Potential Impacts of Solar Energy Integration on Fuel-Mix Strategies in Qatar

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ABSTRACT

This study analyzes the economics of deploying solar photovoltaic (PV) energy in Qatar, specifically the cost savings that could be achieved by replacing oil and gas for electricity generation and for transport with solar energy. A cost utility function based on nonlinear programming (NLP) is developed to optimize the savings/returns that both Qatari consumers and the Qatari government can derive from diverse fuel-mix strategies. In the context of plummeting costs for solar photovoltaic (PV) energy we find that displacing domestic use of oil and natural gas in Qatar is cost-effective in most hydrocarbon price scenarios. Policy recommendations are made based on insights gained.

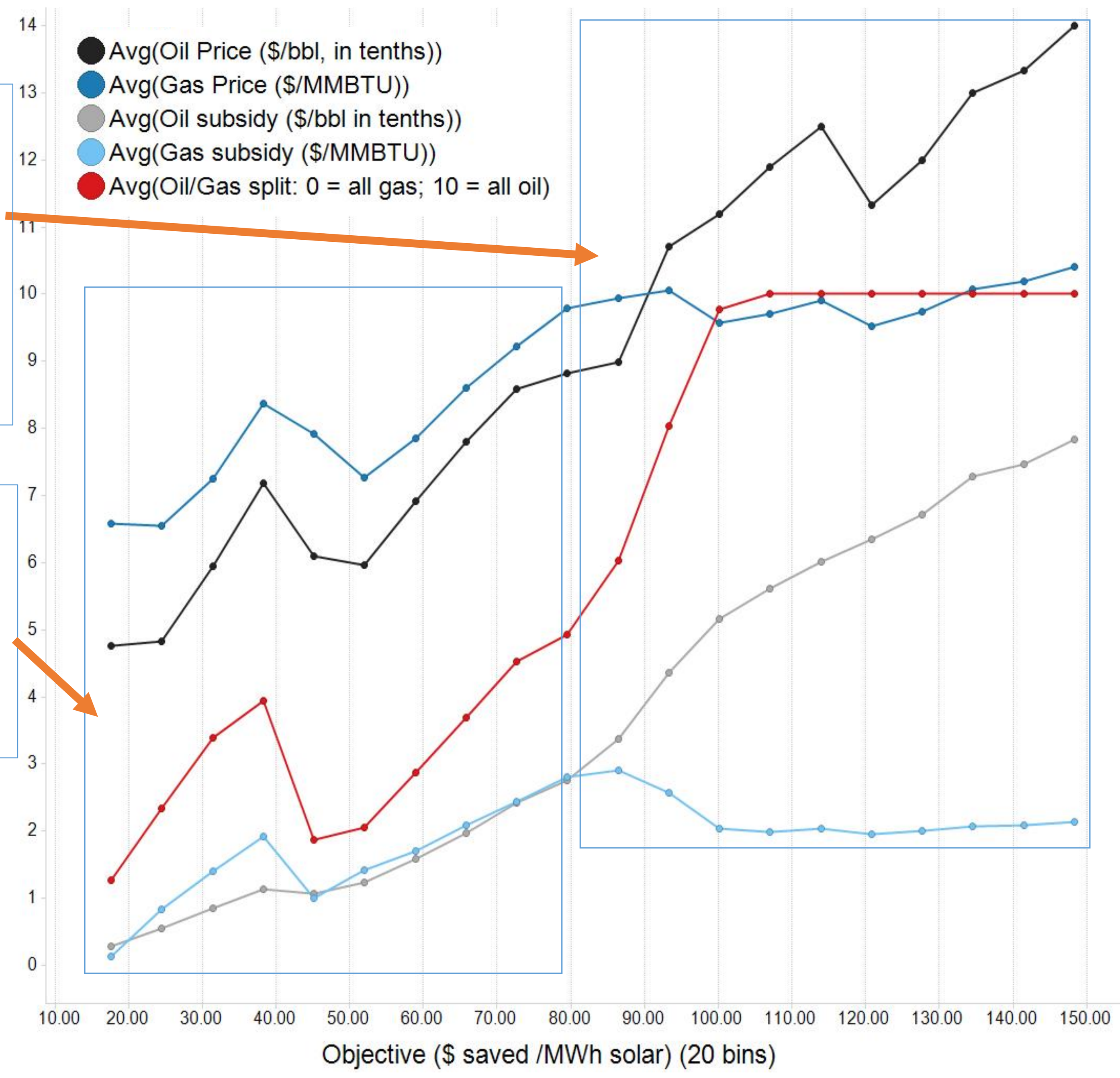
OBJECTIVES

- Establish how much electricity production can be satisfied through solar energy in 2020 and 2030
- Determine the optimal distribution of solar PV energy in replacing oil and gas
- Provide relevant policy insights that promote a sustainable economy in Qatar

RESULTS

More oil replaced
- oil subsidy > gas subsidy
- higher savings

More gas replaced
- gas subsidy ≥ oil subsidy
- lower savings



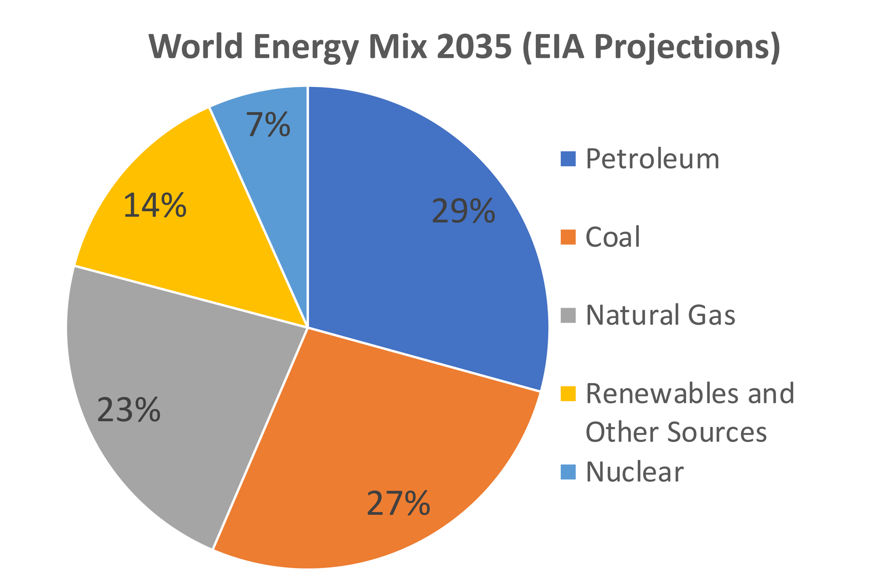
Ranking of variables in terms of their impact on dollars saved per MWh invested.

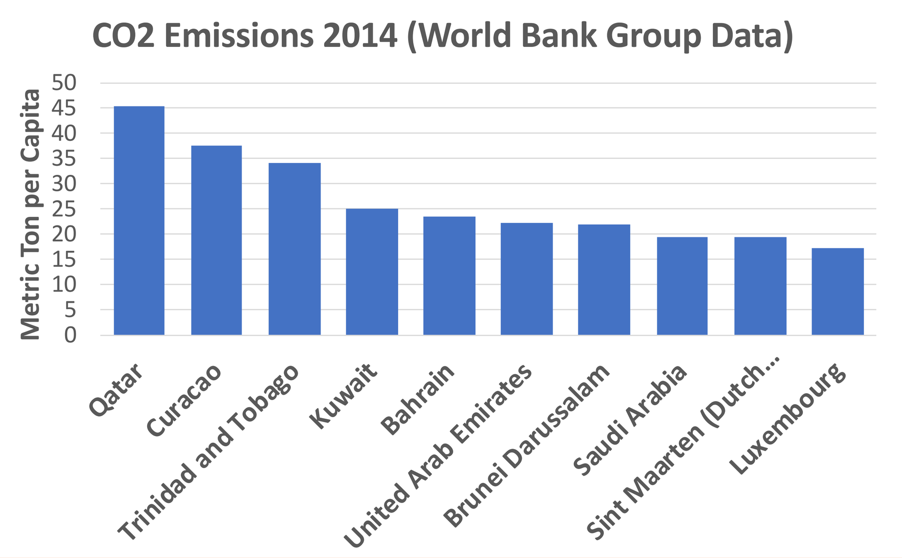
Attribute	Relativized Information Gain Ratio
Oil Price	28.7%
Oil Subsidy	23.5%
Oil-Gas split	22.2%
Gas LCOE	9.5%
Gas Subsidy	8.1%
Gas Price	7.8%
Carbon Tax	0.3%

BACKGROUND

Qatar aims to increase its solar energy output to 2% of total electricity yield by 2020, and 20% by 2030.
Solar energy can be used to
- Power businesses and homes (natural gas is displaced)
- Power (hybrid) electric vehicles (oil is displaced)

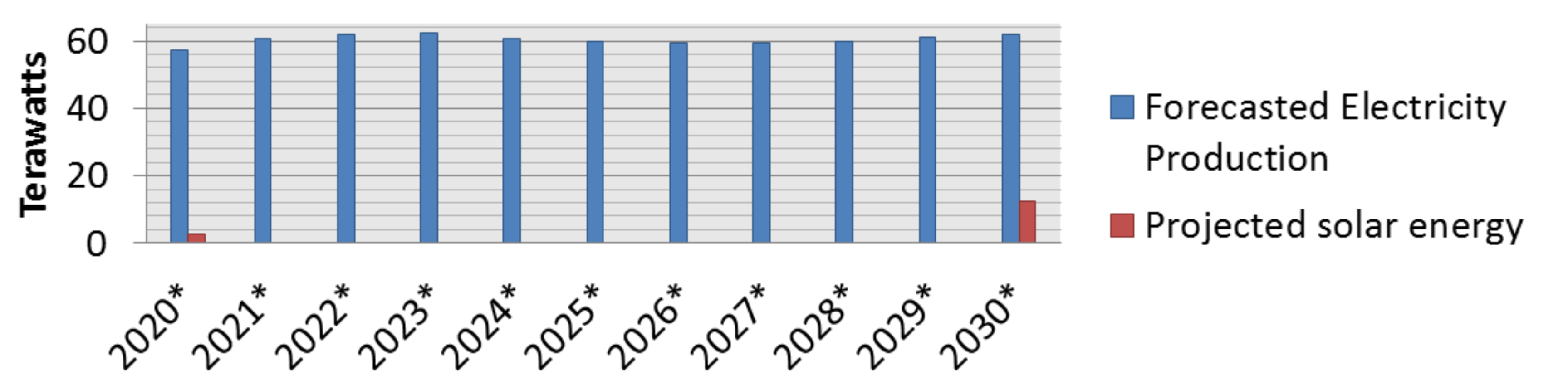
What is the optimal fuel-mix strategy?





METHODS

Quantify solar energy adoption targets as percentages of electricity production forecasts for 2020 and 2030.



Use constrained scenario generation and Nonlinear Programming to optimize gas & oil ratios to replace with solar energy, with reference to ensuing savings/returns.

Total Savings = Subsidy savings + carbon tax savings + electricity generation savings

- $Subsidy\ Savings = Oil\ replaced * (Oil\ Price - Subsidized\ Oil\ Price) + Gas\ replaced * (Gas\ Price - Subsidized\ Gas\ Price)$
- $Carbon\ Tax\ Savings = Oil\ replaced * Oil\ CO_2\ emissions + Gas\ replaced * Gas\ CO_2\ emissions$
- $Electricity\ Generation\ Savings = Gas\ replaced * (Gas\ LCOE - PV\ LCOE)$

Variables	Boundary conditions	Units
Oil/gas split	0 < x < 10	-
Oil price	10 < x < 140	$/bbl
Gas price	2 < x < 14	$/MMBTU
Oil subsidy	0 < x < 56	% of actual cost
Gas subsidy	0 < x < 41	% of actual cost
Carbon tax	0 < x < 10	$/tCO$_2$†
Gas LCOE‡	7.04 < x < 8.55	US cents/kWh

Conclusions

Our findings suggest following policy actions that could be taken:
-Reduce or curtail subsidies for electricity generated from natural gas to level the field for solar energy.
-Maximize cost savings through solar PV adoption by aligning investments with the return opportunity, based on global oil prices
-Reinvest cost savings achieved through solar PV adoption to help consumers switch to renewable energy technologies, such as building-integrated PV and electric vehicles.
-Avoid building new gas-fired power stations to meet growing electricity demand, preferring the use of building-integrated PV applications and solar power plants