IHS ENERGY

National Energy Strategy Study for Oman

Draft Final Report

May 2015 ihs.com

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Executive Summary

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NESS Draft Final Report: Executive Summary

Diagnostics, Preferred Strategy and Implementation Roadmap.

This document summarizes the key findings and recommendations contained within the National Energy Strategy Study for Oman (NESS) Final Report. The full report presents the work undertaken by IHS Energy on behalf of PAEW and the Ministry of Finance focused on Phase II and Phase III of the Oman NESS Project. This Executive Summary highlights the key conclusions from each section with emphasis on the recommended Preferred Strategy and Implementation.

Oman's Energy Landscape

The study has analysed the current Oman energy sector situation and policies, and has developed models of Oman's energy and macro-economic fundamentals, producing a detailed set of forecasts across Oman's energy landscape.

Current Prognosis

Oman's economy remains fundamentally driven by hydrocarbons, albeit to a lesser extent than other major Gulf producers. Whilst progress has been made in diversification and reducing dependence on oil revenues, economic growth remains strongly linked to upstream production and oil prices. Oman has a track record of rapidly developing energy intensive industry but recent growth has been constrained by gas availability, and questions remain as to the role of energy supply commitments—particularly gas—in further developing Sohar and providing a platform from which al-Duqm can grow.

Prior to 2007, supply was considered to be abundant and gas was allocated on an ad-hoc basis, assuming supplies would remain available and cheap. Industrial commitments were based on contractual allocations of lifetime field reserves rather than defined volumetric terms. The accepted view is that this led to over-commitment of reserves and precipitated a situation whereby offtake commitments and actual production can easily get out of kilter. There are no commercial balancing mechanisms or secondary market in place and as a result, curtailments have been required in periods of gas tightness whilst high margin LNG exports have also been structurally constrained.

The pressures on Oman's gas sector are expected to continue into the near future until new gas from the BP Khazzan field comes on line from 2018. As an interim measure, gas is prioritized to power generation.

Recognising rising upstream production costs, gas pricing has generally been transitioned from a range of low contracted prices to a $3.00/MMBtu price level—a doubling of price to power generation and many other outlets (albeit remaining significantly below international benchmark prices) and some measures have been taken to improve upstream gas usage efficiency.

In contrast, applications for new electricity supply have not been subject to allocation and common access to all tariffs apply, thereby allowing some energy buyers to bypass the gas allocation process (although measures are now in place to restrict growth of very large demands). Grid power demand growth has reached 10% compound annual growth rate (CAGR) over 2006-14, the highest in the GCC, and OPWP now expects 9% annual growth through to 2021. Despite this rapid growth in demand, the power system has been generally effective in maintaining reliable electricity supplies to date (although during tight summer periods the operator has resorted to rental plants). This reflects the success which Oman's IPP programme has had in delivering a competitive process and bringing online new capacity.

End-user electricity tariffs have not increased since at least 2005, creating a growing subsidy burden as costs have risen. Oman's energy subsidy costs in 2014 equated to around 5 % of GDP– with oil product subsidies for transportation and other fuels representing around 75% of the total bill, and electricity subsidies 25%.[1]

Oman boasts attractive renewable solar and wind energy resources but, in contrast to most GCC states, has no renewable energy support scheme and has not set a renewable energy target. However several initiatives are underway, notably RAECO investments in decentralized solar PV and a wind farm in Dhofar and OPWP has earmarked sites for potential large scale solar plant tenders. In addition OETC's 2014 Masterplan includes a 15% (in capacity terms) renewable penetration case in the Main Interconnected System (MIS) and the Salalah System.

Future Context

A range of future energy cases through 2040 have been constructed and modelled within the study. These cases test technical, economic and policy uncertainties against a range of exogenous scenarios encompassing international oil prices, global trade and technology evolution futures as well as tailored Oman and Gulf considerations agreed interactively with the study stakeholders. The value of the scenarios approach is well illustrated by the recent low oil price environment and the uncertainty as to how long the situation will persist. The potential impact of a wide range of oil price futures has been considered within the range of scenarios and cases employed.

Three scenarios have been applied as contexts to test the strategic options for Oman's energy sector. These are based on the well-established IHS global energy scenarios as further developed interactively with Oman stakeholders to address local and regional uncertainties:

Global Redesign – Testing sustained healthy oil prices and global trade

- Sustained upstream activity and resource development under supportive oil prices which remain around $100/bbl real. Robust oil and other commodity exports
- Sustained, steady economic growth in Oman
- Limited diversification away from commodity-based industries and oil and gas industries which remain the primary engine of In-Country Value growth

Metamorphosis – Testing oil price volatility and technology evolution

- Early spike in global oil prices prompting a demand response and investment in green technology, leading to generally weak demand growth and lower oil prices. Focus of the Omani economy shifts from hydrocarbons.
- After a period of hiatus, technology adoption supports internal added value development in industry and services.
- Evolving economic cooperation and energy supply interconnections across the Gulf support intra-regional trade optimization.

Vortex – Testing extended low oil prices and low growth, in the context of another global recession

- Oman is hit hard through reduced oil prices and reduced commodity trade.
- Protracted low growth and lack of investment support for many enhanced oil recovery projects or for energy-intensive industry development, despite later oil price recovery.
- Trade and cooperation barriers impede major economic diversification.

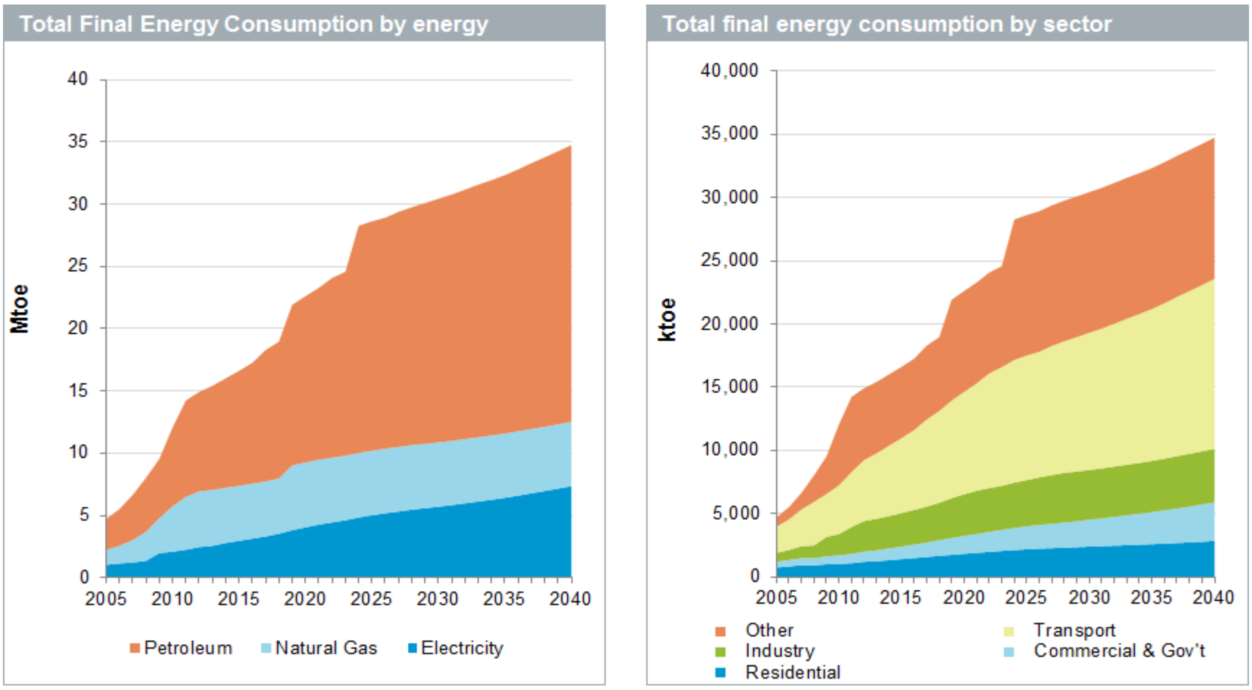
The baseline cases reflect 'business-as-usual' policy and usage of energy. They account for expected developments in indigenous production of oil and gas, a consensus view of Oman's economic development, planned material new energy-consuming projects and evolutionary introductions of new technology and efficiency programs.

Under this baseline, final energy use in Oman is projected to more than double between 2014 and 2040 as shown in Figure 1. Grid-connected electric power demand trebles (around 4.5% p.a. average growth), and industrial final energy demand (including major expansions in feedstock for petrochemicals classified within

[1] Based on actual electricity price support, oil products priced at international market prices and gas costed at weighted average cost of gas production (WACOG) into power generation. Note that other uses of gas including LNG currently return aggregate gas prices above WACOG.

'other') grows somewhat more moderately at 2.5% p.a. Growth rates in transport demand for fuels are 3.4% p.a.

Figure 1: Baseline Projections of Final Energy Use in Oman



The baseline projection for electricity demand growth is lower than that used by OPWP for planning, but will still require additional reliable generation capacity of around 12 GW beyond the 12 GW already in place, under construction or committed, although 4GW of this is to replace expected retirements. Applying the full efficiency improvements that have been proposed in the JICA study conducted in 2012, is estimated to reduce this requirement by up to 5 GW.

A range of cases for oil and gas production have been developed based on international benchmarks, together with projections from the Ministry of Oil and Gas and the main upstream operators, to provide the base for the study. Oil production is a key component of GDP and this in turn is a key driver of electricity and other fuel demand in Oman.

Baseline oil and condensates production is projected to increase through the early part of the next decade as a result of increases in enhanced oil recovery (EOR) projects and improved EOR process efficiency, together with development of conventional discoveries. Further upside may arise from tight oil if this proves economic. Overall, liquids production can remain at or above current levels (950 kbd) for around 10 years under baseline assumptions - implying a more positive view of the future than recent plans. However, depletion of producing reserves is expected to become dominant and the baseline production is expected to fall by over 50% to 450 kbd between 2025 and 2040. The upside case would reduce this rate of overall decline by around a third, but a feasible downside case could see production decline continuously from 2015 towards 250 kbd by the end of the period. Costs are expected to increase as the proportion of EOR grows but the weighted average cost of production grows only from $13 to $16/barrel under the base case. Under the high oil production case, substantial tight oil will be developed but at higher costs. For example, tight oil assumed at $50/bbl would raise the average cost towards $23/bbl under the high case by 2040. All cases assume some ongoing reserves replacement but well below the recent average for replacement of 151%. The base case assumes a reserves replacement ratio of 35% over the period 2015-2040[2], whereas the low case assumes 26% and the upside case

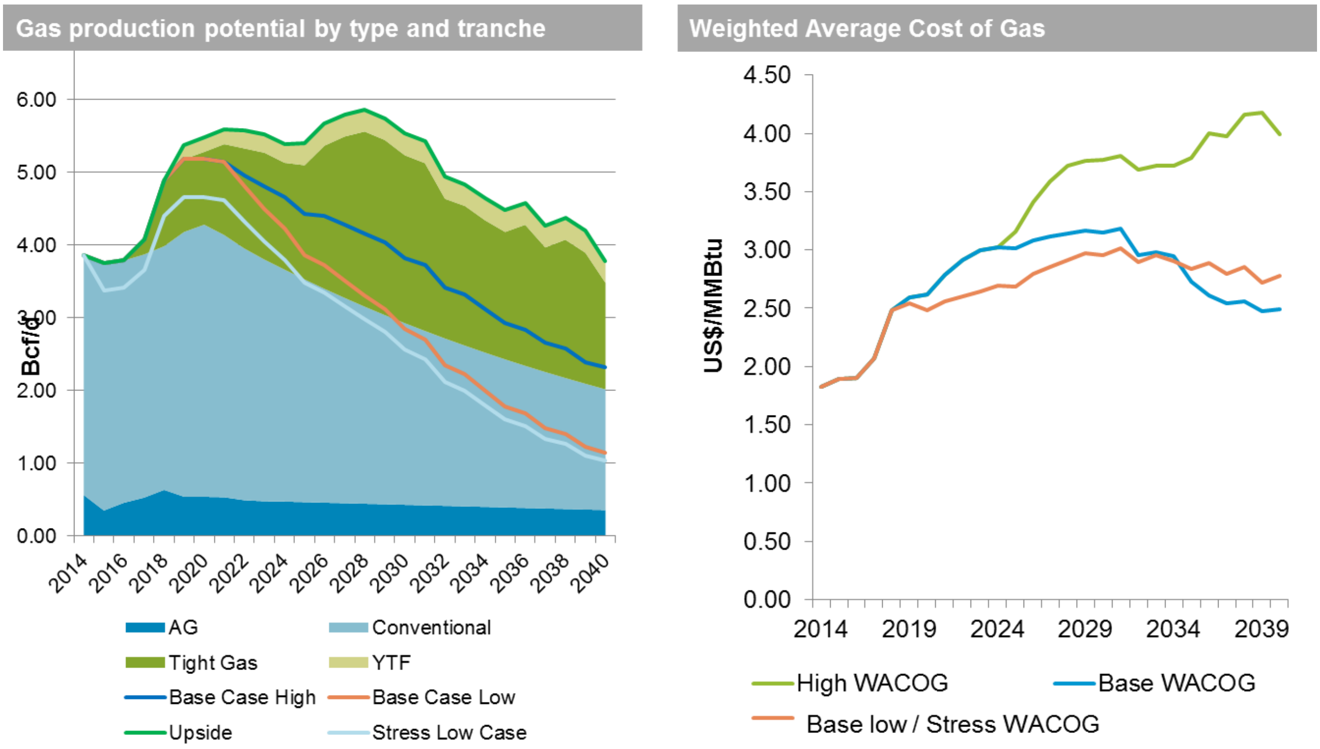
[2] Based on reserves depletion by 2040; securing a further 20 years of continuing but declining production from reserves proven by 2040 would increase the replacement requirements by an additional 20-25% for oil, 15-40% for gas for the stress/low to high cases, respectively.

43%. The low case projections are similar to the single line projection supplied by MOG, whereas the base case tallies more closely with recent statements from Ministry officials.

The outlook for production of natural gas remains highly uncertain but may be more positive than reflected in recent plans. A range of baseline assumptions (high/low) have been developed which include expected new Khazzan production, together with limited tight gas production in PDO, and a range of conventional field developments. Further production upside could come from additional phases of tight gas development in Khazzan, Makarem or elsewhere if these prove economic, and if further conventional discoveries can be developed and made. The lower end of the baseline range assumes that existing producing fields deplete relatively rapidly with limited reserves extension. A stress case has been developed to take into account the risks that existing targets may not be reached and that Khazzan and other new developments may have limited success. The range of reserves replacement[2] to 2040 anticipated varies between 10 % and 46 % across the cases, in contrast to recent levels in excess of 100%[3]. Figure 2 illustrates the range of gas production cases.

The tranches of new gas production entail substantially higher production costs, ramping towards $7/MMBtu for difficult incremental phases of tight gas. The weighted average cost of gas is expected to increase from less than $2/MMBtu currently to above $3 or even above $4 if substantial tight gas is developed.

Figure 2: Gas Production Outlook and Cost Implications



The uncertainty regarding the potential availability of indigenous gas impacts a wide range of considerations within the energy strategy including continued use for new power generation, continuation of LNG production beyond existing contract commitments, and the allocation and pricing of gas for existing and potential new industrial use. In all cases, near term surpluses of potential production are anticipated versus projections of existing usage including power growth, however the scale of these surplus are extremely uncertain and may last from only 5 years to over 20 years. Over the period the aggregate surplus position could be as high as 13 Tcf under the high production case but under a low production environment, shortfalls at the end of the study

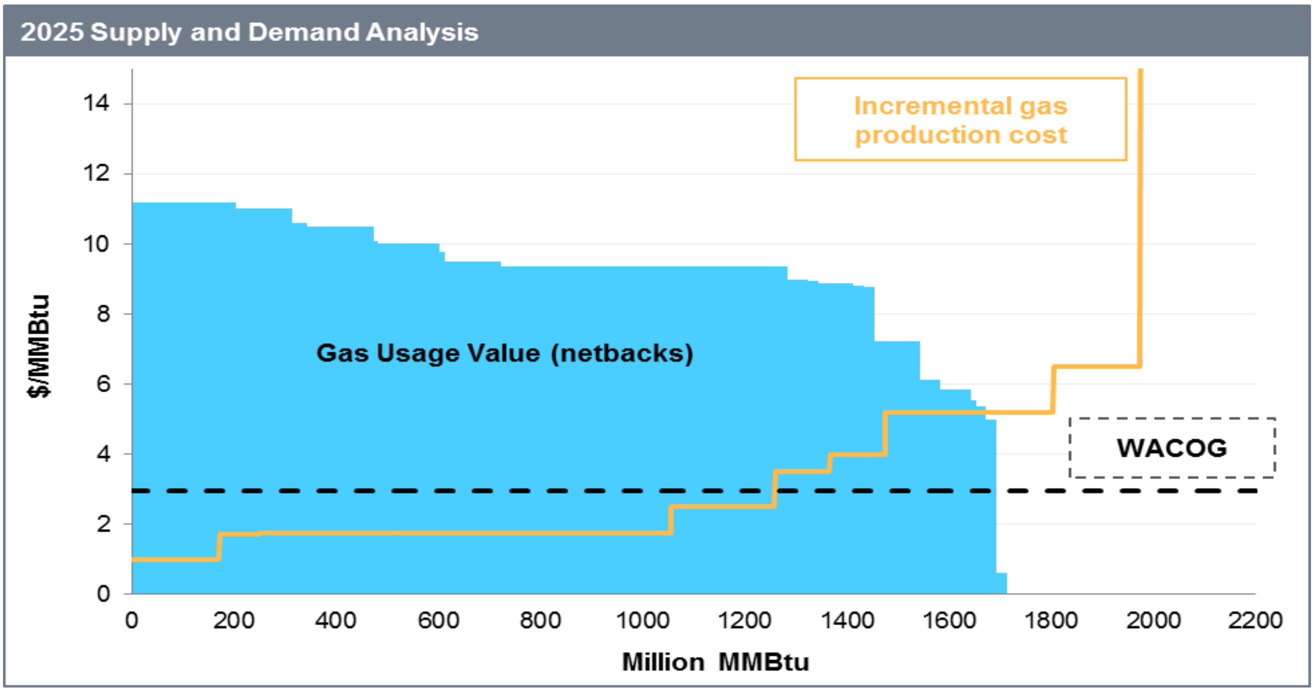
[3] Gas reserves declared by MOG were 24.9 Tcf at end 2013, up 39.8% from 17.8 Tcf in 2012. Excluding the BP additions associated with the commercialization of Khazzan phase 1, other reserves appear to have increased to 18.1 Tcf, implying a gas reserves replacement ratio over 2013 of 122%.

period could exceed near term surpluses. Careful planning of exploitation of near term surpluses is required if sub-economic curtailment is to be avoided in later years.

Many of the energy use decisions depend on the availability, cost and use of gas. The optimal use of energy will depend upon the relative economics of different consuming industries and of gas substitution by other fuels and technologies in areas such as power generation, and indeed the economics of efficiency measures to reduce consumption. The study has developed optimization models for this—examining the optimal usage and value under the range of scenarios, production cases and timeframes considered. Figure 3 illustrates the value versus cost of projected gas deployment for 2025 under the base high case and Global Redesign scenario.

All projected uses of gas are expected to provide a return against the weighted average cost of gas (WACOG) but gas netbacks greater than $5-6/MMBtu are needed to justify utilization of marginal gas production later in the period. It should also be noted that the gas values presented are those based on direct added value only. In addition, the project has produced forecasts of indirect value added from certain key sectors, using a macro-economic input/output model which maps In-Country Value supply chains, downstream linkages and employment effects. From the macroeconomic input/output modeling conducted for the study, it is estimated that the indirect added value (from associated activities) and the induced added value (from consumption associated with employees' spending power) can add up to a further $1-2/MMBtu in realized value for gas in Oman. This additional value applies for the steel, construction materials and derivative petrochemical industries but not for LNG, aluminum and basic chemicals/fertilizers which are largely focused on commodity exports only.

Figure 3: Baseline Gas Supply/Demand Value/Cost Curve Example.



Developing a Preferred Strategy

NESS adopted a sequential process for developing an Optimal Strategy. The starting point was to agree upon a defined vision and set of objectives for the country's energy future. This informed the strategic choices and options which can be addressed by policy-makers. The list of options was then prioritized and rationalized, and selected options tested against the forecasts and diagnostics developed in the study. Lastly, trade-offs between the policy options were identified and critical decision interactions established. The resultant Preferred Strategy thus forms the basis for an energy roadmap: a clear set of implementation actions, policy definitions and accompanying timeline for when decisions must be taken.

National Energy Vision & Priorities

In order to make these choices, the overriding objectives for the role of energy and the energy sector activities within Oman's national vision has been defined and prioritized in conjunction with the Steering Committee and other relevant stakeholders. NESS assumes that the energy sector is to be managed in order to support the future security and prosperity of Oman and its nationals, with the core objectives for the Oman energy sector focused around:

- Encouraging effective exploitation of Oman's hydrocarbon resources
- Providing a foundation of economic value for Oman while supporting economic-diversification away from hydrocarbon-linked activity
- Encouraging long term energy value-chain development (beyond energy-intensive export industries)
- Promoting indigenous job creation and Omanization of the labour force
- Providing fuels with sufficient security of supply and competitive pricing versus competing economies
- Enabling an efficient allocation of resources, and removing obstructive pricing and other distortions
- Promoting a sustainable future, including a reduction in greenhouse gas emissions

These objectives provide a crucial steer in terms of producing a list of potential areas which NESS should focus on and overall policy objectives. For example, the list implies that the upstream industry will be expected to seek to sustain production—especially of oil—for as long as is feasible; that energy industries will continue to take the lead in developing In-Country-Value, and that the full economic value of use of energy (direct, indirect and induced added value) in industry should be recognized in the optimization of energy use. Also, to the extent that current subsidies for oil products and electric power are undermining the efficient use of energy, and impacting the efficient use of government funds, these mechanisms need to be reviewed.

Strategic Options

The Strategic Options are areas in which policy and strategy choices will significantly shape Oman's future energy profile, impact on Omani economic development and progress the objectives noted above. They are specific but high level recommendations. Following the direction set by the NESS Steering Committee, 5+1 Strategic Options have been prioritized for analysis:

- Managing gas supply/demand uncertainty and the need for diversifying the generation mix
- Optimizing energy supply
- Promoting renewable energy in Oman
- Energy price & subsidy reform
- Promoting competitive refining
- (Promoting energy efficiency)

Energy efficiency is recognized by NESS and the Steering Committee as critical to both Oman's national energy strategy and to the analysis contained in this project. However given the recent in-depth study into the topic conducted by JICA, it was recommended that NESS focus its resources on the other five Strategic Options. Conclusions from the JICA study on energy efficiency have been incorporated into the analysis to reflect this, recognizing the core importance of policy in this area but no additional recommendations will be made by NESS.

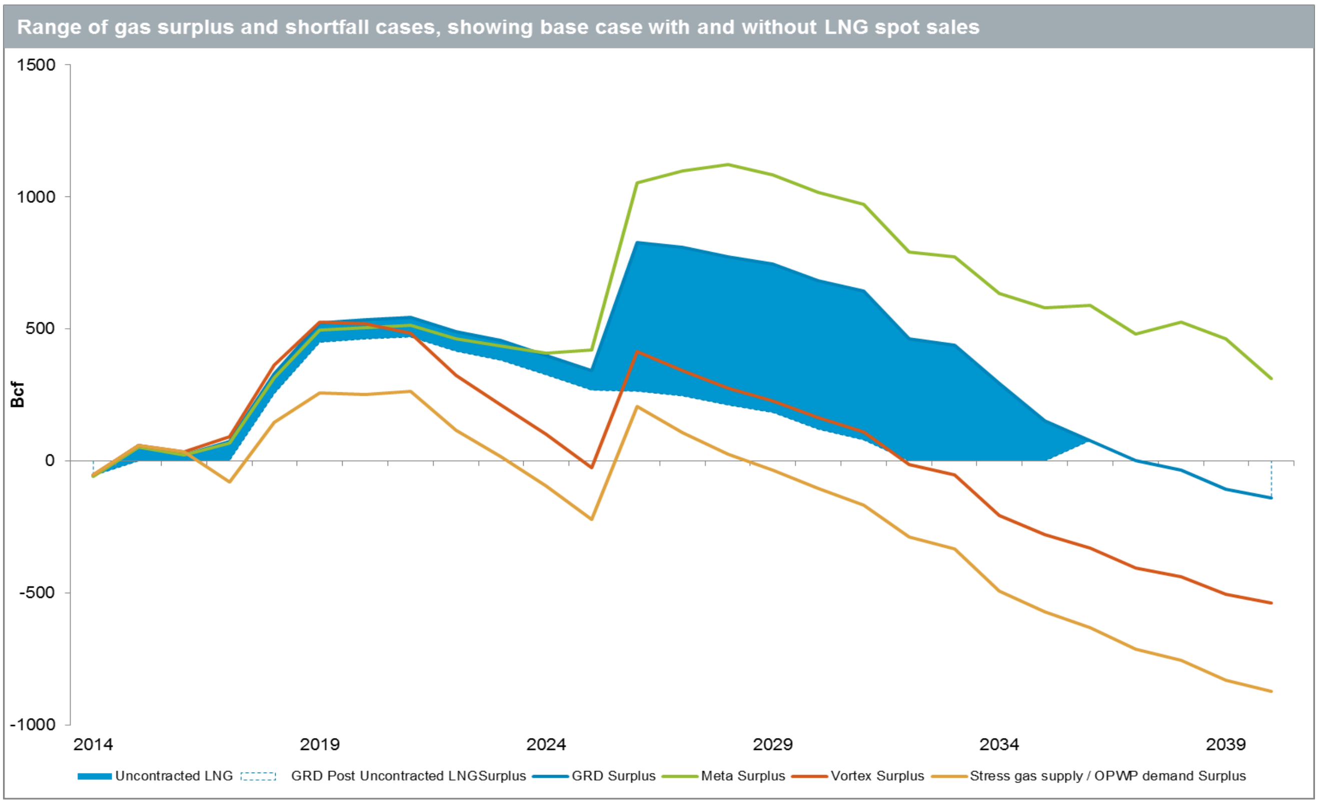
Strategic Recommendations

1. Managing gas supply/demand uncertainty and the need for power diversification

Oman should plan to be able to manage the implications of future gas production uncertainty and put in place a basis to optimize the value of future surpluses or prepare with minimum regret to offset any implications of low production; if needed any major commitment to diversify power generation can be delayed until 2020, but preparations should be advanced.

Under many of the scenarios tested Oman will likely enjoy a mid-term surplus of gas from 2018 onwards beyond the needs of existing off-takers, allowing for continued deployment of gas-fired generation in the near term, alongside limited renewable penetration. The NESS base case projects lower gas demand into power and higher net production than has been assumed for established projections of future Oman gas balances. However the risk of lower than expected production must be continuously monitored. The potential gas surplus under the high base production case could be equivalent to 8 Tcf and up to 13 Tcf under upside assumptions, as shown in Figure 4. The sensitivity analysis using the upside electricity demand and stress production cases implies that surpluses can still realistically be expected to last until around at least 2028 under all cases, although only under the base high or upside case would they support the ongoing production of LNG beyond the expiry of existing export contracts in 2025.

Figure 4: Surplus Gas and Shortfall Cases with Base Case LNG Spot Sales.



Note: Cases shown are for:

- *Global Redesign demand projections associated with the Base gas production case*
- *Metamorphosis demand associated with upside/high gas production case, and*
- *Vortex demand associated with the Base Low gas production case.*
- *OPWP 2013 long term power demand gas case (basis of recent gas balance forecasts) with the Stress gas production case*

The blue shaded area shows the impact of extending LNG production beyond 2025 for the Global Redesign/Base production case.

It will be important to establish clearer expectations for potential surpluses as soon as realistically possible. The size and length of the surplus should be assessed over time based on an improved understanding of upstream developments, in particular the actual performance of the Khazzan field versus plan (both test results from the first wells being drilled in 2015, and actual production performance from end 2017 onwards). At the same time the projections for electricity demand and the needs for gas-fired generation should be kept under review, taking into account factors expected GDP drivers, efficiency gains (use and generation) and penetration of renewables. By 2020 these assessments should enable a much more certain view to be taken as to the surplus or shortage of gas availability beyond 2030, and to allow Oman to take decisions regarding the need for diversification of generation away from gas, for the continuation of LNG production beyond the current contractual commitments, or for new additional gas allocations to new power plants and new industries and for extensions of existing supply arrangements.

The expected surpluses through to at least 2028 place Oman in a position to plan for continued development of gas-fired generation as the dominant power source in the near term, alongside limited renewable energy penetration, together with minimal diesel capacity as required for grid security and rural needs.

However continued reliance on gas-fired generation in the longer term is contingent upon the continued availability of low cost gas. In the event that gas availability falls below expectation, in addition to renewable energy developments which are considered separately, Oman should consider the construction of further additional renewable generation if their costs fall sufficiently, or new coal fired capacity, including associated import infrastructure, additional interconnections with neighbouring grids and/or participation in domestic or regional nuclear projects. Any decision to pursue non gas-based generation beyond renewables, however, should not be required before 2020. This should generally allow for sufficient lead-time for alternative generation to be on-stream before the gas surpluses expire. The development of stand-alone nuclear capacity (even small modules) would take longer however, and for a coal generation option it is recommended that early preparations – location selection, coal procurement options, planning including of logistics, and environmental assessments associated with permitting together with scoping engineering, be conducted prior to 2020. By 2020 an improved assessment should be able to be made of the projected availability of gas from new and established sources as noted above.

Making use of any surplus for increased LNG exports beyond contractual commitments through 2025 and maintaining LNG operation for much longer is likely to be attractive under a wide range of outcomes. Based on an improved assessment of expected gas surpluses, a decision should be made by 2020 for LNG facilities to be maintained and upgraded as necessary to extend contractual sales or for shorter term/spot sales beyond 2025.

2. Energy Supply Optimization

In optimizing energy supply, Oman should put in place new mechanisms to provide for firm, 20+ year contractual commitments when allocating gas and encourage the development of hybrid and secondary markets which can provide value in both gas surplus or shortage situations.

The potential for gas surpluses beyond the needs for incremental LNG may present Oman with growth opportunities in terms of gas-consuming industries—new green-field projects and/or expansions of existing energy-intensive industries. In determining the allocation of gas resources, either in periods of constrained supply and necessary curtailment as now and possibly again later in the period, or when considering how best to deploy medium/longer term surpluses, new mechanisms to optimize the allocation of gas supply should be developed. These should reflect the value of consumption to Oman, realised through direct pricing and/or through the economic benefits of direct, indirect and induced value, including the additional jobs created along the supply chain and downstream by energy users.

Using the input/output model developed for NESS the additional indirect and induced benefits attributable to industries which can generate substantial downstream usage and further processing within Oman, or which can add value to mineral resource extraction within Oman (e.g. chromium, aggregates), are shown to be significant—in the range of $1 to $2/MMBtu—across many industries examined. On the contrary, most of this added value is not available to Oman if the product of the industry is exported (e.g. fertilisers, export aluminium or export base chemicals such as methanol).

Whilst, in principle, the government may prefer that energy be allocated to uses that provide the greatest overall value to the economy, it is difficult to accurately predict the long term employment and wider economic benefits of a gas allocation, across a range of industries, over the long life of the contractual commitments needed to support investments, and therefore new market mechanisms should be considered as a means to deliver government revenue optimization. However, NESS recommends a hybrid system for new allocations to realize wider benefits, whereby a proportion of gas is allocated strategically and the remainder competitively:

- Limited long term strategic commitments should be made to key industries which can demonstrate high indirect economic value (e.g. Duqm petrochemicals, chrome-steel value chain and selected small and medium enterprises)

- Other new allocations should seek the highest prices offered by other industries through long term auctions or similar.

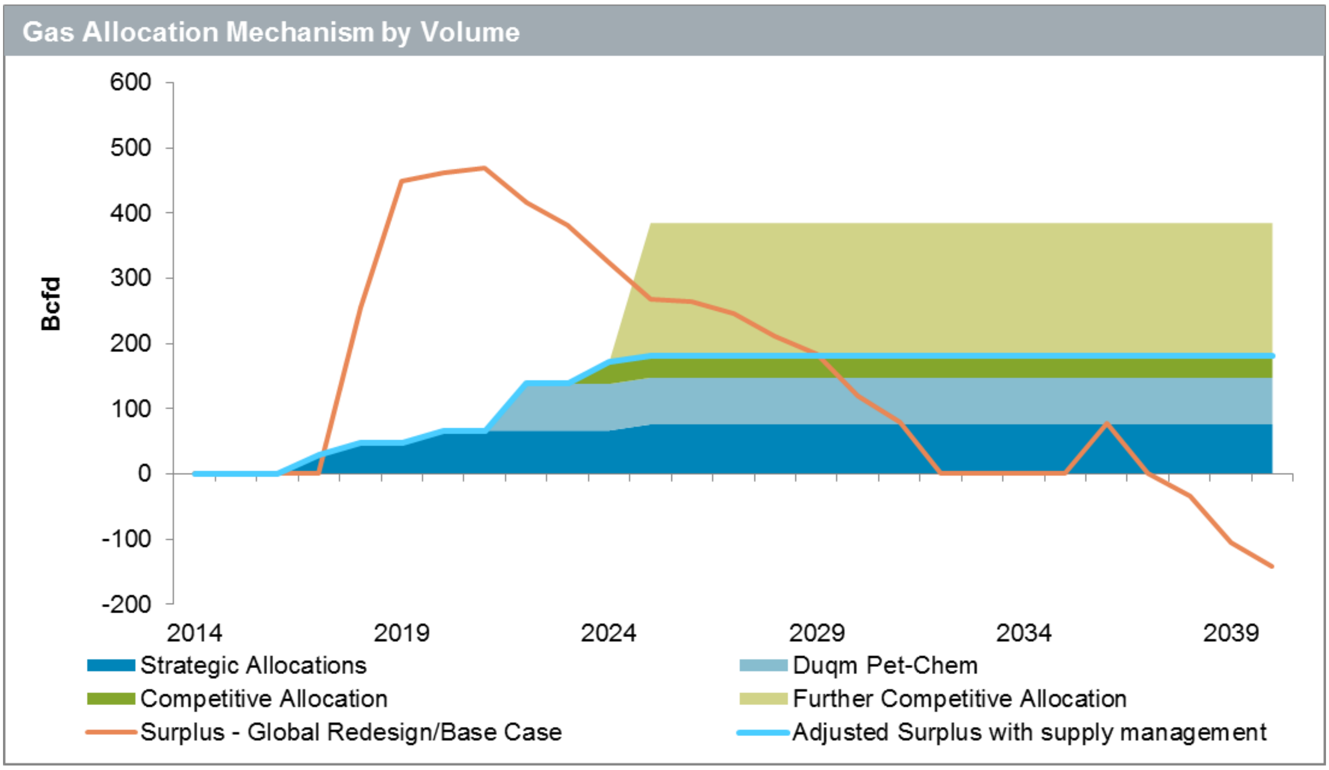
In order to provide for a simple differentiation between the two types of allocations, it is proposed that in principle the strategic allocations should aim to cover the weighted average cost of gas production, whereas the competitively-bid commitments should target to cover the marginal costs of new production. This should ensure that gas production is not state-subsidized, but also that a proportion of the upstream resource value is made available to strategic users.

Gas allocation often underpins long term investment commitments and it is recommended that a significant proportion of sustainable production surpluses should be packaged into firm long term contractual commitments of 20+ years. It is important therefore that any such process takes place when it is reasonably certain that the commitment can be sustained or that gas can be economically freed up from alternative uses if circumstances change. It is recommended that preparations should begin to sell firm long term gas contracts that balance the risk of rapid production declines or disappointing costs developments of tight gas later in the study period with the need to monetise large volumes of new supply. Management of gas surpluses will need to deal with multiple conflicting economic and technical uncertainties. The levers open to provide for long term availabilities could include swinging existing production, delaying new gas production, converting fields for gas storage, using the LNG facility flexibly for balancing spot sales or using fuel switching in power generation as an option to free up gas in poor production outcomes. All of these tools have a cost but can mitigate the lost opportunity of stranded production. Active management of gas production levels to delay surpluses beyond 2030 is now commencing in PDO with a dedicated swing field, and extending this philosophy through active incentives can allow availabilities to be better planned to meet long term contractual commitments.

Figure 5 illustrates how this might be realised if the gas surpluses envisaged under the Global Redesign/Base High production case were to materialise, and also how larger surpluses under the Upside production case may be allocated. The impact of active production management to align surpluses with long term demand commitments is also illustrated.

A more general allocation optimization could be achieved by encouraging bilateral trades and swaps between gas contract-holders. A secondary market would allow re-allocation to higher value uses in years where consumption is constrained or opportunities for increased production in certain industries have high value. It is recommended that a formal process be implemented to enable such trades on a short term basis, and that this is implemented as soon as possible.

Figure 5: Potential new gas allocation mechanisms in the context of envisaged surpluses



The NESS recommendations focus on four potential areas—optimizing existing demand in the short term, optimizing the use of LNG capacity, monetizing potential surplus gas to new industries and managing gas production to provide for long term commitments. Combined these direct value maximizing improvements are estimated to increase the value to the Oman economy of gas monetisation by 6 billion OMR over the study period.

3. Renewable Energy

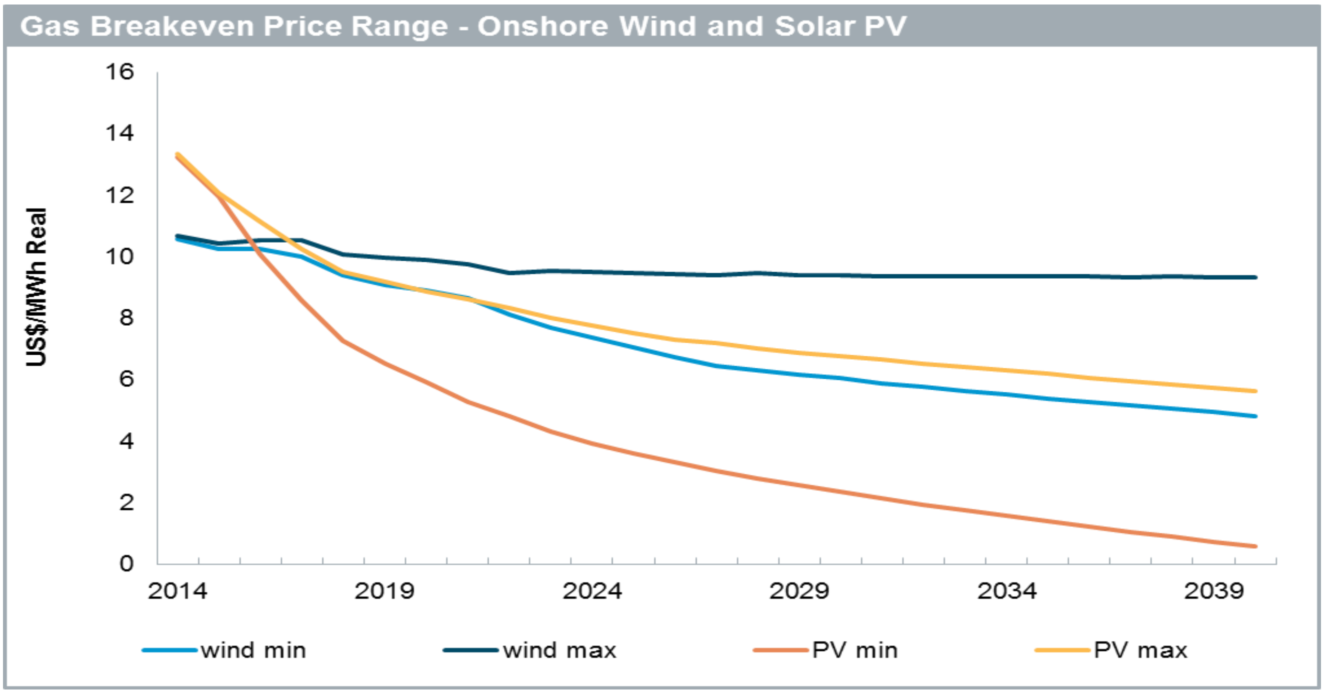
Oman should develop capacity to deliver up to 10% of its electricity supply from renewable sources by 2025, with provisions for rapid, low-cost expansion in the future if warranted. The solar steam business, for which Oman can take a 'first-mover' position, should be supported.

It is recommended that around 10% of Oman's generation mix should come from renewable energy sources (RES)—primarily onshore wind and solar—by 2025, in order to secure a well-established platform and experience base for further rapid renewables growth if warranted. 10% of generation would be equivalent to around 2-3 GW in capacity terms owing to the low load factors associated with wind and solar power. A decision to build additional RES capacity thereafter would be triggered by one or more of the following:

- RES cost declines positioning renewable electricity generation cheaper than from fossil fuels,
- a high value is attached to carbon emissions,
- or a high alternative value can be realised for gas displaced from electricity generation.

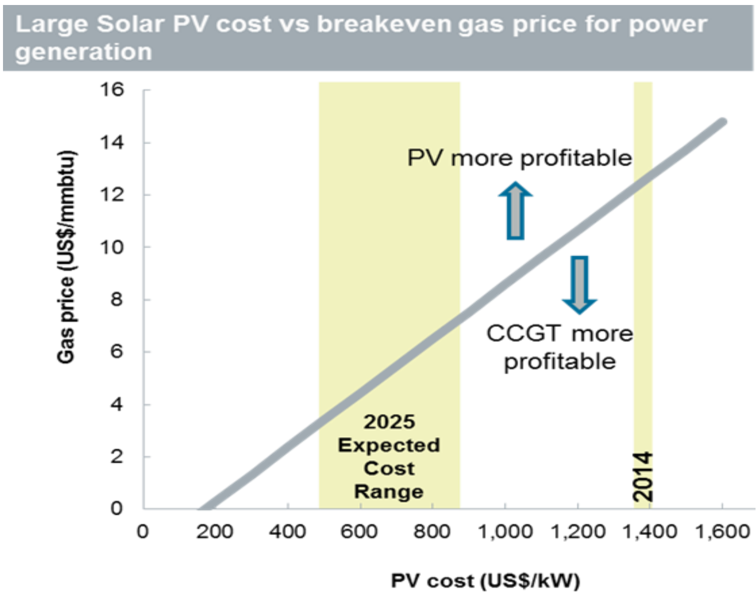
The experience gained from developing this initial 10% platform should eliminate the premium costs that are typically incurred from immature contracting, local supply chain, procurement, financing, grid optimization and operations of RES projects. This experience will assist Oman in instituting a stable tendering and administration regime for RES projects, including efficient integration of permitting, connections and access to finance. Operationally, the platform will allow different grid players to familiarize themselves with intermittent energy sources, and their integration in the overall dispatch management, grid development, and to develop associated standards and procedures. On the industrial side, the platform will also provide benefits in terms of familiarizing local industries and construction companies with these technologies, but also institutions in charge of standards, monitoring, and supervision. Finally, a major benefit of the platform also resides in the flexibility it provides: the experience gains will translate, if the decision to build additional RES is triggered, into faster development, at lower cost. More capacity, at lower unit cost, will be made available faster if warranted.

Figure 6: Large PV & wind gas breakeven range across scenarios



A wide range of potential cost decline rates for RES are predicted by knowledgeable observers, including IHS forecasts associated with the three Scenarios utilized for this study. The range of forecast prices across the NESS Scenarios for solar PV and for onshore wind in Oman translate into break-even economics versus investments in gas-fired generation as shown in Figure 6 and Figure 7, implying that RES could evolve to be very attractive versus the marginal costs of gas production or versus the alternative values available from incremental industrial uses of gas within the Oman economy. In the event of either outcome it would be attractive to further increase RES penetration into the Oman power generation mix at the expense of gas-fired generation.

Figure 7: Implications for the value of solar PV versus the value/cost of gas displaced from power generation



The recommendation to install this level of renewables is in principle agnostic as to the technology employed. To reach the 10% platform, Oman is recommended to consider and test a diversity of technologies, locations, and project sizes. To start the platform, a program of phased tenders focused on large plants is proposed. This should present the highest opportunities to lower cost. NESS also recommends supporting decentralized plants, notably rooftop PV which can be beneficial for the grid. Support measures such as net metering or feed-in tariffs will be required.

This commitment to renewables is expected to incur a premium cost versus continued build of gas-fired power. Dependent on the rate of RES cost-decline, this premium could be of the order of 40-60 million OMR p.a. by 2025, but the 'option value' associated with the value of the platform should further RES development be warranted could provide for around 0.5-1.5 bln OMR or more in net benefits versus the case where no platform is built.

However, in view of the relatively small scale of RES adoption compared to other countries, only limited In-Country-Value is anticipated to be available from this program and most of the RES value will be realized through gas savings or gas diversion to higher value outlets. Potentially more ICV could be realised were Oman to further support the development of solar steam for upstream and other industrial use where there could be genuine indirect economic value and job creation value from establishing a leading scale 'first-mover' concentrating solar power (CSP) industry in the region with key component industries and services centres being established within Oman. This would be over and above anticipated cost advantages from substituting direct gas-fired or cogeneration-based steam raising.

The demand for CSP would be linked to growth in EOR in the upstream industry and the ability to exploit large applications such as Mukhaizna could present the opportunities to build critical mass within Oman and to leverage out to EOR opportunities in other Gulf countries. Initial analysis by PDO and by solar EOR developer Glasspoint indicates that savings provided by solar thermal EOR as an alternative to direct steam raising using natural gas could become equivalent to a gas price of around $5/MMBtu in case of new greenfield large scale projects. However substantial additional in-country value could enhance the value of gas saved as a major part of the equipment can be manufactured within Oman, with significant downstream expansion potential. This potential could be further leveraged, should the technology be also used for EOR in neighboring countries, or in other industries, including power (via integrated solar combined cycles) or in refining and/or petrochemicals. It will be important to ensure that existing low price gas supply allocations being used for EOR do not sub-optimally block the uptake of this technology in Oman.

4. Energy Price and Subsidy Reform

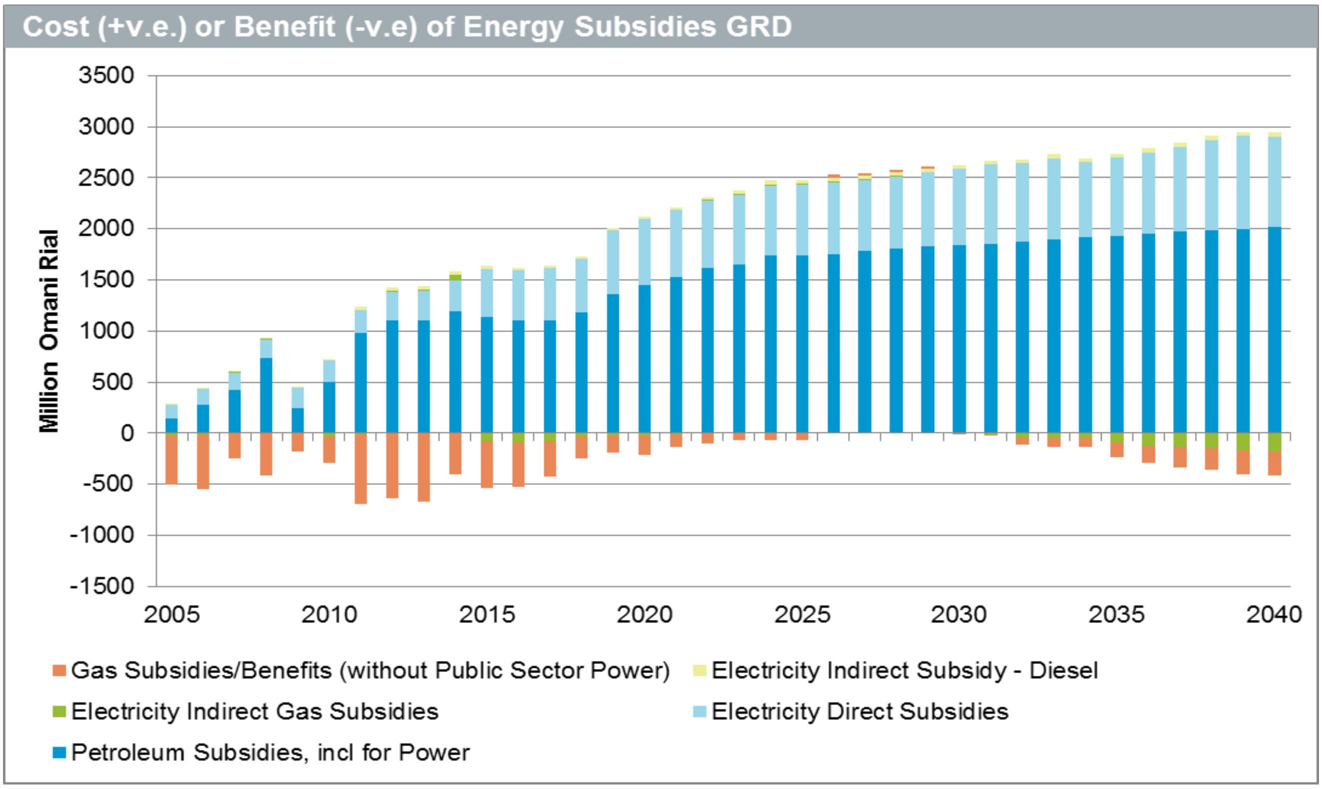
Oman should reform the subsidy schemes for transport related oil products, electricity and gas consumption within a phased timeframe, in order to mitigate the risk to future government deficits and incentivize efficient energy use.

Energy subsidy costs in Oman for oil products, electricity and gas can potentially grow rapidly. Maintaining the current pricing approach would increase the annual subsidy burden from around 1 billion OMR[4] in 2014 to over 3 billion OMR by 2035 in a $100/bbl crude environment as illustrated in Figure 8. By 2035, nearly two thirds of the burden would be associated with oil products (gasoline, diesel etc.) and close to one third from rapidly rising electricity consumption costs.

The subsidy burden associated with industrial gas will be relatively low under the baseline case as contract prices have already moved towards average production costs, but could be 450 million OMR greater under the upside production case which is associated with increasingly expensive incremental gas production and higher industrial consumption. These subsidies impact directly on government budgets and the NESS macro-economic modeling suggests that there is a real risk that government deficits grow significantly if oil production falls below current levels and/or prices fail to recover from recent low levels. Early, well-planned action to actively manage and reform subsidies will prevent the need for emergency cuts at a later time.

[4] Based on international reference prices for oil products, WACOG for gas costs and full cost recoveries in electricity supply versus actual domestic realized prices, and net of gas 'profits' from sales to LNG and other high price offtakes.

Figure 8: Energy Subsidy Expenditure



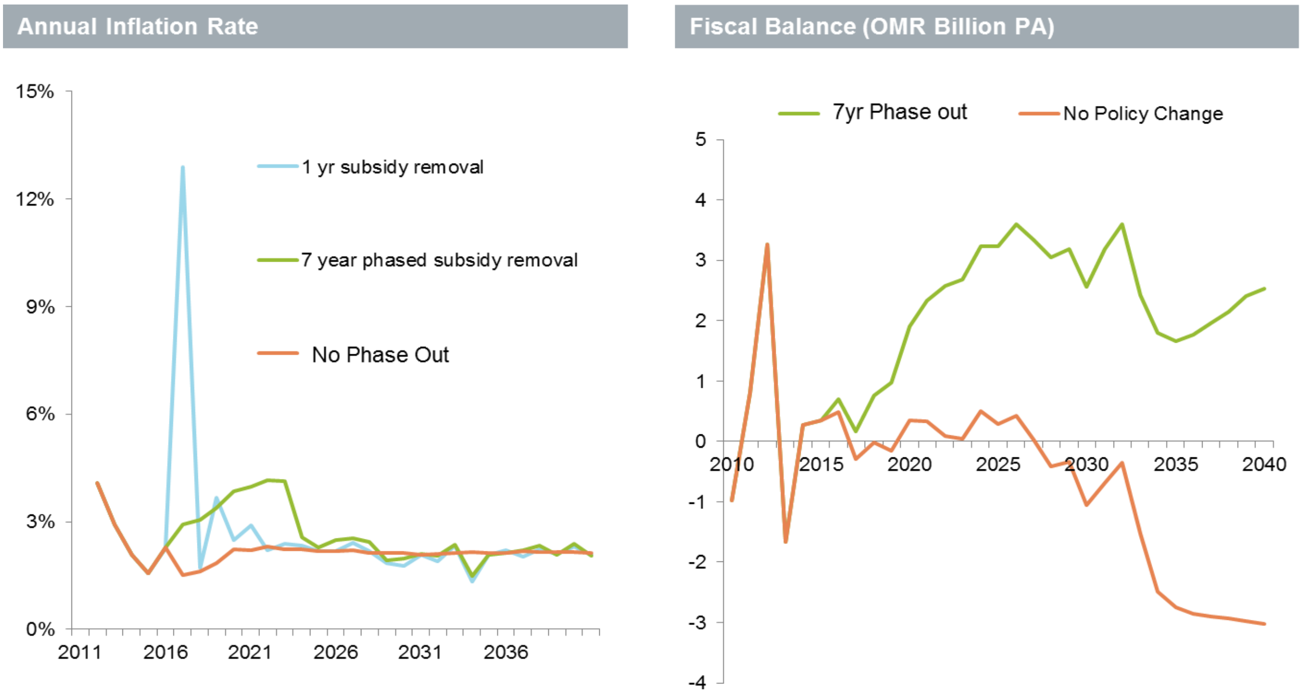
Nevertheless, even a gradual elimination of subsidies will have an impact on industrial and especially household costs which may in turn adversely impact the economy and possibly pose a social threat. Longer term the redeployment of saved government expenditure and the efficiency benefits promoted by higher energy prices will more than compensate, but the pacing of subsidy removal, together with implementation of a social program to compensate for the impacts on vulnerable sectors of society and to continue to stimulate industries that are adversely affected, will need to be closely managed. PAEW have instituted a separate study to review the social planning needs around the potential withdrawal of utility subsidies, but NESS macro-economic modeling suggests that a sudden removal would trigger major recession and inflationary pressures. Phasing the reform over a multi-year timeframe will markedly reduce these adverse impacts—for instance a seven year phase-out is expected to contain inflation at or below around 4-5% p.a. and preserve fiscal balances as noted in Figure 9.

Market-based energy prices would also encourage more efficient use of energy in industry and business and support investment in energy-saving technology as well as improve investment conditions for energy suppliers. The impact of subsidy removal would however adversely impact economic growth, only in part ameliorated by the improvements in energy usage stimulated by a price elasticity response from users. NESS modelling suggests that this impact (based on correlations for price elasticity established internationally) would only counter around 20-30% of the GDP penalty. However use of a portion of the government savings resultant from subsidy removal to either stimulate the economy – for instance by direct support for sectors penalized by the subsidy withdrawals, and/or by direct investment in new industries and service sectors, would be expected to more than compensate.

Although NESS modelling implies that a seven year phase-out of subsidies will allow inflation to be adequately managed, a process for regular monitoring of the impact—which will vary according to actual market and economic conditions—should be put in place, allowing the phasing to be adjusted as needed. It should be noted that the current drop in global energy prices presents a window of opportunity to Oman to fast-track energy price reform—especially for transport fuels—with limited risk of socio-economic hardship. A number of countries with large government costs for fuel subsidies have already taken successful actions to erode subsidies while international prices are low, e.g. India and Indonesia. By the end of the subsidy transition period it is recommended that energy pricing should be in line with international oil prices and weighted average gas production costs (WACOG), and electricity prices fully cost-reflective.

The prize for the Oman Government could be up to 5 billion OMR p.a. savings in subsidy costs, a portion of which could be redirected for alternative economic stimulation and for support of vulnerable consumers.

Figure 9: Subsidy removal – impacts on inflation and Government fiscal balances



All cases before redeployment of govt. savings and other mitigation measures

5. Promoting Competitive Refining

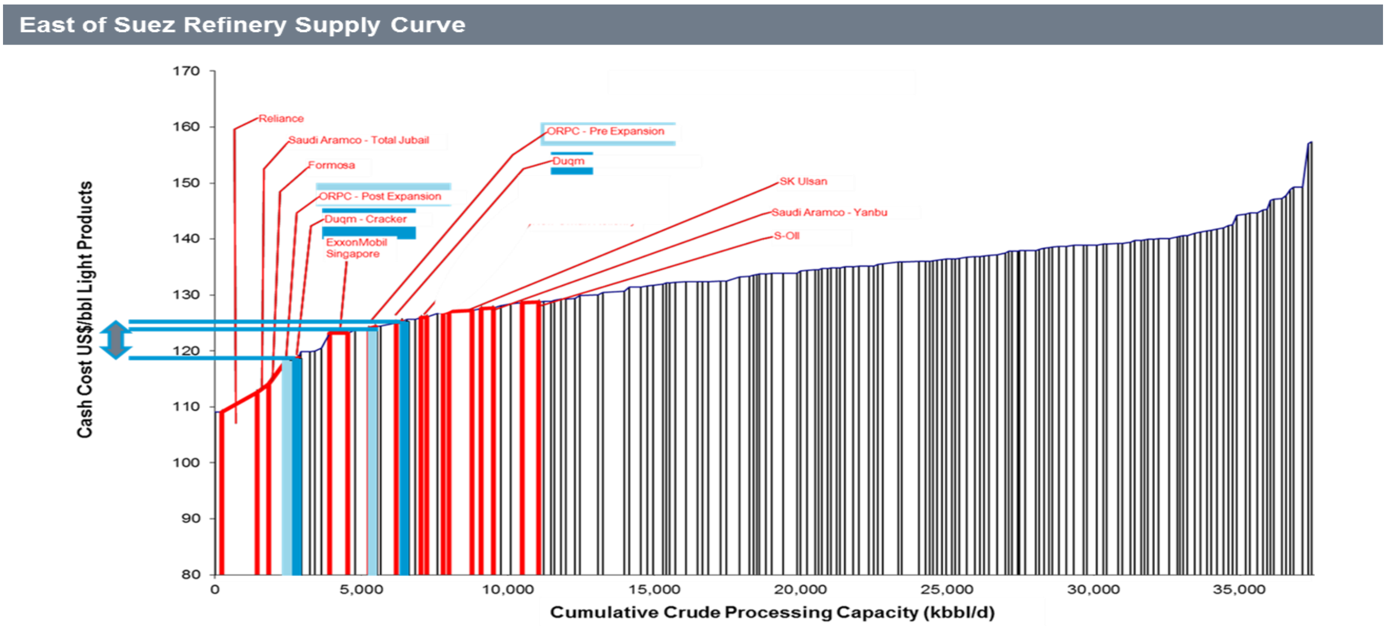
Oman should commit to new major export-oriented refining capacity in Duqm to the extent that it is well-integrated with petrochemicals. A gas allocation for petrochemical feedstock should support this.

Two major refining projects are under way / being planned for Oman—an expansion of the ORPIC Sohar refinery and a new refinery in Duqm. Both projects will rely on export markets for oil products, although the Sohar 2 capacity could eventually be absorbed to support growing domestic oil product demand and should reduce the cost of domestic production.

IHS analysis indicates that new export-focused refining capacity in Oman can be economically justified but only to the extent only that it is well-integrated with petrochemicals because standalone refining developments in Oman are unlikely to prove sufficiently competitive to secure robust loadings based on exports to Asian, African and European markets, in the face of widespread competition from other Gulf and SE Asian export refinery projects.

This logic supports both the plans for the Sohar II refinery expansion project integrated with the Liwa Plastics plant, and the concept for the Duqm refinery with an integrated petrochemical complex. Using proprietary IHS models NESS analysis has demonstrated that the effective cash cost of export fuels from the refinery is lowered as a result of the contribution from the integrated petrochemical production, essentially improving the cash cost competitiveness from top quartile to top decile when compared to all refineries active East of Suez, as noted in Figure 10.

Figure 10: Competitiveness of East of Suez refineries and Oman refinery positionning



The development of an integrated refinery-petrochemicals project would also provide an "anchor" development for the Duqm Special Economic Zone providing critical mass and stimulating other industries—especially those converting, fabricating and using petrochemical products such as polymers—to locate there. Using an archetypal petrochemical project typical for Gulf countries, the NESS macroeconomic input/output model indicates that the Duqm project could create a net GDP impact of between 0.5 and 0.9 % p.a. and job creation of 10-15,000 jobs long term, together with shorter term major construction activity.

To ensure the competitiveness of the integrated project, sufficient gas and electricity supply commitments should be made to both activities, including an allowance for industries to be developed in Duqm downstream of the petro-chemicals.

IHS analysis notes that olefin production in GCC countries is typically disadvantaged versus leading international competitors by virtue of increased capital costs, technology access fees, logistic and commercial penalties and limited by-product integration. To compensate for these effects in Oman, it is estimated that around 30% of the feedstock would need to be made available through access to cost-based ethane/NGLs from natural gas (i.e. costed at WACOG) which would provide a cost advantage versus liquid feedstocks priced at international levels. This is not currently committed to the Duqm project, and it is recommended that this be reviewed, in the context of an early strategic commitment of future gas surpluses as noted above.

6. Energy Efficiency

NESS also notes the importance of efficiency savings in Oman's overall energy strategy and supports the recommendations of other studies.

Efficiency improvements across the production to end-use chains for electricity and oil and gas appear economically attractive. Other studies have identified significant opportunities for improvements and the recommendations to develop a national energy efficiency program and conservation masterplan should be incorporated into the national strategy. This could include use of distributed renewable energy in applications such as solar water heating.

However it should be kept in mind that even under an aggressive efficiency scenario, in which most economical efficiency measures are implemented, by 2040 installed electricity generation capacity would still need to increase substantially (around 19GW vs 24GW without the measures) compared with the current installed base of 8GW (12 GW including committed new capacity).

Overall Impact of Recommendations

The recommendations made will provide flexibility for Oman to adapt to, and to optimize the outcomes from, a variety of energy futures resulting from a combination of external factors and from the range of uncertainty underpinning future indigenous hydrocarbon production.

All the recommendations support to a greater or lesser extent the core objectives set for the Oman Energy Sector, noted above, although there are some trade-offs which need to be accepted on balance – see Table 1.

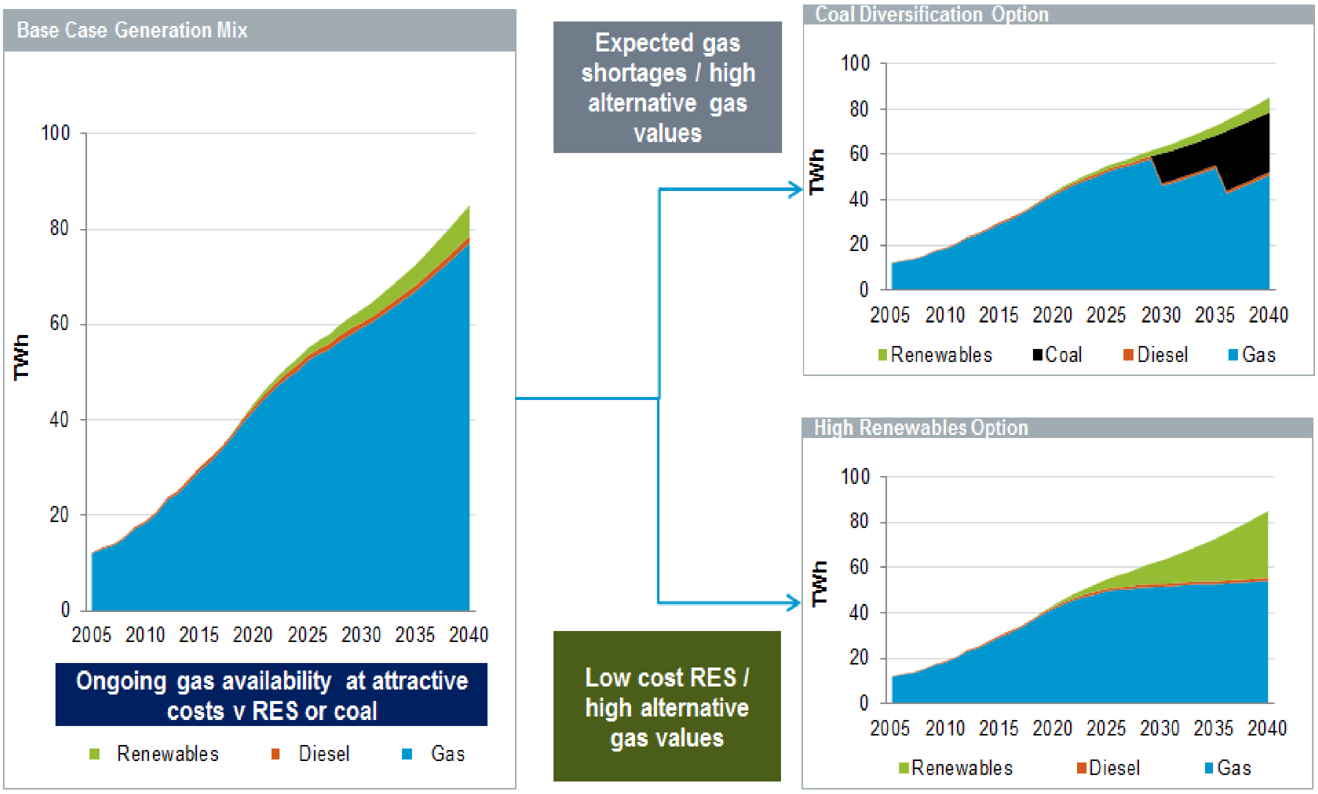
Table 1: Fit of Sector Objectives by Recommendation

Recommended Strategic Options / Energy Sector Objectives	Plan for mid term gas surplus and LNG production post 2025	Optimize gas supply with 20yr gas supply contracts & secondary gas markets	Target 10% renewable generation by 2025; create option for additional capacity	Phase out energy subsidies	Commit to new refining capacity in Duqm with integrated petrochems and gas feedstock
Exploit Oman's Resources					
Support Oman's Economic Vision					
Build Up / Downstream Value					
Promote Omanization					
Supply competitive, secure fuels					
Drive efficiency of use					
Contribute to sustainability					

The monitoring of potential for gas surpluses, and the institution of mechanisms to realise the maximum value for gas allocations and short-term / secondary re-allocations, will allow options for future key decisions to be kept open until key decisions are required. This will minimize the regret of making the wrong or high cost decisions earlier than is needed.

For instance the decisions related to future power generation mix can be delayed until 2020 or beyond as noted in Figure 11.

Figure 11: Potential drivers for deciding to move away from gas-fired generation for Oman.



High level quantification of the value of the recommendations (see analysis in sections above) can be seen to offer up to 2% incremental annual GDP growth, 12+ billion OMR added value over the period, and very substantial savings in government fiscal balances.

Implementation Roadmap & Final Policy Recommendations

Decision Map

The proposals laid out above entail major directional decisions and in many cases capital outlays which in some cases will effectively close off other policy options in the medium term.

Any policy decision thus entails the potential for significant regret value (or opportunity costs) at a later date and it is critical that all decisions are made with as much data visibility as possible to minimize such regrets. With the passage of time, data visibility on certain issues will improve – for example the extent of Oman's tight gas recoverable reserves or the cost evolution of renewable technologies. However, the lead times involved in constructing certain energy assets or infrastructure can be years or even decades. Failure to initiate new energy projects in good time can lead to capacity shortages and bottlenecks, risking security of supply and constraining economic development. Thus policy-makers face a trade-off between delaying decisions as long as possible to improve data visibility (and avoid regret) whilst at the same time ensuring policy actions are initiated sufficiently far in advance to deliver the necessary infrastructure in time.

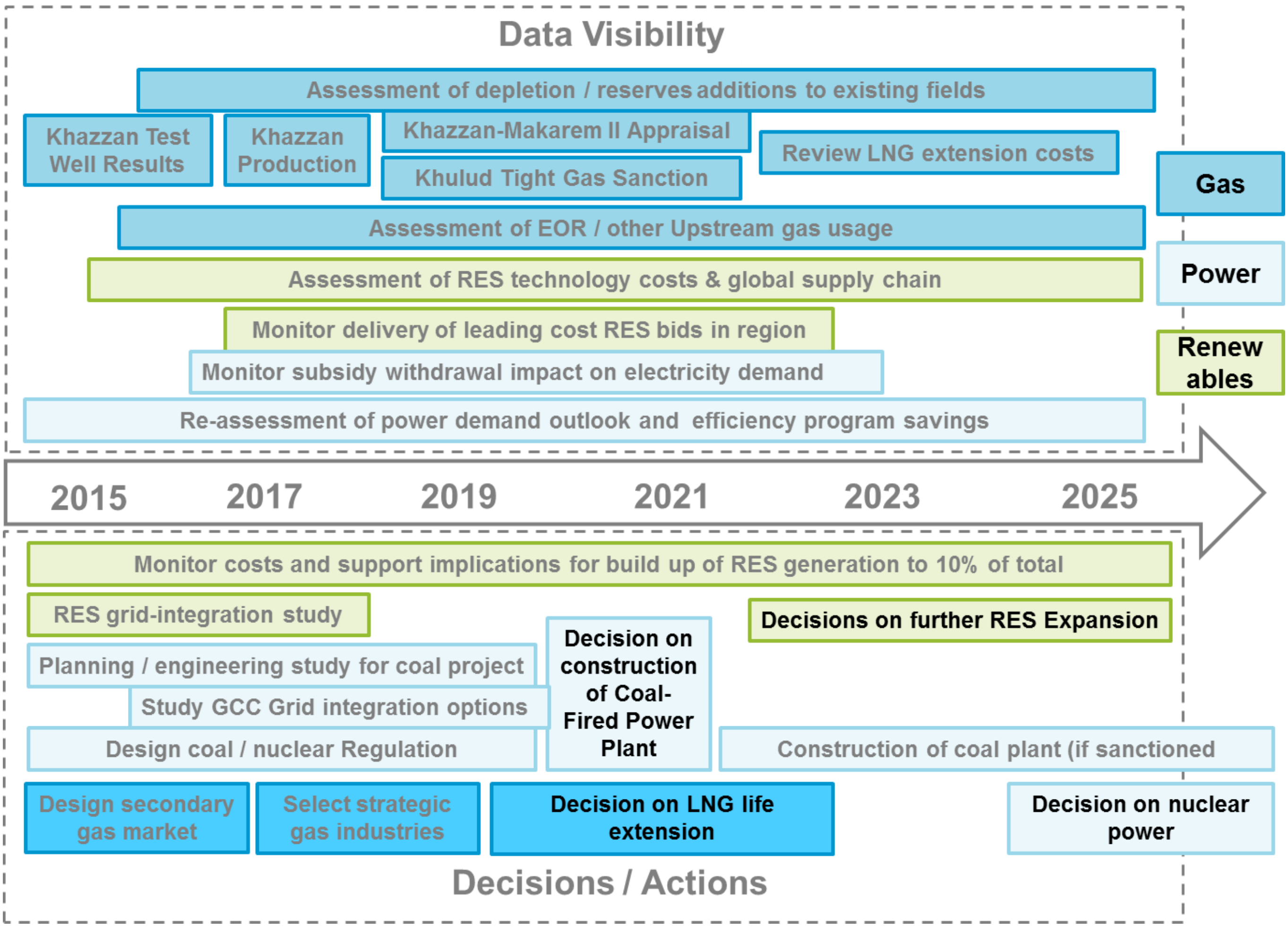
Not all policy decisions carry major regret risks. NESS recognizes that there are some choices which can be taken immediately and processes which should be initiated as soon as possible. These include the establishment of an institutional framework in which to develop new gas optimization and allocation mechanisms, the initiation of a renewable energy policy aimed at delivering a material 'base platform' of supply through renewable electricity capacity additions by 2025, a commitment to export refining in Duqm alongside petrochemical facilities (with gas feedstock commitments) and moves to begin subsidy reform.

However, a second set of policy decisions should be deferred until a later date, principally when policy makers have a firmer understanding of Oman's natural gas resource base, renewable energy cost evolution and power demand growth (including the impact of efficiency programs and subsidy removal). To that end NESS recommends a second set of decisions be deferred until 2018 (or later). These include decisions to diversify the generation mix to protect against possible gas shortages, further commitments of major new gas allocations to new industrial developments and commitments to new gas import projects. This will materially improve visibility on critical key uncertainties without significant risk to Oman's energy supply security.

Taking these the uncertainties and timings into account, Figure 12 illustrates a proposed Decision Map for policy makers. The top section maps out uncertainties and when data availability will improve in regards to each topic. The section below shows how policy-makers can best respond – either by making a specific decision or following a specific course of action.

A monitoring program to track the key uncertainties such as the confidence in, and cost of, future tight gas production needs to be put in place.

Figure 12: Decision Map



Policy set

In terms of actual policy development needed to support implementation NESS has focused on the high level 'aspirational' and secondary level 'target-setting' requirements related to gas optimization, renewables introduction, subsidy reform and efficiency program. The requirement for detailed 'enabling' policy are beyond the scope of the NESS work but key regulatory capabilities needing to be put in place have been highlighted.

The key aspirational policy requirements are summarized below:

To drive gas optimization and reallocate short and long term surpluses or shortages of gas to maximize the benefit for the Oman economy:

1. When or if sufficient confidence in future gas surpluses is ascertained, a significant proportion of sustainable production surpluses should be made available and packaged into firm long term contractual commitments of 20+ years. This allocation would need to be released commercially at around [5] years before the anticipated gas availability in order to allow potential buyers to make necessary downstream investments.

2. The availability for firm commitments should be backed by identified reserves, although contingent reserves (yet to be firmed) can be considered for provisional commitments to ensure suitable lead time for the planning of additional gas consumption projects.

3. The production profile of potential reserves will need to be managed in order to balance out periods of surplus with periods of shortfall, including with the introduction of appropriate fiscal incentives for producers.

4. Economic and social criteria should be developed to define the criteria for strategic projects for future gas consumption. These criteria will be based on enhanced supply chain and downstream economic and employment benefits to Oman identified over and above the direct returns (netbacks) from gas sales revenue.

5. Subject to the identification of potential new strategic industrial consumption a primary reservation of capacity should be allocated to such use.

6. Any remaining available surplus long term capacity should be made available to long term contractual offtake by non-strategic industries.

7. Strategic industries will enjoy long term gas-pricing in principle linked to the weighted average cost of Oman gas supply.

8. A tender process will be introduced to ensure competitive pricing and terms are received for non-strategic industrial offtake. The Government will not be obliged to accept bid prices if they are not expected to cover marginal costs of supply (e.g. highest tier of production cost).

9. Further surpluses of gas which cannot be guaranteed long term can be offered in shorter term tender processes or can be offered through the secondary market (see below).

10. As soon as possible, all gas offtakers meeting defined criteria will be allowed to participate in a well-defined secondary market where gas allocation volumes can be traded bilaterally between parties on an ‘over the counter’ (OTC) basis. This is intended to optimise the direct economic value that can be realised for gas at any point in time between the various consuming industries in Oman, and present an opportunity for shorter term surpluses to be offered into the market. Similarly shortages can be managed on a value-maximising basis to ensure that scarce gas is reallocated to industries with the highest realised value.

11. Oman Gas Company should be obliged to facilitate these trades by means of appropriate transferable ‘postage stamp’ transportation tariffs or other clearly differential tariff mechanisms which will allow redirection of traded physical gas supplies freely and without undue penalty.

12. Over time the development of the secondary market will be encouraged, potentially establishing discoverable marker prices and to allow financial trades with the involvement of independent traders. Opportunities to develop a formal gas trading exchange should be examined.

13. The price paid to upstream producers should reflect the marginal value as reflected in the price paid by consumers in order to incentivize new production at its marketable rate.

14. Upstream developments that cannot cover their incremental cost of production through these market responses should be considered for postponement.

To drive the penetration of renewables to forge a base experience platform for the Oman electricity generation sector which can then be stepped up quickly at the lowest cost is warranted:

1. Develop progressive targets towards a 10% net generation contribution from renewable electricity sources by 2025, and institute processes to implement.

2. Introduce a transparent procurement process for new renewables generation projects where process visibility is used as a key to attract investment, track developments and ensure a sustainable build-out.

3. For utility-scale plants this will be via a well-defined tender driven procurement process open to experienced international companies.

4. For distributed renewables, such as a rooftop solar program, establish appropriate support schemes which can be managed with distribution companies.

5. Establish a 'One-stop-shop' agency to facilitate and streamline the processes for private investors to develop and finance renewables projects, to act alongside existing agencies.

6. To set targets for local content which balance the potential to create In Country Value and job creation with cost-effectiveness and lead time streamlining.

7. To institute a review process which can adjust targets and trigger major new programs to build beyond the 10% target when and if considered to be in the interests of the Oman economy.

8. To target a [50%] penetration for replacement of gas-fired steam raising for the upstream oil industry with Oman-developed concentrating solar systems, providing early stage support and addressing commercial and technical barriers with specific Operators.

For initiating and managing energy subsidy and price reform:

1. Subsidies for energy products (transportation fuels, cooking fuels, natural gas and electricity) should be rationalised in stages as recommended by assigned institutions (e.g. MOG or MoCA for fuels, PAEW for electricity) and approved by an appropriate authority (e.g. Energy Council or MoF).

2. Such staging should take account of the implications for the performance of the Oman economy, regular monitoring of which will allow for speeding up or delaying the pace and sector phasing of subsidy elimination, which will initially be phased over a maximum of seven years depending on consequential impact of removal.

3. Subsidy removal stages should only be sanctioned subject to acceptable social programmes and/or offsetting transfer payments being introduced to limit undue hardship for vulnerable consumers.

4. Subsidy removal for industry should consider the commitments made under pre-existing contractual arrangements if they undermine the attractiveness of future investments by energy intensive industries in Oman.

5. The phasing of subsidy removal should be as best possible coordinated across fuels and sectors to avoid misalignment of pricing which may lead to arbitrage opportunities for consumers.

To establish and manage an energy efficiency programme:

1. A coherent national plan to promote efficiency of energy use should be instituted under the auspices of the Energy Council or other Cabinet-level body, and powers for regulation established under a designated institutional responsibility, to include sector-specific measures and sourcing funding for the programmes.

2. Separate programmes to improve the efficiency of the Oman transport sector, in line with good international practice (including fuel consumption targets, penetration of unconventional vehicles, usage of mass transit, etc.), should be set by the Ministry of Transport in conjunction with the Institutional Authority assigned for Energy Efficiency, and with other government entities overseeing urban planning etc.

3. District cooling networks should be encouraged with regulatory support, especially for retrofit urban schemes. Supportive tariffs should be promoted.

Planning and Institutional Coordination

It is clear from the analysis undertaken for NESS that individual areas of responsibility within the Oman Energy Sector are generally well-managed and planned. However there is inconsistency in the rationales between the individual sector plans and inconsistency in planning cycles and timetables. These act to compound the inconsistencies at the energy supply chain integrated level and a process to ensure 'joined-up' planning should be addressed.

Coordination of planning, cycles and assumptions around uncertainty are therefore recommended. This can either be done via a common energy planning institution or by much closer cooperation between the existing planning entities. Based on assessed best practice elsewhere NESS recommends:

1. To manage a regular comprehensive strategy and policy update process to be undertaken at least every five years.

2. To oversee a consistent, co-ordinated and coherent rolling [10]-year supply-and-capacity planning system that should be formally introduced across the whole energy supply chain, linked with simplified permitting and other key processes – to be updated annually.

3. To manage the programmes and pacing of price reform and subsidy removal, market introduction, and any allocation mechanisms to different end-use segments on a basis coordinated across all the relevant energy sectors.

4. To liaise with other key government planning activities, such as environmental, industrial, transport, and urban development in policy setting and co-ordinated national planning exercises (e.g. five-year economic plan, transport policies).

5. To coordinate across all energy sectors and to lead the interface with other stakeholders in developing the national efficiency program, and potentially any national Climate Change Action Plan.

In view of this recommendation and the uncertainties noted in Section Figure 13 regarding the areas of policy responsibilities, a further recommendation of NESS is that:

Oman should study most appropriate institutional framework to coordinate the policy development, policy regulation and planning processes for the integrated areas and supply chains of the Oman energy sector, and to determine to what extent this should include areas of centralized responsibility.

Implementation Roadmap

Overall a roadmap for implementation actions based on the above has been proposed as outlined in the timetable shown in Figure 13.

Figure 13: Proposed High Level Implementation Roadmap for NESS.

Strategic Option	Action	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4	2018 Q1	2018 Q2	2018 Q3	2018 Q4	2019 Q1	2019 Q2	2019 Q3	2019 Q4	2020	2021-2025	2025-2030	2030-2040
Energy Supply Optimization	Authorise / Initiate OTC Secondary Gas Market																						
	Review Khazzan Ph 1 devt; Ph 2 appraisal - review implications for med term gas surplus																						
	Establish protocols / offer* tranches of strategic gas allocations																						
	Establish tender process / offer* competitive gas tranches																						
	Review extending physical OTC secondary gas market with independent traders/brokers																						
	Allow incremental gas supply to be offered in the secondary market																						
	Decision on Oman LNG operations - extend beyond 2025 or not*																						
	Review implications of new spot power market on gas secondary market																						
	Further development of Secondary gas market																						
Subsidy Reform	Establish institution to set and roll out subsidy removal schedule																						
	Review applicability of proposed industrial cost-reflective tariffs for electricity																						
	Identify vulnerable sectors of industry and society, and target for counter measures																						
	Agree and institute compensation and other counter measures for vulnerable sectors																						
	Initiate phases of subsidy withdrawal across oil products and electricity sectors																						
	Monitor economic & social impacts of subsidy removal phases and consider to adjust pace																						
	MOF to review options for redistribution of fiscal savings																						
Renewable Energy	Set Targets for up to 5 phases of RES development to achieve target 10% penetration																						
	Set rules for utility-scale tenders																						
	Agree chosen support basis for rooftop solar PV																						
	Establish one-stop-shop to facilitate private/PPP RES projects																						
	Launch RES tenders																						
	Award RES contracts																						
	Initiate grid re-inforcement study																						
	Monitor success of program and implied support costs; review targets if necessary																						
	Provide incentives for development of EOR / heavy oil projects																						
	Eliminate sub-optimal barriers to key areas of solar steam penetration																						
	Review opportunities for scale up of RES in electricity beyond initial 10%*																						
Power Diversification	Initiate planning, commercial and engineering studies for possible coal-fired generation																						
	Agree location and permitting process for provisional coal project																						
	Review power import opportunities via GCC grid																						
	Investigate participation in regional nuclear generation																						
	Decision to sanction investment in coal fired project*; implied start-up																						
	Stage gates for review and possible sanction of domestic nuclear project.																						
Refinery Expansion	Review availability of gas-based NGL feedstock for C2 petrochemicals - Liwa Plastics & Duqm																						
	Consider firm allocation of C2 feedstock to LPP																						
	Assign Duqm refinery/petchem and downstream industries for startegic gas allocation*																						
	Allocate provisional strategic gas-based NGL supply to Duqm petrochemicals*																						
	Allocate provisional C1 gas feedstock for acetic acid Duqm project* (options)																						
	Firm allocations and sanction investments in Duqm refing plus petchem* (options)																						
Efficiency Program	Institute National Efficiency program based on JICA recommendations																						
Integrated Energy Planning	Agree institutional requirements / appropriate bodies for energy policy making and planning																						
	Initiate coordinated planning cycle for electricity and gas forecasting																						
	Develop consistent assessments of uncertainty around energy supply chains																						
	Institute and manage a regular comprehensive strategy and policy update process																						

* to be progressed dependent on firming of expectation of gas surpluses or shortages

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