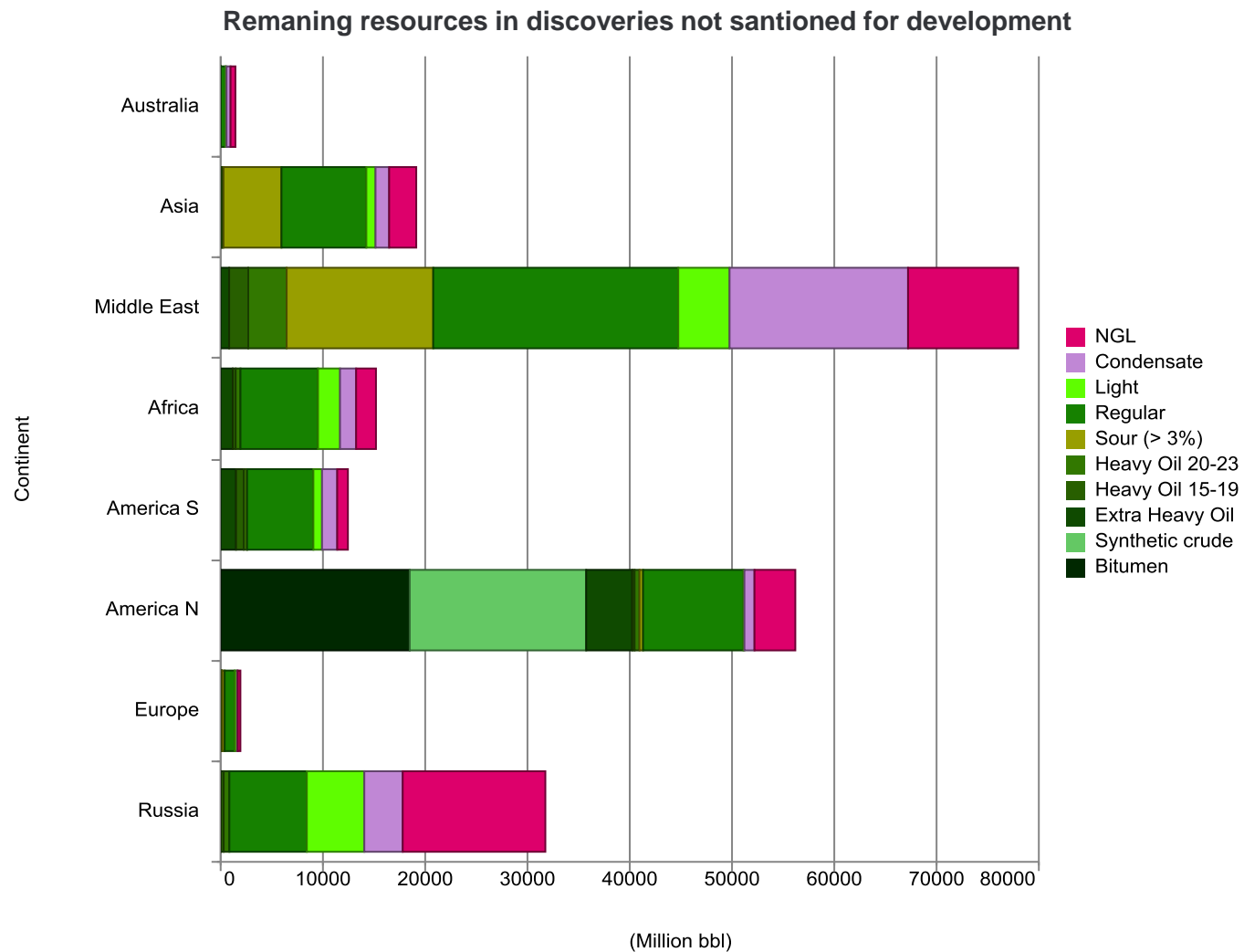


Unsanctioned liquid resources with break even above USD 80, by contient and HC type



Source: Rystad Energy UCube

Unsanctioned liquid resources with break even above USD 80, by contient and HC type



Source: Rystad Energy UCube

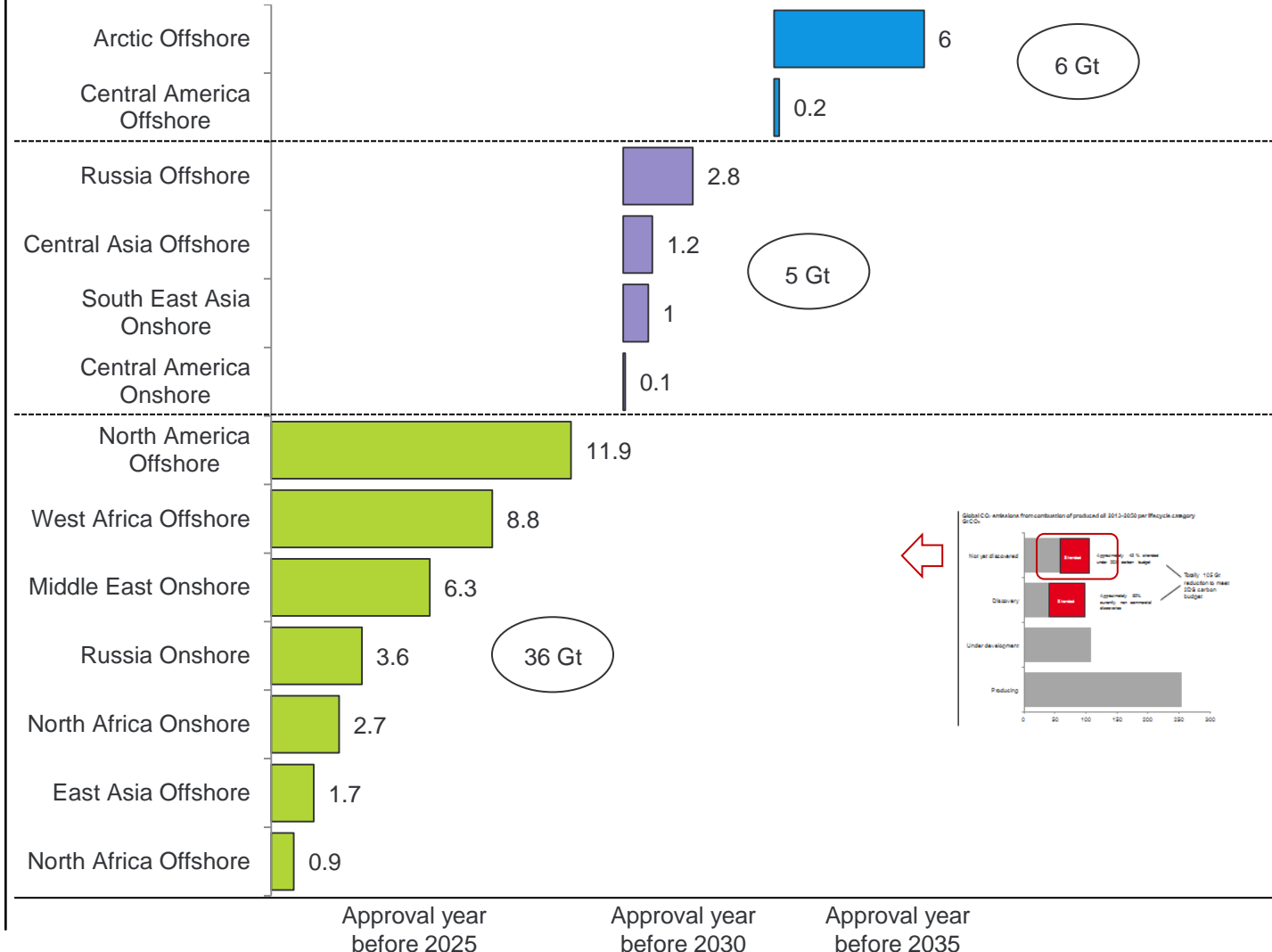
Most stranded undiscovered resources under 2DS are forecasted to be approved for development before 2030 under an unlimited price scenario.

The chart shows which yet to be found areas that are likely to not be developed given the 2DS scenario.

A significant part of stranded undiscovered resources might be approved for development before 2020 in an unrestricted price scenario, implying that exploration and development decisions during the next ten years will impact

The area listed in the right chart will likely see break-even prices for new developments above 70-80 USD/bbl. Taking an assumed 15 USD/bbl in contingency into account, these areas will probably be stranded in a 85-90 USD/bbl oil price regime.

CO₂ emissions from stranded oil resources yet to be found
Gt



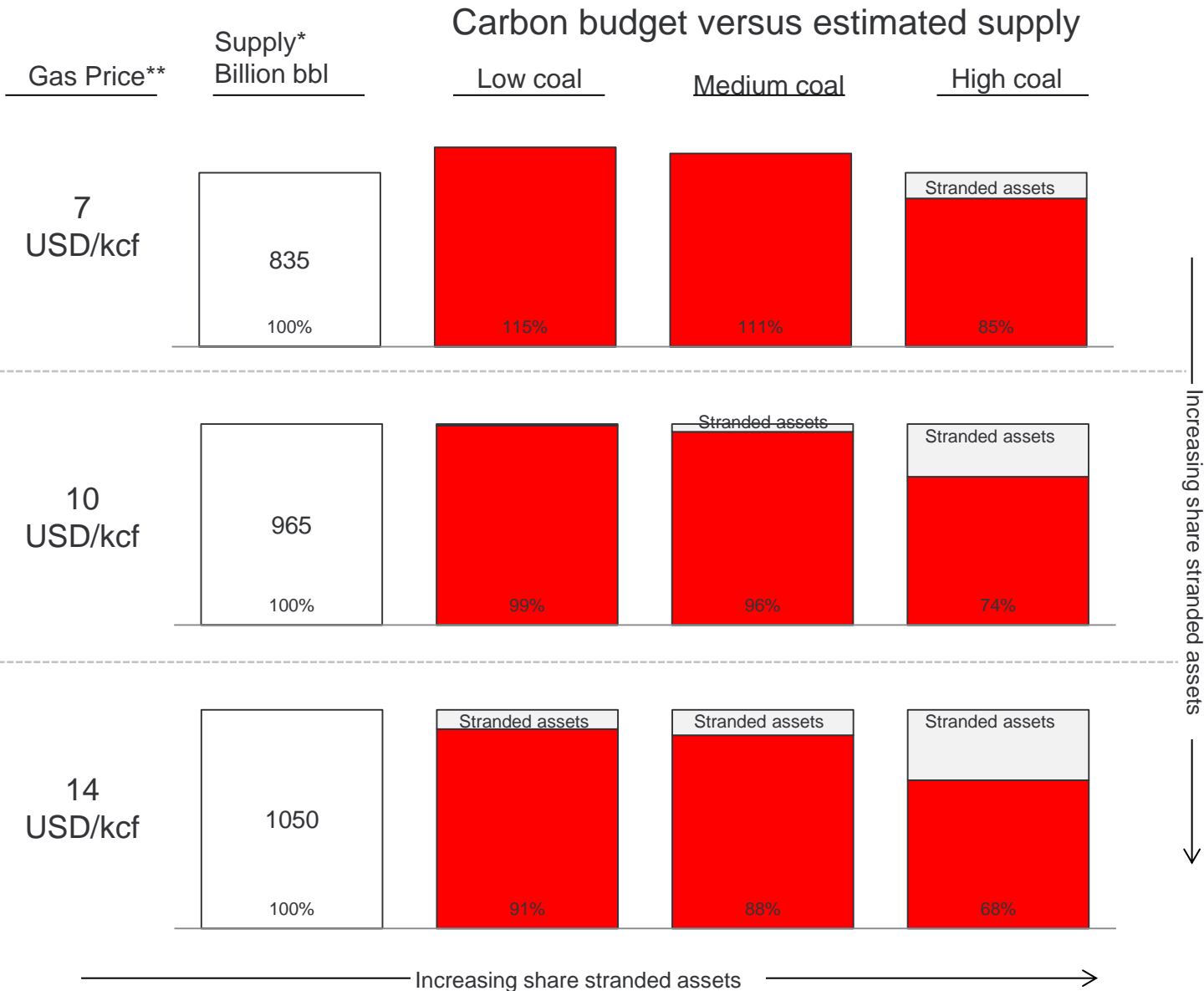
Source: Rystad Energy research and analysis

Stranded gas varies from 0-32% of max. supply, depending on oil price level and energy mix

Right table compares forecasted global unrestricted gas production 2013-2050, including resources not yet found, with gas carbon budget under the three coal fraction scenarios at three different oil price scenarios.

The share of production potential that is stranded increases both with increasing coal fraction in the energy mix and with increasing oil price level.

Significant levels of stranded gas exist most likely only in the high coal or high oil price scenarios.



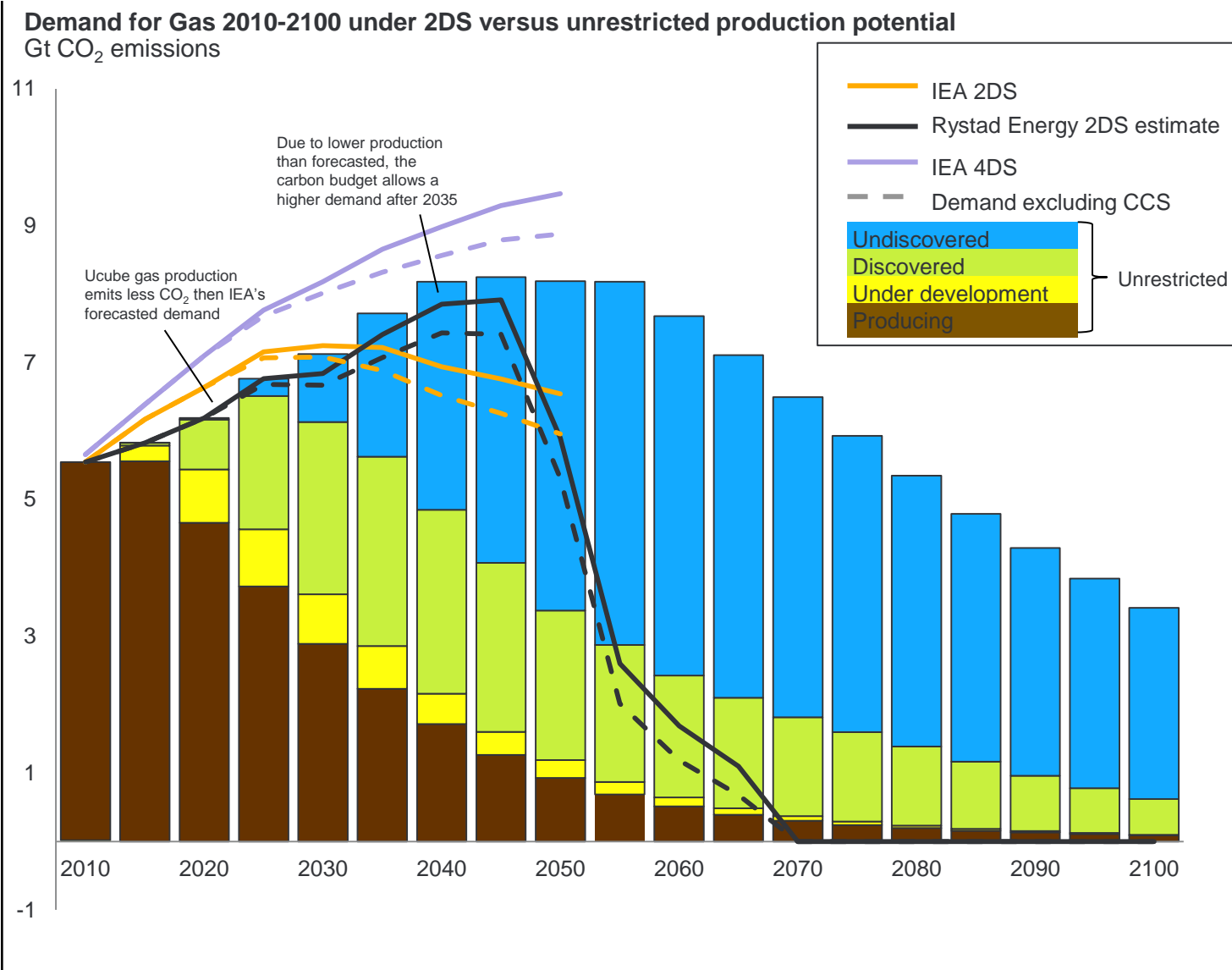
*Source: Rystad Energy Ucube
**Europe continental price estimated to be oil price/10.

The transition from coal to gas may result in tight supply-demand balance for gas before 2035

The right chart outlines CO₂ emissions from the global gas production towards 2050 spilt by current life cycle (fields in production, under development, discoveries not yet approved for development and undiscovered).

The yearly CO₂ emissions are based on 68.000 fields assessed bottom-up by Rystad Energy. The emissions factors used are estimated individual for each oil- and gas category, and are calibrated to best match the factors used by the IEA.

The IEA demand curve illustrates gas demand during transition from the high to medium coal scenario, implying a tight supply/demand balance for gas before 2035.



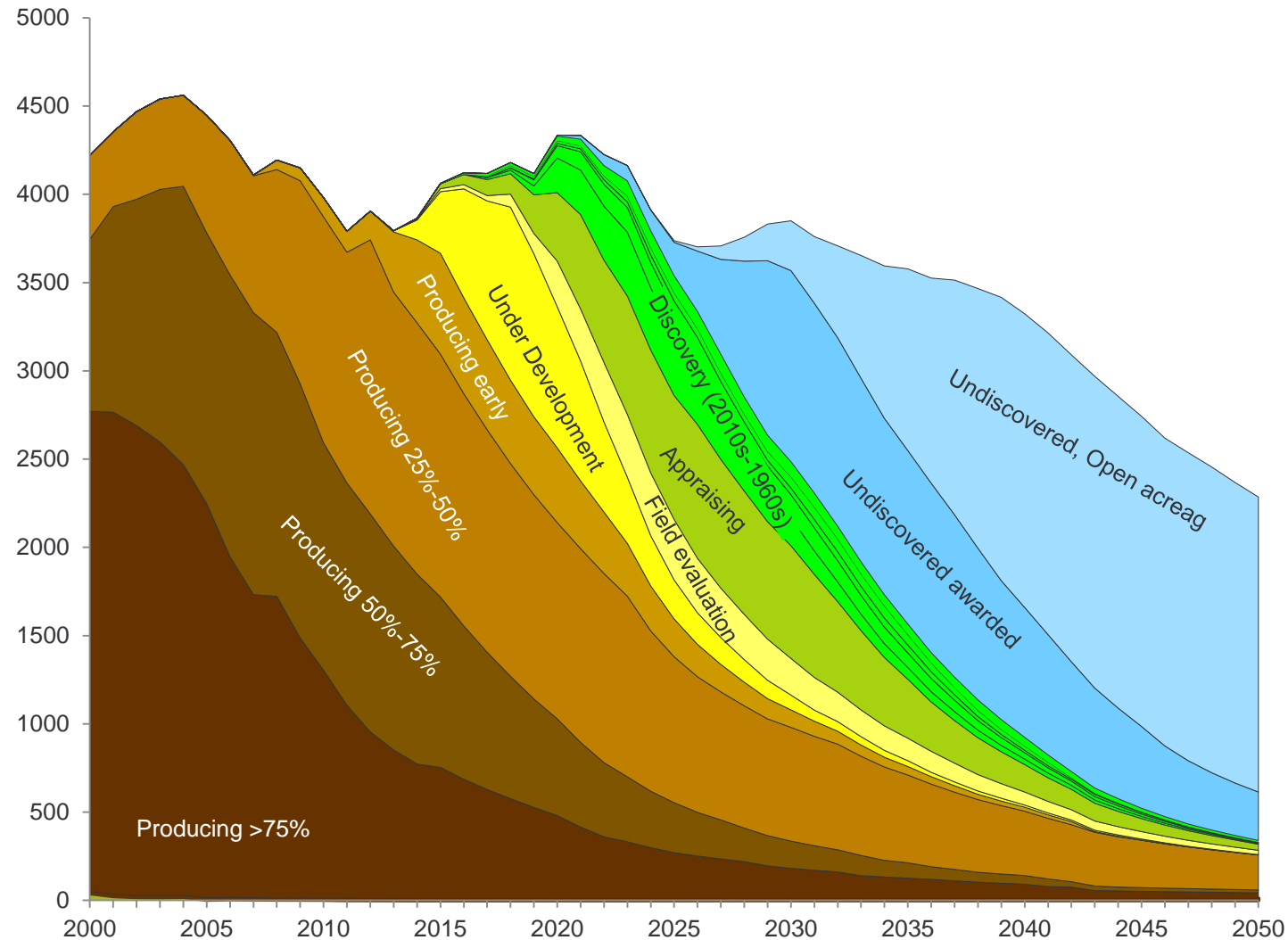
Source: Rystad Energy UCube, Rystad Energy research and analysis, IEA Energy Technology Perspectives 2012

Production from Norway in a unrestricted case with high oil price

This graph shows the production potential from Norway in an unrestricted case, meaning that all fields will be produced, including fields that are currently marginally commercial or clearly uncommercial with current oil and gas prices.

Oil and gas production from Norway – by life cycle

Thousand boe per day



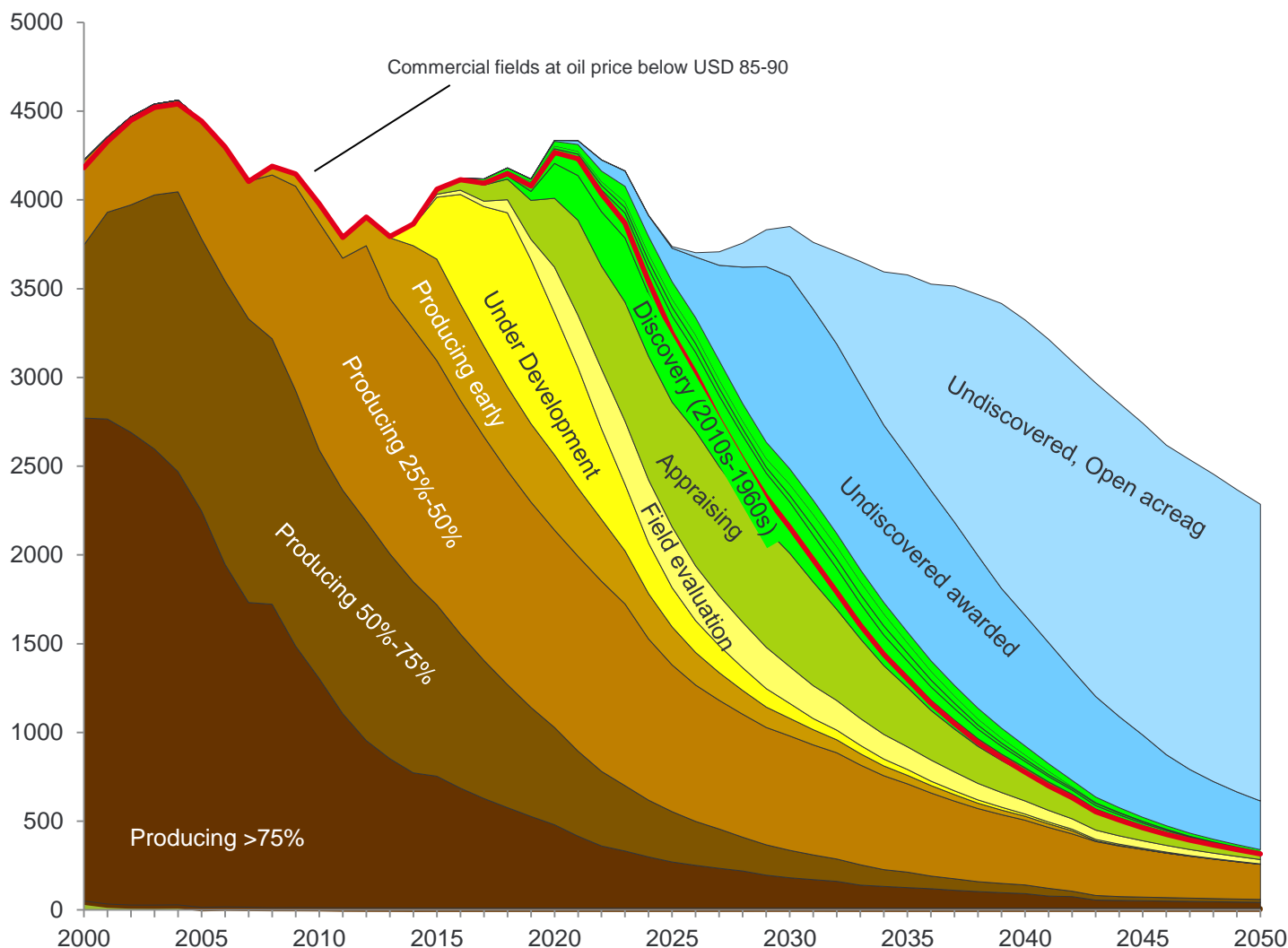
Restricted oil price assumptions results in more non-commercial fields

This graph shows the production potential from Norway in an unrestricted case, meaning that all fields will be produced, including fields that are currently on the borderline to be commercial or clearly uncommercial with current oil and gas prices.

The red line shows the production profile for fields that will be commercial under a restricted oil price assumption.

Oil and gas production from Norway – by life cycle

Thousand boe per day



Potential production from Norway from fields that are not robust for lower prices

This graph shows production from fields not commercial under a regime with weak oil and gas prices in Norway, i.e. a scenario compliant to the current climate ambitions.

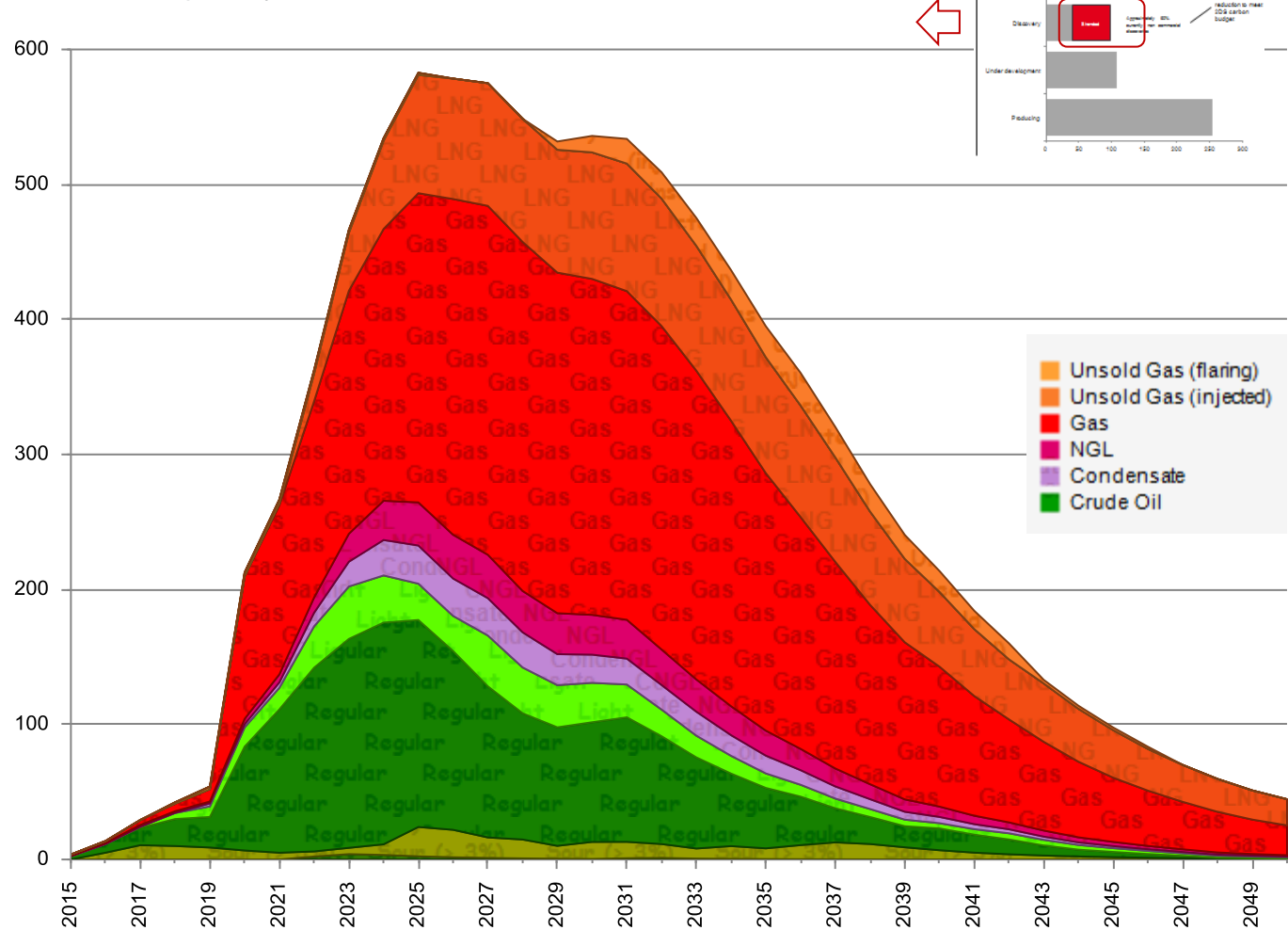
(However, most of the omitted production is gas, which from a climate perspective would be good if it could replace coal.)

As we see, peak production from these fields could be above 500 thousand barrels per day in the 2020s

Total omitted CO₂ emissions are about 1.4 Gt

Potential lost oil and gas production from commercially uncertain fields Norway – by HC type

Thousand boe per day



Potential production from Norway from fields that are not robust for lower prices

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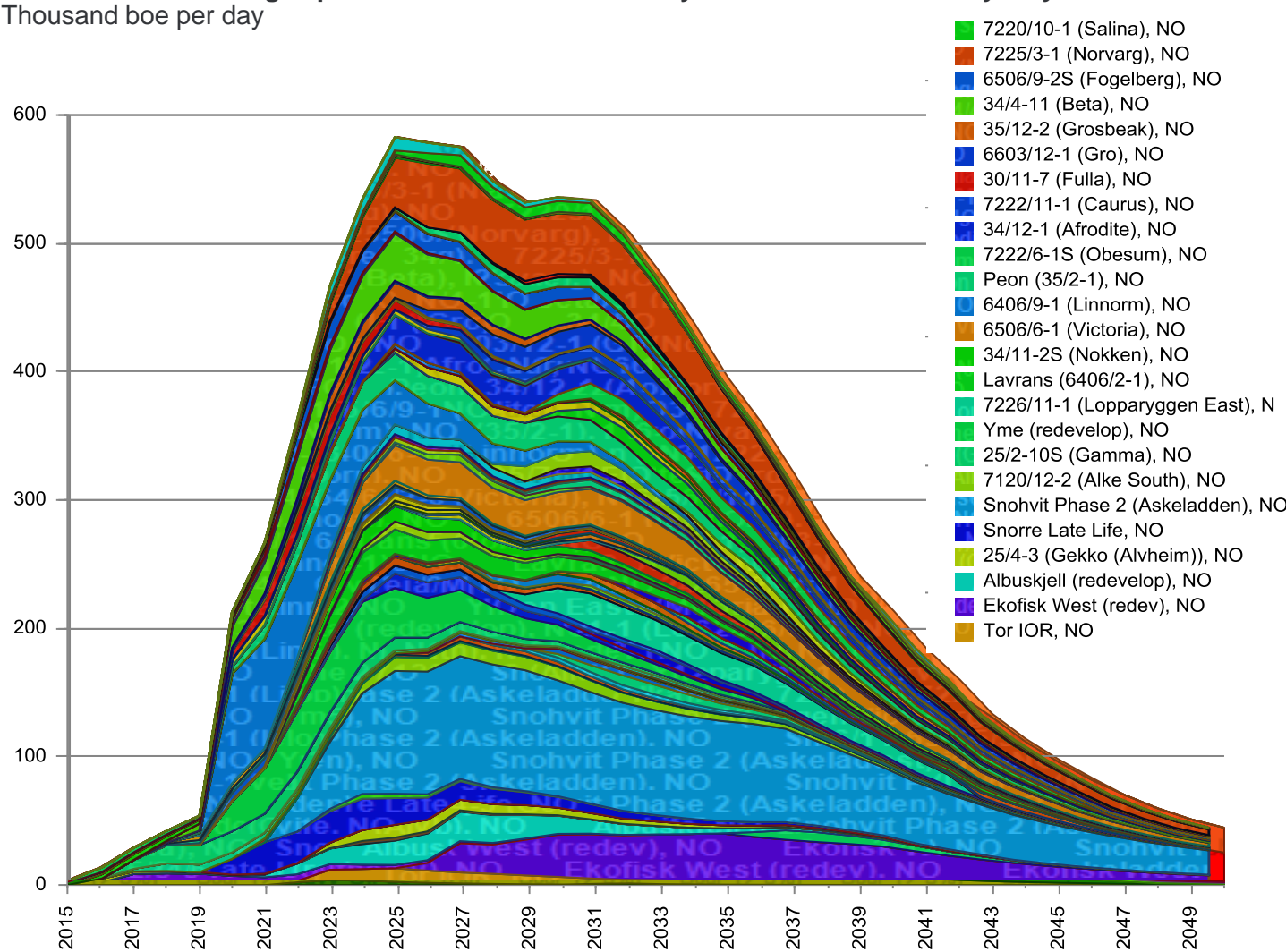
(However, most of the omitted production is gas, which from a climate perspective would be good if it could replace coal.)

As we see, peak production from these fields could be above 500 thousand barrels per day in the 2020s

Total omitted CO₂ emissions are about 1.4 Gt

Here the same production overview field by field

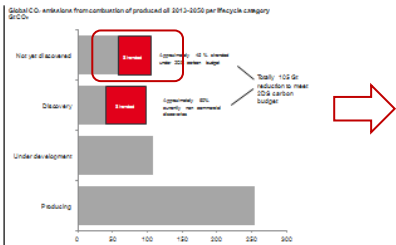
Potential lost oil and gas production from commercially uncertain fields Norway – by field



Globally, 55 percent of undiscovered volumes could be found and produced by 2050 – Example from Norway

This graph shows the production potential from Norway in an unrestricted case, meaning that all fields will be produced, including fields that are currently on the borderline to be commercial or clearly uncommercial with current oil and gas prices.

The red line shows the production profile for fields that will be commercial under an restricted oil price assumption.



Oil and gas production from Norway – by life cycle
Thousand boe per day

