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Pricing electricity and supporting renewables in Heavily Energy Subsidized Economies

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Heavily Energy Subsidized Economies' energy subsidies cost the budget on average 4% of GDP in 2014. Resource rents permit administratively undemanding transfers to citizens to maintain political support, whose removal will be resisted, despite resulting inefficient consumption and lock-in risk. Collapsing energy prices delivering severe fiscal shocks combined with growing concerns over climate change damage make carefully designed reforms both urgent and politically more acceptable. Political logic suggests designing reforms that compensate vocal interest groups. The paper presents evidence on the magnitude and impacts of oil, gas and electricity subsidies, and discusses how the electricity sector can be weaned off subsidies, enabling CCGTs and unsubsidized renewables to reduce carbon emissions.

Keywords Energy subsidies, interest group politics, reforming electricity tariffs, renewables.

JEL Classification H23, h53, Q41, Q48, Q54

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Abstract
Heavily Energy Subsidized Economies' energy subsidies cost the budget on average 4% of GDP in 2014. Resource rents permit administratively undemanding transfers to citizens to maintain political support, whose removal will be resisted, despite resulting inefficient consumption and lock-in risk. Collapsing energy prices delivering severe fiscal shocks combined with growing concerns over climate change damage make carefully designed reforms both urgent and politically more acceptable. Political logic suggests designing reforms that compensate vocal interest groups. The paper presents evidence on the magnitude and impacts of oil, gas and electricity subsidies, and discusses how the electricity sector can be weaned off subsidies, enabling CCGTs and unsubsidized renewables to reduce carbon emissions.

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1. Introduction

Typically, Heavily Energy Subsidized Economies (HESEs), defined in the next section, choose energy subsidies on the back of energy rents and energy exports as a way of passing those rents back to their citizens, and to buy public support with generous welfare benefits and subsidized energy. In the face of limited capacity to invest returns profitably locally, and perhaps lacking the confidence of the population that sovereign wealth funds will provide future benefits (or because the discount rate that the population applies exceeds the likely return to such funds) there are evident attractions in transferring at least some of the resource rents directly to the population.[2]

Once subsidies are in place, the groups that benefit are likely to strongly resist their removal. Social welfare theory argues that resource rents in excess of the costs of basic administration should ideally be returned as lump sum demo-grants, translated into the public finance precept that they should be used to finance essential public services such as health and compulsory education that are their practical equivalent. Given the volatility of resource rents, it is also desirable to smooth revenue fluctuations by investing in or withdrawing from a sovereign wealth fund, such as the Norwegian Government

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[2] Victor (2009) sets out the political economy theory of interest groups that influence a government's chances of survival.

Pension Fund (previously called the Petroleum Fund of Norway). The kinds of reforms to tax and expenditure systems favoured by public economics presuppose an efficient, trusted and uncorrupt fiscal system and public administration that may be lacking. Once alternative forms of rent allocation are chosen they can be hard to change.

Just as energy taxes are easy to collect, so energy subsidies are easy to administer, even if they cumulatively lead to highly inefficient patterns of consumption with the risk of lock-in. As rents decline and/or as energy prices fluctuate, so the HESEs suffer increasingly severe fiscal shocks. As international pressure to alleviate climate change increases, HESEs find themselves increasingly isolated and face the risk of either global agreements on carbon pricing, or heavy import taxes on their energy exports, which may be extended through border tax adjustments to their energy-intensive exports.

Subsidy reform is considered difficult (GSI, 2010; Whitley and van der Burg, 2015) but understanding their political logic suggests designing reforms that compensate the most vociferous interest groups, while it may be easier to make structural reforms when the resource rents have fallen and budgets are under stress (OECD, 2010). Recent experience in some Gulf countries has belied the earlier pessimism that removing fuel subsidies was almost impossible. Saudi Arabia doubled gasoline prices and trebled diesel prices between 2015-16, with Bahrain, Kuwait and Qatar all making major price increases (Krane and Hung, 2016). That suggests that concepts of solidarity may allow the removal of other subsidies that most benefit higher income groups – and the electricity sector is therefore a good sector for further reform.

This paper examines strategies to reduce subsidies to electricity and decarbonize that sector. HESEs that have both oil and gas, and still use oil in power generation, would seem to have a simple option of switching to gas, which was the main source of electricity decarbonisation in Britain in the 1990s. HESEs that have already switched to gas face a harder task, as further decarbonisation would involve supporting renewable electricity supply, and in some cases, CCS or even nuclear power, if costs can be adequately reduced. Fortunately many HESEs have high levels of insolation that makes solar PV increasingly attractive and recent PV price falls have reinforced that prospect. That makes bringing fossil-fuel generation prices up to cost-reflective levels even more important so that an economic choice between fossil fuels and renewables can be made.

The next section of the paper defines the concept of a heavily energy subsidizing economy and characterizes the extent and form that these subsidies take. Section 3 is the core of the paper, looking in detail at electricity subsidies, which requires an estimate of the opportunity cost of gas to determine the cost of gas-fired electricity generation. This involves a discussion of carbon pricing, and allows a comparison of the social costs of local gas and solar PV. The final subsection addresses electricity subsidy reform, building on evidence of successful reforms. Section 4 concludes.

2. HESEs – definitions and characteristics

IEA (2016) presents the latest data on energy subsidies, discussed in IEA (2015). That shows world-wide fossil-fuel consumption subsidies of $493 billion in 2014, "$39 billion down on the previous year, in part due to the drop in international energy prices, with subsidies to oil products representing over half of the total. Those subsidies were over four-times the value of subsidies to renewable energy." Heavily Energy Subsidized Economies (HESEs) are defined in this paper as those countries that devoted more than 1.5% of GDP in 2014 to explicit subsidies to energy, as defined by the IEA (2016). The emphasis on explicit subsidies directs attention to their impact on the budgets of these countries, and massively understates the *economic* subsidies set out in Coady et al. (2015) and in Table 1. The fact that this paper concentrates on a subset of HESEs does not alter the fact that many other countries, including many advanced OECD countries, continue to subsidize fossil fuels while agreeing to the COP21 climate commitments.

Table 1 Estimates of economic subsidies to fossil fuels, 2014, $US billions

fuel	pre-tax subsidies	global warming	air pollution	foregone consumption tax revenue	Total	shares
Oil	$267	$202	$291	$224	$984	23%
Coal	$5	$617	$1,889	$19	$2,530	60%
Nat gas	$112	$267	$56	$48	$483	11%
Electricity	$156			$76	$232	5%
Total	$541	$1,086	$2,235	$367	$4,229	100%
shares	13%	26%	53%	9%	100%	

Source: Coady et al (2015)

Note: excludes subsidies attributed to not charging for congestion, accidents and road damage as these are properly road vehicle externalities and would arise even with electric vehicles.

The difference between the two measures of subsidies lie in the failure to charge for environmental externalities (air pollution and climate change damage), granting preferential treatment (state aids) to energy producers (lower borrowing rates to state enterprises) and the failure to levy efficient taxes on final producers (e.g. taxing energy at a lower rate of Value Added Tax than almost all other commodities). This difference is massive, as table 1 shows. Pre-tax subsidies, the explicit subsidies that effectively come out of the budget or deprive the budget of revenue, amounted to $541 bn in 2014, only 13% of the total of $4,229 bn. Note the very high social cost of air pollution from coal, and that air pollution costs twice the estimated global warming damage (at the assumed 2013 carbon price of $36/tonne CO_2 from US Government, 2013).

Table 2 gives the subsidies for the 30 HESE meeting the criterion of at least 1.5% of GDP in pre-tax subsidies in 2014, as a share of GDP and in US$ amounts, ranking the countries by the share of subsidies in GDP in descending order.

Table 2 2014 Subsidies (% of GDP and $ bn), 2013 resource rents and gasoline prices

Country	Oil	gas	Elec.	Total	$US bill	GDP US$ bn	US$GDP/kg oil eq.	Resource rents 2013	gasoline price $/L
Iran	9.9%	5.5%	3.9%	19.3%	$78.0	$425	$5.74	29.4%	$0.37
Libya	16.1%	0.2%	1.9%	18.0%	$7.4	$41	$8.27	47.0%	n.a.
Turkmenistan	7.3%	6.9%	2.3%	16.3%	$7.8	$48	$2.52	32.1%	$0.22
Venezuela	10.2%	1.6%	3.4%	15.2%	$31.4	$381	$6.92	26.0%	$0.02
Uzbekistan	0.8%	11.3%	2.2%	14.3%	$9.0	$63	$2.90	20.2%	$1.02
Saudi Arabia	6.6%	1.1%	1.8%	9.5%	$71.3	$746	$7.19	46.4%	$0.16
Algeria	6.5%	1.5%	1.4%	9.4%	$20.2	$214	$10.67	28.2%	$0.27
Oman	3.7%	3.2%	1.9%	9.0%	$7.0	$82	$5.55	38.8%	$0.31
Egypt	5.6%	0.6%	1.8%	8.0%	$23.0	$287	$11.03	10.9%	$0.88
Bahrain	2.3%	0.0%	4.4%	6.7%	$2.3	$34	$4.26	23.6%	n.a.
Bolivia	4.7%	0.6%	0.6%	5.6%	$1.9	$33	$6.97	16.1%	$0.70
Ecuador	5.1%	0.0%	0.5%	5.6%	$5.6	$101	$11.04	17.0%	$0.60
Iraq	4.7%	0.0%	0.9%	5.6%	$12.4	$224	$10.64	42.9%	$0.43
Kuwait	2.0%	0.8%	2.3%	5.1%	$8.8	$164	$7.61	59.1%	$0.22
Ukraine	0.0%	2.8%	2.1%	4.9%	$6.4	$132	$3.09	9.7%	$1.17
UAE	1.2%	2.4%	0.9%	4.4%	$17.6	$399	$7.97	23.7%	$0.47
Trin. & Tob.	2.2%	0.0%	1.4%	3.6%	$1.0	$29	$2.09	34.4%	n.a.
Indonesia	2.2%	0.0%	0.9%	3.1%	$27.7	$889	$10.78	7.6%	$0.93
Qatar	1.1%	0.8%	1.1%	3.0%	$6.2	$210	$7.07	34.6%	$0.23
Pakistan	0.0%	1.8%	0.9%	2.7%	$6.8	$244	$9.06	3.9%	$0.94
Argentina	0.4%	0.9%	1.2%	2.5%	$13.6	$538		3.8%	$1.52
Brunei	1.9%	0.0%	0.0%	2.5%	$0.4	$17	$7.65	35.1%	$0.41
Kazakhstan	1.2%	0.2%	0.2%	2.5%	$5.3	$218	$4.82	31.5%	$0.81
Russia	0.0%	0.9%	1.2%	2.1%	$39.6	$1,861	$4.41	18.8%	$0.81
Azerbaijan	0.4%	0.9%	0.7%	2.0%	$1.5	$75	$10.79	36.4%	$1.21
Angola	1.7%	0.0%	0.2%	1.9%	$2.4	$138	*$11.02*	35.0%	$0.76
India	1.5%	0.2%	0.2%	1.9%	$38.2	$2,049	$7.79	5.9%	$1.10
El Salvador	0.0%	0.0%	1.8%	1.8%	$0.5	$25	$10.71	1.7%	$1.12
Bangladesh	0.1%	1.0%	0.5%	1.7%	$3.1	$173	$12.71	3.4%	$1.30
Malaysia	1.6%	0.0%	0.0%	1.6%	$5.3	$338	$8.11	10.0%	$0.68
Total/wted av.	2.2%	0.8%	1.0%	4.0%	$462	$10,175	$6.83	17.6%	$0.75
All 37 countries	1.1%	0.5%	0.5%	2.1%	$493	$23,432			

Sources: Subsidies: IEA (2016), other data: WDI (2016).

The penultimate line in Table 2 shows that the GDP-weighted average share of GDP subsidies to oil and gas is 3.0% and for all subsidies is 4%. Electricity subsidies are 1% of GDP. As we have excluded the other 7 less-heavily subsidized countries (i.e. less than 1.5% of GDP) that account for more than half the total GDP, the subsidy share for the fuller IEA sample of 37 countries is roughly half that of the HESEs.[3] The 37 countries account for 32% of world GDP, and the 30 listed for 13% of the world total. The total natural resources rents in table 2 are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents as a share of GDP for 2013.

[3] The IEA reports on 41 countries, but the data above excludes Colombia, Ghana, Taipei and Vietnam.

Figure 1 shows the top 25 countries ranked by total $ subsidy. The top six countries account for 60% of the total subsidies paid by these 25 countries (58% of the whole sample of 37 countries). China – a large country with a small subsidy share of GDP - ranks 10th in this group but falls outside table 2.

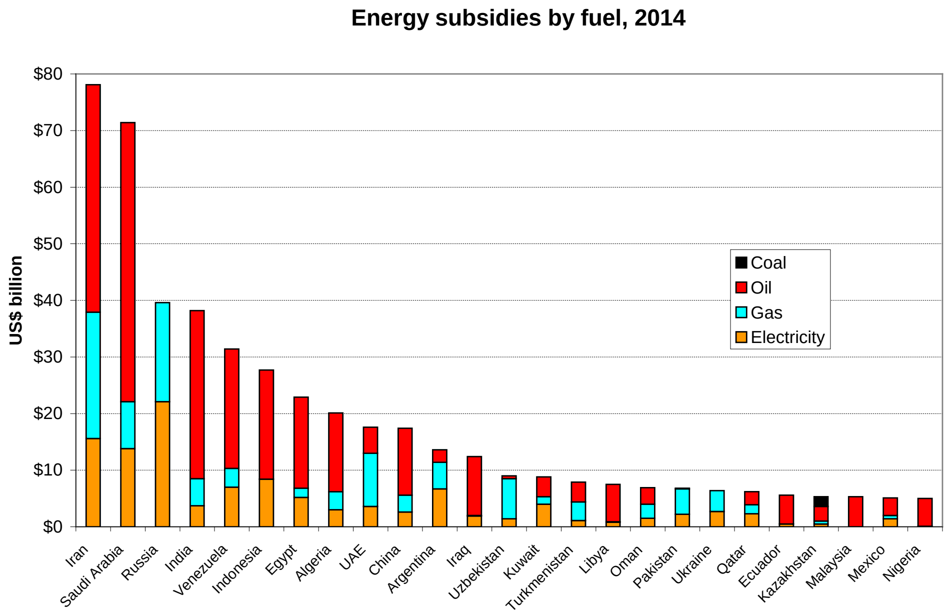

Figure 1 Total subsidies by fuel for selected countries, US$ billion, 2014
Source: WDI (2016).

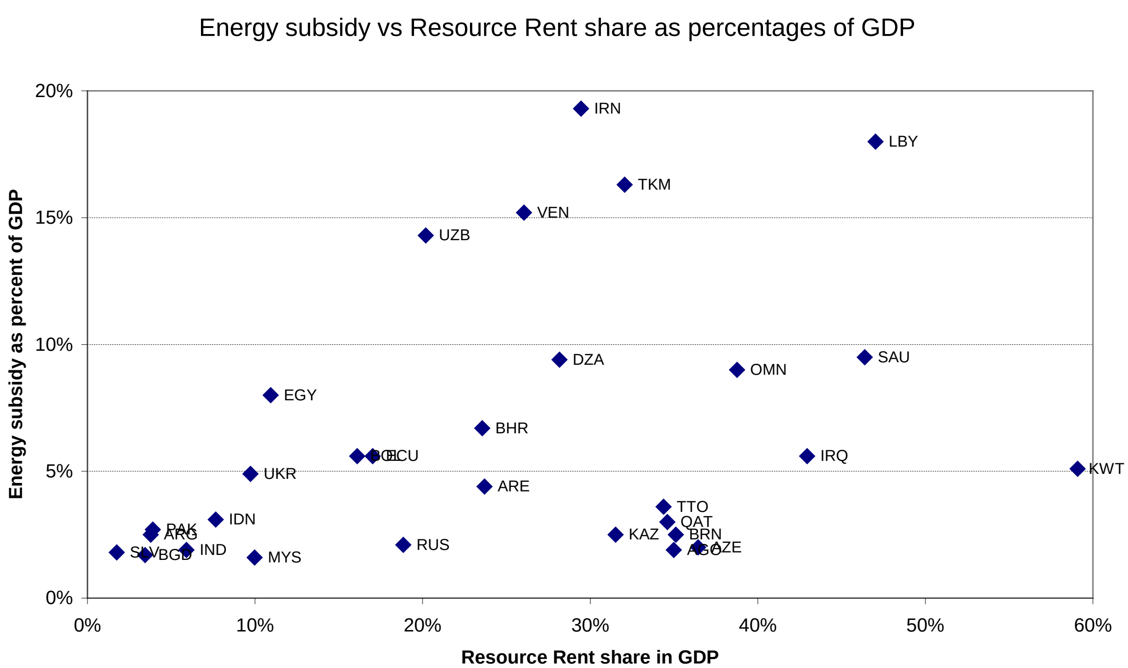

Figure 2 Energy subsidy rates increase with resource rent
Source: WDI (2016).

Figure 2 and 3 show the expected relationship between resource endowment (rents as a share of GDP) and energy subsidies in total (also as a share of GDP) and the extent of gasoline subsidy (the price is for 2012, in which year the world average price was $1.41/litre and the US pump price was $0.97/litre).

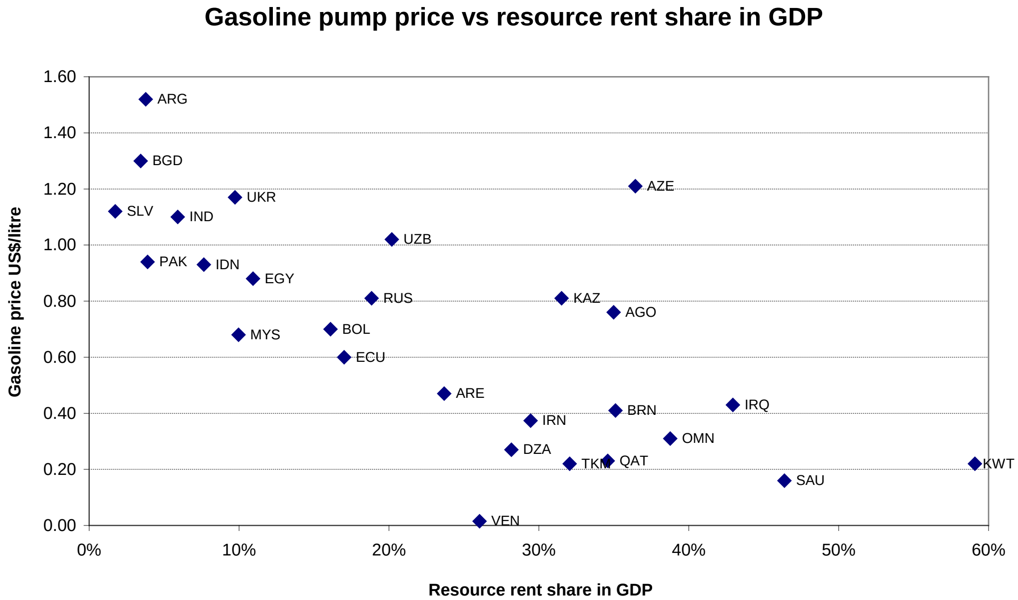

Figure 3 Highly resource intensive economies subsidize gasoline more heavily
Source: WDI (2016). Gasoline pump prices include taxes as well as subsidies.

Since 2013-14, oil and gas prices have fallen considerably, as figure 4 shows.

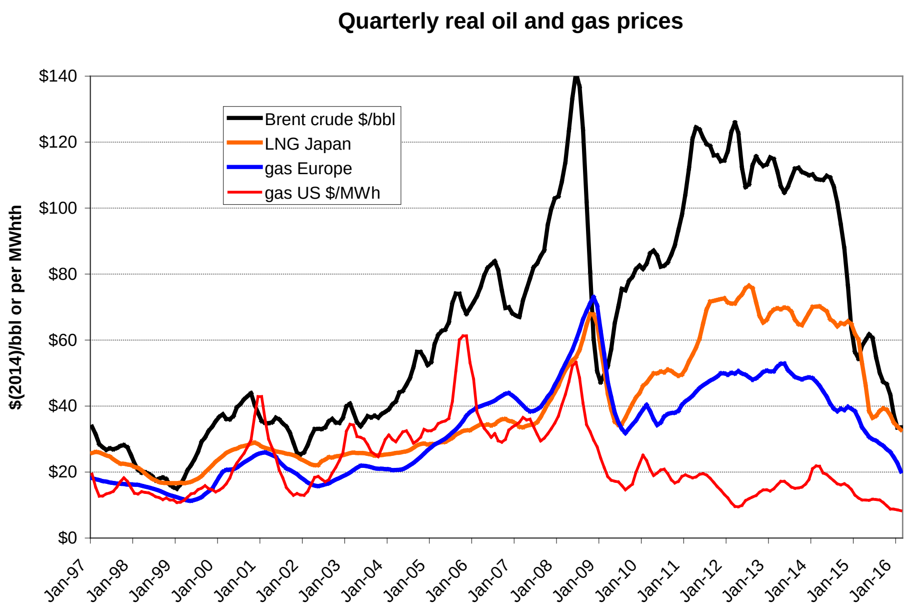

Figure 4 Quarterly centred real oil and gas prices, 1997-2014
Source: EIA, BP (2015) and World Bank (2016) deflated by US CPI.

As many of the HESE rely on resource rents for a large share of fiscal and export revenues, this will have had a dramatic effect on the budget and trade deficits, reducing the ability of these countries to maintain subsidies. If subsidies take the form of setting the domestic price of energy at an absolute level then the subsidy element will naturally fall with the fall in energy prices, offering the opportunity to ensure that local energy prices rise in line (and ideally catch up) with export (or import) prices. Indeed, one could defend this strategy as a rather inefficient way of hedging domestic consumers against fiscal and hence public spending volatility, although not as good as a sovereign wealth fund (that requires highly competent administration of the kind that few countries other than Norway have achieved for any sustained period).

However, in many countries, Figure 3 shows that the domestic oil product prices are so far below export parity that this will not solve the problem without considerable price increases, and the Gulf States examples cited above suggests that once citizens appreciate the nature of the budgetary challenge they are often willing to accept the removal of the more visible subsidies on diesel and gasoline. Raising energy prices is likely to be politically more acceptable than reducing other social transfers.

Figure 5 shows the significance of oil exports and total subsidies relative to GDP, showing what would have happened if the 2013 volume of exports were continued to 2015, reflecting the impact of the price fall then. (The absolute level of oil production at these two prices and the level of oil subsidies are shown in Appendix figure A1.)

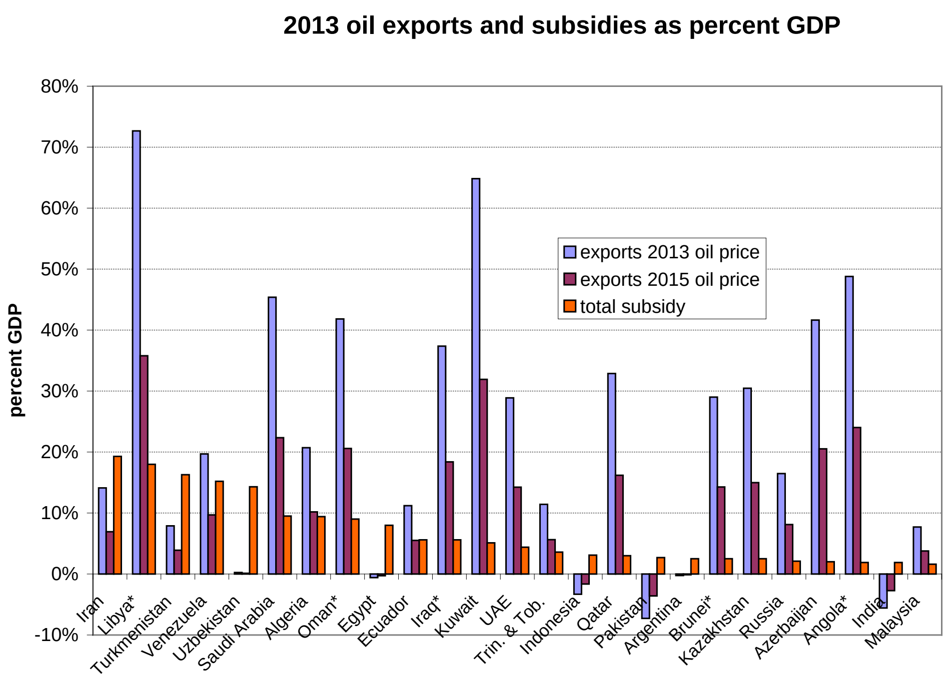

Figure 5 Estimated values of 2013 oil exports and total subsidies as a share of GDP
Note: Exports = production less consumption from BP (2015), valued at Brent oil prices
* From IEA (http://www.iea.org/statistics/statisticssearch/) as BP consumption data lacking.

Clearly the impact on the balance of trade for some HESEs exceeded 10% of GDP, which represents a massive trade shock.

3. Electricity subsidies and the pricing of gas for power

Figure 6 shows that electricity intensity (kWh/$(2011) PPP per capita GDP) rises with the electricity subsidy as a share of GDP. The squares show that across low middle and high income OECD countries electricity intensity rises somewhat but by nothing like as much as the range displayed by HESEs, suggesting that the relationship between electricity intensity and subsidy is strongly affected by the subsidy rate. (The squares are given a notional 0.4 of 1% subsidy to avoid overlaying the y-axis. Table A2 in the appendix gives the relevant additional data and also the carbon intensity for these countries.)

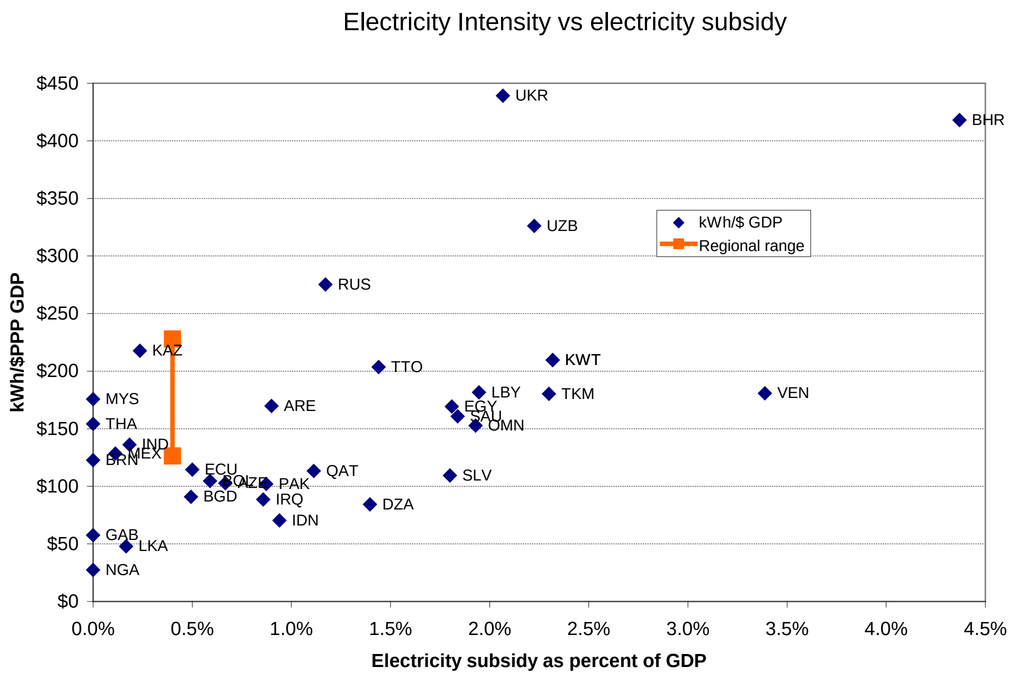

Figure 6 Electricity intensity increases with electricity subsidies

Note: The linked squares are the average intensities for Lower Middle Income (bottom) and OECD (top) countries

Source: Appendix Table A2, IEA (2016), WDI 2016.

Table 3 provides additional data for the electricity sector in HESEs, ranking the countries by the share of electricity generated by oil, and giving the size of electricity subsidies as a proportion of GDP. Zero carbon electricity shares are mainly hydro but include wind and nuclear power, so the residual from the sum of the three fuel shares is the share of coal. The final two columns indicate the importance of gas in the country. Production is valued at German import gas prices (which in most cases represents a massive overstatement of the true value, as discussed below, but allows a quantitative comparison relative to GDP across countries of very different sizes). The final column gives the ratio of reserves to 2014 production (which for Iraq is misleadingly high as production was unusually low in 2014).

Table 3 Data for electricity sector, HESEs

Country	subsidy/ GDP	fuel shares in generation 2013 gas	oil	zero-C	prodn. gas/GDP	R/P gas 2014
Kuwait	2.3%	37%	63%	0%	3%	109
Saudi Arabia	1.8%	53%	47%	0%	4%	75
Libya	1.9%	61%	39%	0%	12%	123
Iraq	0.9%	54%	38%	8%	0%	2860
Pakistan	0.9%	26%	37%	37%	6%	14
El Salvador	1.8%	0%	34%	66%	0%	n.a.
Iran	3.9%	66%	26%	8%	13%	197
Venezuela	3.4%	17%	15%	68%	3%	195
Egypt	1.8%	77%	15%	9%	7%	38
Argentina	1.2%	55%	14%	31%	3%	9
Bangladesh	0.5%	83%	13%	4%	12%	n.a.
Indonesia	0.9%	24%	12%	13%	3%	39
Algeria	1.4%	93%	7%	1%	14%	54
Malaysia	0.0%	48%	4%	9%	7%	16
Oman	1.9%	98%	3%	0%	12%	24
India	0.2%	5%	2%	20%	2%	n.a.
UAE	0.9%	99%	1%	0%	5%	105
Russia	1.2%	50%	1%	34%	11%	56
Kazakhstan	0.2%	10%	1%	8%	3%	78
Uzbekistan	2.2%	74%	1%	21%	33%	19
Ukraine	2.1%	7%	0%	51%	7%	34
Bahrain	4.4%	100%	0%	0%	14%	11
Turkmenistan	2.3%	100%	0%	0%	44%	252
Trin. & Tob.	1.4%	100%	0%	0%	53%	8
Qatar	1.1%	100%	0%	0%	21%	138
Azerbaijan	0.7%	93%	0%	7%	7%	69
Bolivia	0.6%	66%	0%	34%	17%	14
Ecuador	0.5%	100%	0%	0%	1%	n.a.
Angola	0.2%	93%	0%	7%	1%	n.a.
Brunei	0.0%	100%	0%	0%	n.a.	n.a.

Sources: BP (2015), IEA (2016).

Note: coal shares are the residual = 100% - sum of gas, oil and zero C

The first point to note is that the domestic value of oil is effectively its world market price, but the domestic value of gas depends very much on the type of gas and its access to export or import facilities. Associated gas can have a zero commercial (and negative social) value if surplus and flared, but if it can be exported or used domestically, its value will depend on its netback value. The value of non-associated gas will depend on whether it is scarce, whether it is in domestic surplus and can be exported, and whether exports are constrained by LNG or pipeline capacity. In these cases, if exports are capacity constrained and production constraints can be reasonably easily removed, the value of an extra unit of gas consumed locally (and specifically in electricity generation) is the extraction cost plus the present discounted future rent at the date of exhaustion or the date at which export constraints cease to bind. If R/P is high then this rent element could be very low.

Krane (2015) provides useful data for the six Persian Gulf Monarchies (Saudi Arabia, UAE, Kuwait, Qatar, Oman and Bahrain, italicized in Table 3). Most started with associated gas, often flared and hence with zero (private) marginal value. Oman exports LNG and Qatar is the largest gas exporter, but domestic consumption is growing rapidly in Gulf countries, mainly for electricity production. Many countries fixed the price of gas and electricity in nominal terms when gas was surplus in the 1970s or 1980s, and have often not revised them or, in the case of Saudi Arabia, have reduced them. Saudi and Kuwaiti domestic electricity tariffs fell to less than 1 US ¢/kWh, and all six have tariffs for nationals less than 2 US¢/kWh (Krane, 2015, fig 10).

Looking at the R/P ratios in table 3, one might expect the scarcity price of gas in seven of the top 9 countries (all except for Pakistan and El Salvador) should be low while their share of valuable oil use in generation is high, as are their subsidies to electricity (in all but one case above 1.8% of GDP, which is almost the share of value added of electricity in OECD countries). Assuming that they can expand gas production, removing any oil subsidies used in electricity generation and investing in cheap CCGTs would release oil for exports, and, with sensible gas pricing (at least for electricity), should be commercially attractive. The Saudi Electricity Company has had long-standing plans to reduce direct crude burn for electricity generation by more than 500,000 bbl/d by switching to natural gas, and has even more ambitious plans to expand solar and nuclear power in the next decade.[4] However, rapid electricity demand growth continues to thwart that switch given the shortage of available gas, and the Kingdom continues to build oil-fired capacity.

3.1 Calculating electricity subsidies

The way that electricity subsidies are calculated in table 3 is described as follows: "electricity reference prices were based on annual average-cost pricing for electricity in each country (weighted according to output levels from each generating option). In other words, electricity reference prices were set to account for the cost of production, transmission and distribution, but no other costs, such as allowances for building new

[4] EIA at http://www.eia.gov/beta/international/country.cfm?iso=SAU

capacity. They were determined using reference prices for fossil fuels and annual average fuel efficiencies for power generation. An allowance of $15/MWh and $40/MWh was added to account for transmission and distribution costs for industrial and residential uses, respectively. To avoid over-estimation, electricity reference prices were capped at the levelised cost of a combined-cycle gas turbine (CCGT) plant."[5]

That immediately raises the question of what is the sensible gas price and whether it is likely to differ from the reference gas price used in the subsidy estimation. The IEA uses export prices for gas exporters, but this seems to exclude the cost of any liquefaction or other transport costs and the shadow price of export constraints.[6]

For gas-rich countries it is the current cost of extracting and delivering it to the power station *plus* the resource rent, which in many cases of high R/P, will be nearly zero. (Another test would be the netback value of gas used to manufacture and export fertilizers or LNG, fully accounting for the investment costs needed). However, in some of these countries gas extraction costs can be high (most Gulf Monarchies have difficult gas geologies and tight gas; Krane, 2015). Finding reliable data on the opportunity cost of gas for power is difficult, and evidence is patchy. Thus in 2014 Iran and Oman agreed on a gas pipeline to export 350 Bcf/yr to Oman, but while Iran expected a price of $11-14 /mmBtu Oman aimed at $6-8/mmBtu (which would also have to cover the cost of the pipeline).[7] At that time European gas prices were $11/mmBtu and in the US $5/mmBtu. Since then spot gas prices have fallen 60% in both these markets (Figure 4). In 2013 Saudi Arabia sold domestically at $0.75/mmBtu compared to the Henry Hub price of $3.73/mmBtu,[8] but this has since been increased to $1.25/mmBTu for power production. In the gulf Monarchies (apart from Qatar) extraction costs range from $3-9/mmBtu, but in Qatar might be below $1/mmBtu.[9]

Egypt typically paid $2.65/mmBtu to foreign operators, considered by them too low to develop new fields. More recently, EGAS has signed deals ranging from $3.95 to $5.88/mmBtu but this is for off-shore and deep-water fields that would be considerably more costly than on-shore fields. To gain some sense of on-shore gas costs excluding a

[5] http://www.worldenergyoutlook.org/resources/energysubsidies/methodology/

[6] The IEA methodology states that "For net exporters, reference prices were based on the export parity price: the price of a product at the nearest international hub, adjusted for quality differences if necessary, minus the cost of freight and insurance back to the net exporter, plus the cost of internal distribution and marketing and any VAT." This doubly overstates the opportunity cost of gas into power stations.

[7] The 400 km pipeline (200 km subsea) was estimated to cost $1.5 bn which, amortized over 20 years at 12%, represents a cost of $1.75/MWh$_{th}$ (see https://www.pipelinesinternational.com/2016/03/26/kogas-to-construct-iran-to-oman-pipeline/)

[8] Price data mainly comes from the country fact sheets on the EIA website, http://www.eia.gov/. All $ are US$.

[9] Krane (2015) suggests production costs are below $1/mmBtu.

large scarcity rent, the US pre-shale gas prices from 1990- 2000 averaged $(2014) 3.06/mmBtu ($10.4/MWh$_{th}$)[10] with a standard deviation of $0.73/mmBtu.

The conclusion is that the efficient cost of gas for power generation varies even across the cheaper gas-rich countries, from $1-5/mmBtu ($3-17/MWh$_{th}$), but this could be below the cost of tight gas, off-shore gas, or even pipeline gas, depending on the pipeline transit fee and the way the gas is priced (effectively how much monopoly rent the gas producer can extract from its favoured location and the extent of competition).

3.2 Gas-fired generation costs

The costs of generating electricity in a Combined Cycle Gas Turbine (CCGT) includes fuel, other O&M costs and the return on and of the capital cost (capex). To convert from gas prices to fuel costs multiply the cost of gas measure in $/MWh$_{th}$ by two to give $/MWh$_e$. Variable O&M costs were estimated at $3.6/MWh, fixed O&M at $13.2/MWh and capex at $14/MWh for a baseload CCGT in the US,[11] totaling $31/MWh, but this might under-estimate the cost in the countries under consideration. Comparable European estimates (VGB, 2011) are €(2011)20/MWh or $(2015)29/MWh, so somewhere from $30-35/MWh might be a reasonable base-load charge to add to the fuel cost. For the gas-rich countries considered above the levelised generation cost might range from $34-70/MWh, with off-peak costs as low as the variable costs ($7-37/MWh) and the peak costs carrying an additional capacity cost of $90-105/MWh if recovered from 8 peaks hours per day. Thus even if the gas has a low opportunity cost, the capital and running costs considerably raise average generation costs, although with efficient hourly pricing the highest priced hours could be 10+ times off-peak prices (even higher multiples at seasonal peaks).

As 177 countries have or are likely to sign a climate change agreement arising from COP21 in Paris in December 2015, it would be prudent to include a shadow carbon price when making electricity investment decisions, and arguably as a target for a subsidy-free future electricity price that should guide tariff setting policy. The US Government figure of $36/t CO_2 cited above is highly sensitive to discount rates, and it is unlikely that oil and gas producers would agree (at least initially) prices much above the EUA rate of $7/tonne CO_2. A price of $10/tonne CO_2 (high by actually charged CO_2 prices) that would only raise the cost of CCGT generation by $4.5/MWh$_e$, which is low compared to the capital and running costs, although quite significant when compared to off-peak variable costs. The lack of a carbon price does not seem to be a major factor in any observed underpricing of gas-fired electricity (oil would be at least twice as bad).

Krane (2015) gives electricity prices to industrial customers in 2011 at $30/MWh in Saudi Arabia and Oman (or an implied wholesale price of $15/MWh if the IEA's transmission and distribution (T&D) costs of $15/MWh are reasonable), $40/MWh in

[10] Subscript th refers to the thermal value of the fuel as an input, subscript e to electricity output.
[11] From http://www.eia.gov/forecasts/capitalcost/pdf/updated_capcost.pdf at 12% over 25 yrs.

Bahrain ($25/MWh wholesale), $20/MWh (or $5 wholesale) in Qatar, and less than $9/MWh in Kuwait (not even bearing the T&D cost). Former Soviet countries in central Europe were notorious for underpricing energy and it is no surprise that industrial electricity prices in Ukraine are 6€¢/kWh and to households only 2€¢/kWh.[12]

Given that oil costs would be many times gas costs (and the carbon cost twice as high for oil compared to gas) and given that oil would be the peaking fuel in many of these countries, there is clearly massive electricity subsidy even if a lower opportunity cost of gas is used. Domestic electricity prices are typically even lower than industrial prices, despite needing substantially higher T&D costs, explaining the high overall level of electricity subsidy.

[12] http://www.differgroup.com/Portals/53/images/Ukraine_overall_final.pdf

3.3 Decarbonizing electricity – the cost of renewables

For the Mid-East and North Africa (MENA), grid-scale solar PV must be an attractive low-carbon option, particularly given the coincident air-conditioning load.[13] MENA has insolation of 1,900-2,300 kWh/m^2/yr, while the sunniest part of Germany (Munich) has only 1,200 kWh/m^2/yr, and Berlin just over 1,000 kWh/m^2/yr.[14] One would therefore expect PV costs in MENA to be half those in Germany, which has enjoyed massive (although heavily subsidized) PV penetration. The costs per peak Watt (W_p) continue to fall, and were projected to be \$1.43/W_p by 2020 (Brattle, 2015). Fraunhofer ISE (2015) forecasts levelised costs in North Africa and Saudi Arabia in 2025 at \$33-55/MWh.[15] This is higher than off-peak gas-fired CCGT even with a \$10/t CO_2 price, but considerably lower than peak prices, so much depends on the coincidence of load and PV output. Just the variable cost of running a CCGT on distillate could be \$80/MWh_e (\$90 including a \$10 CO_2 price) so PV should be cheaper than oil-fired generation.

Deserts near the sea, such as those in MENA countries, often have attractive wind conditions as dramatic land temperature changes relative to the sea can induce strong winds which rise in early evening and stay high overnight falling off mid-morning. In Saudi Arabia the wind speed can be over 7m/sec in some areas, and estimates that there are more than 20 GW of sites with capacity factors of 40% or more. The timing of wind power can therefore complement the fall off in solar PV and coincide with the evening peak air-conditioning demand, so competing with the high cost period of fossil generation. Egypt and Morocco had installed 800 MW by 2015 and Saudi Arabia set a renewable energy target of 9.5 GW by 2023. Recent tender prices ranged from \$25-30/MWh in Morocco, and \$40/MWh in Egypt, with one of the main barriers to further deployment being the lack of reliable wind data.[16] At these prices, wind is clearly competitive against fossil generation, particularly as these three countries have relatively higher valued gas than in some other countries.

3.4 Reforming electricity subsidies

Electricity is so valuable that consumers are willing to pay very high prices rather than go without. This can be seen in the very high values for estimates of the value of lost load or energy unserved, and in the willingness to install diesel generators in countries where electricity is unreliable. There is clearly a high willingness and ability to pay, as evidenced by the very high costs for off-grid electricity and prices that are comparable to OECD levels for grid connected customers in many poor countries, notably in Africa.

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[13] In very hot countries there is another peak electric demand in the early evening when cooling is needed for night-time comfort and then desert wind may also be blowing more strongly, failing which back-up gas-fired generation will be needed.

[14] See http://solarelectricityhandbook.com/solar-irradiance.html

[15] Opex €20/kW_p, 25 year life for cells, 15 yrs for inverter, 0.2% p.a. degradation, interest 5-6%

[16] The information in this paragraph is at http://analysis.windenergyupdate.com/emerging-markets/suppliers-use-global-desert-data-spur-middle-east-growth accessed 19/8/16

The problem of eliminating electricity subsidies is therefore entirely political – Governments fear it would be highly unpopular to remove existing consumer subsidies.

Reforming electricity prices has, however, two related aspects, each of which raises different problems. The first step is to reform wholesale price-setting, which is critical to facilitating unsubsidized renewables, and, as the Chilean example shows (Galal, 1994, 1996), for privatizing the electricity supply industry and entrenching the removal of subsidies. In that sense it is the most direct way of supporting renewables and decarbonization. While this step has the advantage that the interest groups (owners of generation companies, investors) are likely to support it, the distribution companies (which may still be part of the generating companies) will go bankrupt if they cannot raise retail prices, which is the second and politically harder step.

There are several possible responses to the feared unpopularity of raising retail prices. In some countries electricity reliability may be very low, forcing consumers to pay for back-up generation, and revealing a willingness to pay for improved reliability (Oseni and Pollitt, 2013). This offers the opportunity for the electricity utility to offer improved service for higher tariffs, which ideally could be contracted, with those unwilling to move to the higher quality service and pay cost-reflective tariffs being selectively disconnected before those with the improved contract. Such priority contracts have appealing efficiency properties as well as offering an escape from the subsidy dilemma (Chao and Wilson, 1987).

Whitley and van der Burg (2015) provide supporting evidence of increasing willingness to remove fossil fuel subsidies, citing IEA (2014) and an IMF study of 28 reforms, 12 of which were deemed successful (Clements et al., 2013). Thus Egypt has raised fuel prices by 78% and planned to double electricity prices over five years. Whitley and van der Burg (2015) note that low oil prices made it easier to remove consumption subsidies to oil products. They list a number of principles for reform, including "the efficient and visible reallocation of resources to those groups most affected through complementary measures. … where possible the best approach is to set ambitious goals, with slow, credible and specified timeframes for phasing out subsidies. This can include staggering the elimination of subsidies, and ideally should take place as part of broader sector or economy-wide reforms as part of a comprehensive approach."

That suggests finding a way to compensate those who would lose from reforming subsidies to the extent necessary to overcome entrenched opposition. Saudi Arabia is committed to reducing energy and utilities' subsidies, by $30 billion/year by 2020.[17] As part of its energy subsidy reform, the Iranian government has increased energy prices on several occasions, sometimes dramatically, but a failure to index prices in the face of high inflation has reversed these gains. Iran announced in early 2014 that electricity prices would increase by 25% and that in 2015 prices would increase again by another 20% to

[17] Financial Times, 10/4/16. P7.

reduce subsidies.[18] A clear example of a successful move to efficient pricing came from the trend-setting Chilean electricity reforms on the 1980s (Galal, 1994, 1996).

The standard solution to reforming subsidies while protecting specified groups is to provide a specified number of kWh per month per household at the existing price, but charge the efficient price for amounts taken above that level. Such increasing block tariffs have been used in many countries (California is an example) and the Gulf countries including Iran have adopted this strategy, but often failed to have sufficiently high upper tiered tariffs. Between 2015 and 2016, Saudi Arabia slightly raised oil prices for power generation (but only to $5.87/bbl), considerably raised gas prices for power to $1.25/mmBtu and considerably raised the above 2,000 kWh/*month* block tariff for residential electricity (below that it remains at 1.25 US¢/kWh), so that above 6,000 kWh/*month* it reaches 8 US¢/kWh (Krane and Hung, 2016, fig 4.). Note that the *annual* average UK residential consumption is less than 4,000 kWh, so these are still extraordinarily generous blocks.

Another strategy has been to raise prices to foreign residents, and Dubai has eliminated all electricity subsidies on foreign residents (Krane and Hung, 2016). This may make electricity subsidies to nationals more explicit and hence ripe for reform.

Fixed Transport and Distribution (T&D) costs can be also recovered from higher consuming customers per kWh/month up to the fixed T&D cost by offering customers a choice between a T&D charge per kWh or a fixed monthly payment. The size of the subsidized quantum may include an element of grandfathering for existing customers, reduced possibly to zero for new customers, and ideally reduced each year by a modest amount (e.g. 10%). Similarly, the carbon price can be phased in over time as part of the COP 21 reporting requirements. (Raising the domestic price of transport fuel to include not just the export parity value but also a reasonable road tax charge has higher priority in terms of reducing subsidies and restoring budgetary deficits, as figure 3 demonstrates.)

4. Conclusion

Energy subsidies in HESEs averaged 4% of GDP in 2014 (table 2), and were a major contributor to budget deficits. While they may have fallen as a share of GDP with falling oil and gas prices, so will tax revenues, and hence the budgets of resource rich countries will have been put under considerable stress. While it is difficult to reform subsidies, the best time to start the process is when oil and gas prices have fallen, the attraction of rents to potential opposition parties is reduced, and when the absolute level of subsidies may be at an historic low. The strategy is to incrementally remove subsidies by linking final prices to world market prices, and ideally escalating them in real terms over time. The UK successfully moved from almost the lowest gasoline taxes in Europe to the highest by raising fuel duties at 3% above the rate of inflation until the prices and taxes were

[18] Business Monitor International (BMI) Research, *Iran Power Report Q2 2015*, p8.

deemed acceptable (a balance struck between the Treasury and the people). One of the simplest ways of reducing oil subsidies would be to replace oil-fired generation with gas, as oil has a world market price and gas should be substantially cheaper.

In the electricity sector, underpricing was often inherited from past eras when gas had a negligible opportunity cost, as the alternative for associated gas was flaring, and a failure to index prices to the price index, and to index fixed cost to the written down *replacement* cost of the generation and transmission assets. That combination cumulatively led to extraordinarily low current domestic prices and correspondingly excessive electricity consumption per $GDP. With gas often now in short supply, no longer a cheap by-product as associated gas, its opportunity cost has risen, although how high depends on whether gas is export-constrained or imported, or requires the development of more costly fields. The wholesale levelised cost of CCGT with low gas costs might be $35/MWh, or $40/MWh with a $10/t. CO_2 price, but could easily be double that level. At these prices, grid-scale solar PV and on-shore wind in suitable locations (notably MENA countries) can be viable without subsidies, although this will depend critically on the coincidence of load and PV and wind output, as off-peak gas power will be substantially cheaper than on-peak power. Fortunately wind and PV output appears complementary in coastal desert conditions, facilitating their joint deployment.

To this would need to be added transmission and distribution (perhaps $15/MWh for industrial customers and up to $40/MWh for households, although the latter could be targeted on those of above average consumption). At these costs unsubsidized grid-scale solar PV can be competitive in high insolation countries, depending on its coincidence with load, such as the many HESEs in MENA.

The transition to cost-reflective retail electricity pricing could start with rising block tariffs, in which existing tariffs (indexed at least to retail prices and better, to the export price of oil or gas) would be offered for the first number of kWh/month, with rates rapidly raised to cost-reflective levels above that. The first tranche could be either reduced in volume or raised in price more rapidly than the marginal tariffs, with the aim of eliminating subsidies over a modest period, depending on the degree of push-back. High electricity prices are politically sustainable in many countries – certainly in Germany and Denmark – and past electricity prices in relation to average incomes were, at least in inter-war Britain, ten times current ratios. The problem is not the level, but the transition to the efficient level, and designing an acceptable transition should be feasible but will need to be done with care.

Once retail pricing has been reformed, wholesale electricity and gas prices can be allowed to rise to their efficient level, at which point unsubsidized renewable electricity becomes a realistic prospect in many of these countries.

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Table A1 Gas data for HESE

Country*	average 2006-14	production CV	value** 2014	subsidy $bn	R/P '14 yrs	GDP $bn	prod/ GDP
Iran	$53.26	20%	$55.73	$22.30	197	$425	12.5%
Libya	$4.78	24%	$3.95	$0.10	123	$41	11.6%
Turkmenistan	$21.16	27%	$22.37	$3.30	252	$48	44.2%
Venezuela	$10.93	16%	$9.23	$3.30	195	$381	2.9%
Uzbekistan	$20.46	14%	$18.50	$7.10	19	$63	32.7%
Saudi Arabia	$31.87	20%	$34.95	$8.30	227	$746	4.3%
Algeria	$29.81	15%	$26.90	$3.20	54	$214	14.0%
Oman	$9.61	18%	$9.36	$2.50	62	$82	11.7%
Egypt	$20.89	17%	$15.73	$1.60	38	$287	7.3%
Bahrain	$4.86	19%	$5.46	$0.00	11	$34	14.4%
Bolivia	$5.73	25%	$6.92	$0.20	14	$33	17.4%
Iraq	$0.45	37%	$0.41	$0.10	2860	$224	0.2%
Kuwait	$4.92	22%	$5.29	$1.30	12	$164	3.0%
Ukraine	$9.61	18%	$9.36	$3.70	62	$132	7.3%
Trinidad&Tobago	$15.34	13%	$13.58	$0.00	8	$29	53.1%
Indonesia	$27.43	14%	$23.70	$0.00	39	$889	3.1%
Qatar	$44.28	46%	$57.23	$1.60	4	$210	21.1%
Pakistan	$15.09	15%	$13.57	$4.50	14	$244	6.2%
Argentina	$14.56	16%	$11.44	$4.70	9	$538	2.7%
Kazakhstan	$6.08	20%	$6.22	$0.50	78	$218	2.8%
Russia	$212.12	16%	$186.87	$17.50	56	$1,861	11.4%
Azerbaijan	$5.02	31%	$5.47	$0.70	69	$75	6.7%
Malaysia	$22.79	14%	$21.45	$0.00	16	$338	6.7%
Nigeria	$13.07	23%	$12.46	$0.10	132	$569	2.3%
Thailand	$12.39	25%	$13.60	$0.30	6	$405	3.1%
Mexico	$20.50	12%	$18.76	$0.60	6	$1,295	1.6%

Sources: IEA (2015), BP (2015)

Notes * Countries ranked in descending order of total subsidies as share of GDP

** Gas valued at real German import prices

Table A2 Electricity and energy data

	electricity subsidy % GDP	per $(2011) PPP '000 energy kgoe	electricity MWh	CO_2 tonnes	electricity cons kWh/yr	GDP PPP per cap	electricity Cag* % p.a.
Bahrain	4.4%	243	418	452	17,530	$41,932	-2.6%
Iran, Islamic Rep.	3.9%	185	166	435	2,662	$16,023	4.0%
Venezuela, RB	3.4%	128	181	377	3,197	$17,690	1.3%
Kuwait	2.3%	132	210	368	15,552	$74,181	-2.4%
Turkmenistan	2.3%	370	180	1,072	2,444	$13,555	3.0%
Uzbekistan	2.2%	284	326	887	1,631	$5,002	-1.0%
Ukraine	2.1%	306	439	756	3,662	$8,338	0.8%
Libya	1.9%	139	182	563	3,552	$19,557	0.5%
Oman	1.9%	160	153	476	5,929	$38,835	5.0%
Saudi Arabia	1.8%	130	161	381	7,870	$48,963	4.1%
Egypt, Arab Rep.	1.8%	88	169	262	1,701	$10,050	3.4%
El Salvador	1.8%	88	109	145	857	$7,838	1.4%
Trin & Tobago	1.4%	478	204	1,248	6,189	$30,390	3.8%
Algeria	1.4%	94	84	255	1,122	$13,301	5.8%
Argentina	1.2%				2,901	$3,175**	4.0%
Russian Fed	1.2%	216	275	560	6,486	$23,561	1.0%
Qatar	1.1%	143	113	328	15,123	$133,395	-0.5%
Indonesia	0.9%	88	70	260	681	$9,675	6.2%
United Arab Emirates	0.9%	124	170	355	10,537	$62,056	-1.3%
Pakistan	0.9%	106	102	218	457	$4,476	-1.2%
Iraq	0.9%	98	89	318	1,341	$15,124	9.2%
Azerbaijan	0.7%	89	103	232	1,705	$16,593	-2.8%
Bolivia	0.6%	129	105	286	637	$6,091	4.7%
Ecuador	0.5%	92	115	237	1,217	$10,626	6.3%
Bangladesh	0.5%	76	91	144	258	$2,843	6.3%
Kazakhstan	0.2%	213	218	761	4,893	$22,470	2.0%
India	0.2%	118	136	355	698	$5,132	5.9%
Sri Lanka	0.2%	48	48	82	491	$10,242	4.0%
Mexico	0.1%	96	129	246	2,074	$16,141	1.3%
Brunei	0.0%	105	123	333	8,657	$70,535	1.9%
Gabon	0.0%	79	58	83	1,045	$18,172	2.7%
Malaysia	0.0%	129	176	361	4,114	$23,419	5.7%
Nigeria	0.0%	142	27	103	149	$5,448	3.5%
Thailand	0.0%	133	154	332	2,305	$14,943	3.1%
High income: non-OECD		149	201	387	6,309	$31,367	1.6%
Lower middle income		115	126	294	699	$5,527	4.1%
Middle income		140	190	413	2,716	$17,299	3.5%
Upper middle income		153	220	473	2,909	$13,201	6.6%
World		131	216	368	3,021	$13,994	1.9%

Sources: IEA (2105), World Bank Development Indicators

Notes: * compound average growth (rate)

** Argentina PPP GDP estimated from market prices and Latin American conversion to PPP.

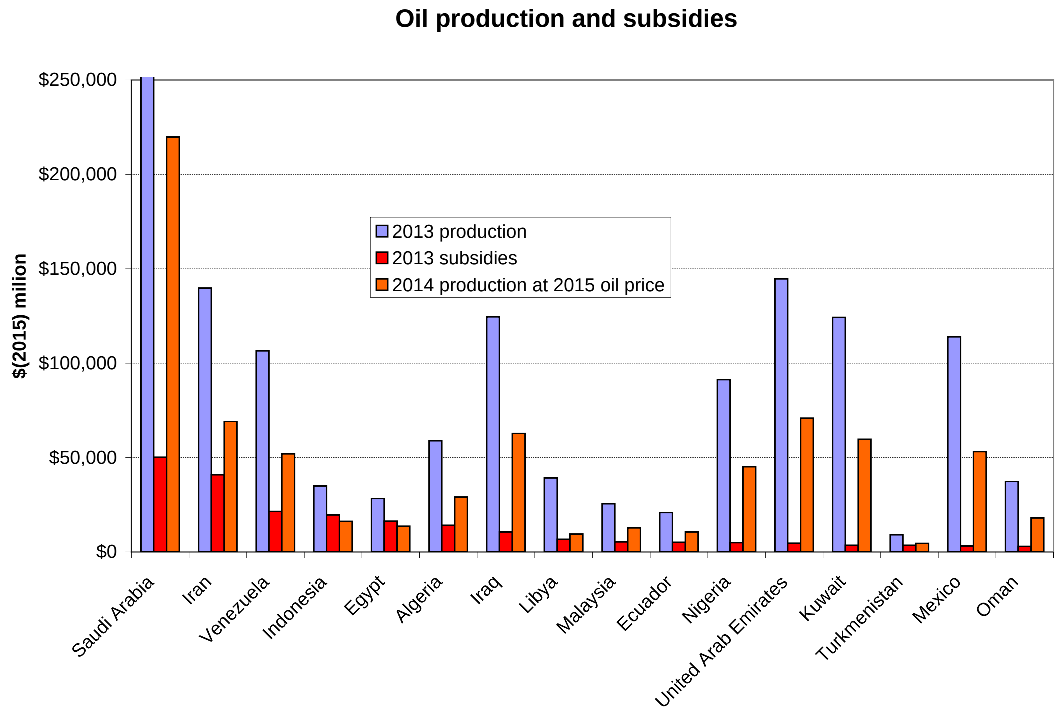

Figure A1 Value of oil production and subsidies for selected HESE
Note: Oil valued at Brent crude prices. Saudi production in 2012 was US$452 billion

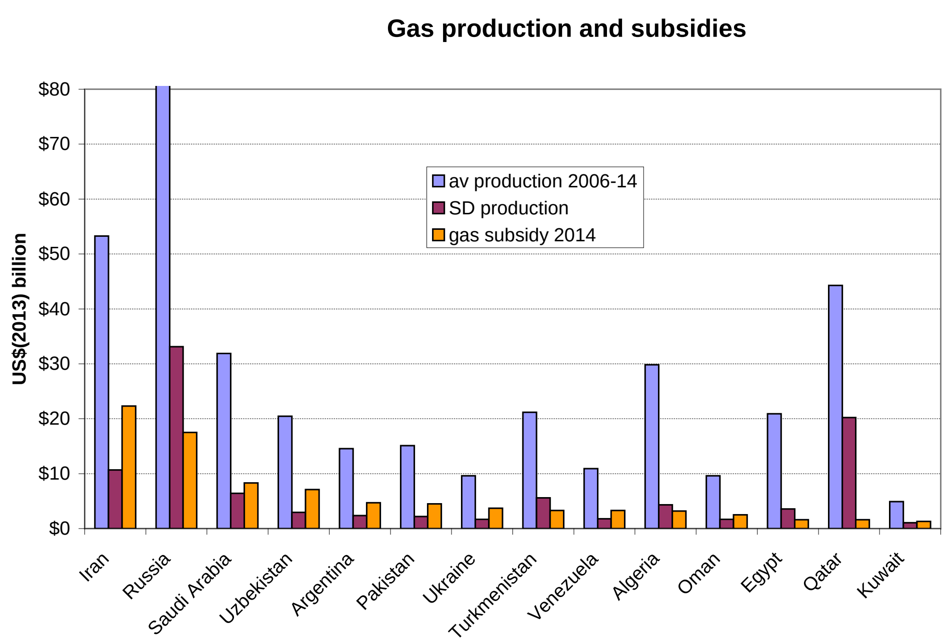

Figure A2 Production average and variability and subsidies for selected HESE
Note: Production valued at German gas import prices, Russia average = $212 bn