



Multinational uranium enrichment in the Middle East



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ABSTRACT

The Joint Comprehensive Plan of Action (JCPOA) agreed to by Iran and the P5+1 in July 2015 placed restrictions on Iran's nuclear program while other Middle Eastern countries—Egypt, Jordan, Saudi Arabia, Turkey, and the United Arab Emirates—are planning to build their own nuclear power plants to meet increasing electricity demands. Although the JCPOA restricts Iran's uranium enrichment program for 10–15 years, Iran's neighbors may choose to develop their own national enrichment programs giving them a potential nuclear weapons capability. This paper argues that converting Iran's national enrichment program to a more proliferation-resistant multinational arrangement could offer significant economic benefits—reduced capital and operational costs—due to economies of scale and the utilization of more efficient enrichment technologies. In addition, the paper examines policy aspects related to financing, governance, and how multinational enrichment could fit into the political and security context of the Middle East. A multinational enrichment facility managed by regional and international partners would provide more assurance that it remains peaceful and could help build confidence between Iran and its neighbors to cooperate in managing other regional security challenges.

1. Introduction

A lot of effort has gone into helping reach an agreement between Iran and the P5+1 – The United States, Russia, China, France, The United Kingdom and Germany – over Iran's nuclear program. However, so far little effort has gone into exploring the next steps. With Iran gaining the international community's conditional acceptance of its nuclear program and the UAE constructing four planned nuclear reactors, nuclear energy has become a reality in the Middle East. Turkey, Saudi Arabia, Jordan and Egypt also are at different stages of planning their first nuclear power plants.

Regardless of the economic suitability of nuclear power for countries in the region, national nuclear programs, particularly those that would include nuclear fuel cycle activities such as uranium enrichment and/or reprocessing, would offer states the implicit capability to develop nuclear weapons, posing a major security threat. Such a threat seems especially prevalent when we look at existing geopolitical tensions within the region, especially between Iran and Saudi Arabia whose rift has only deepened over the years. Additionally, the spread of non-state actors and terrorist groups in the region makes the management of nuclear security, against sabotage of nuclear facilities, a more urgent and complex task.

Considering Iran's plans to expand its uranium enrichment program to produce fuel for nuclear power reactors, which will also have the effect of shortening the time needed to produce a significant quantity of highly-enriched uranium (HEU) for a nuclear weapon, other regional powers such as Saudi Arabia would certainly value added assurances that Iran's enrichment program remains peaceful. Consequently, the concept of multinational enrichment could be seen by regional players as a major step in ensuring nuclear security, therefore, allowing them to forgo their own national programs.

In a recent study, Alexander Glaser, Zia Mian and Frank von Hippel proposed to use the next 10 years to convert Iran's enrichment program to a multinational one that could include other countries in the region that are planning to establish civil nuclear programs as well as one or more members of the P5+1 group (Glaser et al., 2015). In a subsequent study, Ali Ahmad and Ryan Snyder presented a preliminary assessment of the enriched uranium capacity required to fuel planned nuclear power programs in the Middle East, and found the range of enriched uranium capacity to be between 1.2 and 4.4 million SWUs per year (Ahmad and Snyder, 2016).

With the proper framework, a multinational uranium enrichment facility could add to the transparency of current and future enrichment operations taking place in Iran and in the region. This would further

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reassure the international community of Iran's non-proliferation promises and consequently lead to better relations between Iran and both its neighbors and world powers.

In April 2016, Behrouz Kamalvandi, the spokesman for Iran's Atomic Energy Organization (AEOI), said “There is an enormous ground for cooperation with neighbors, especially in the Persian Gulf region, in the peaceful nuclear energy field” (PressTV, 2016). More recently, Ali Akbar Salehi, AEOI's President, announced Iran's “readiness to share our accumulated experience in the nuclear industry with our Persian Gulf neighbors” and “to establish a regional nuclear scientific contact group, as was the model between Brazil and Argentina” during a World Nuclear Association conference in London (Nuclear Intelligence Weekly, 2016). More specifically on enrichment, Kamalvandi, mentioned the role that could be played by Iran's enrichment facilities “Our centrifuges can help with the regional development at very reasonable prices. What is called for is to work out a cooperation mechanism among ourselves.”

As part of assessing the concept of establishing a multinational uranium enrichment in the Middle East, this paper examines the economics of such a proposal. Such an economic analysis could provide further incentive for concerned countries to move forward with a joint initiative as opposed to establishing their own national enrichment programs. Our results showed that having a multinational uranium enrichment facility could indeed offer significant cost savings due to benefiting from economies of scale and higher utilization of efficient enrichment technologies. Politically, such an arrangement also could improve transparency and promote cooperation between Iran and its neighbors. It is worth noting that Israel is not included in this analysis because it does not have a civilian nuclear program.

Beyond economics, the paper highlights some relevant policy questions such as how a multinational uranium enrichment facility in the Middle East could be governed and financed* Additionally, the paper examines the political context for such an initiative in the region, and more importantly, how it could help reduce tension and security concerns while promoting technical cooperation and trust.

2. Method

The analysis presented in this paper is based on a combination of discourse and quantitative elements. The discourse analysis used information obtained from the existing academic literature on the deployment of nuclear power in Iran, Egypt, Jordan, Saudi Arabia, Turkey and the United Arab Emirates. Additionally, the discourse analysis used information sources such as official government statements and documents, policy reports released by international organizations such as the International Atomic Energy Agency (IAEA) and articles in the popular media.

The quantitative analysis used a discounted cashflow methodology to estimate the levelized cost of uranium enrichment for each country separately and for the Middle East region as a whole. Estimates of overnight capital costs and labor costs based on proposed enrichment capacities are obtained using a microeconomic-cost-engineering model proposed by Rothwell (2009). Fig. 1 shows the parameters used to estimate the levelized enrichment costs (\$ per SWU).

Overnight capital costs are estimated using a function of plant's enrichment capacity proposed by Rothwell:

$$k_i = 0.914 \times (SWU_i)^{0.76}$$

where k_i is the overnight capital cost in 2008 dollars, measured in billions, and SWU_i is the plant's annual enrichment capacity, measured in millions. Annual capital costs are calculated using a capital recovery factor that depends on a certain discount rate and loan payback period.

Similar to Rothwell's approach, the model assumes contingency (cost of known uncertainties) and interest during construction (IDC) rates to be 10% and 7.5%, respectively. It should be noted that the cost of physical depreciation of the plant's centrifuges and other equip-

ments, which essentially covers the cost of replacing old centrifuges with newer ones, are calculated based on the assumption that depreciation cost would be 1% of the overnight capital cost.

This model is based on different centrifuge technologies found at five different facilities in the U.S., France and Brazil. Specifically, the performances of these technologies vary with their maturities and thus have different separative capabilities from the centrifuges currently operating at Natanz, in Iran. For example, annual SWU capacity per centrifuge is estimated to be at 3 SWU/yr in Iran, while at URENCO plants it is between 50 to 100 SWU/yr (Rothwell, 2009). These ranges in separative performance make estimates of the capital costs rather difficult given the underlying confidentiality of certain cost parameters of enrichment technology. Further data regarding Iran's enrichment technology would need to be revealed for a more accurate assessment of capital costs. Nevertheless, the performance of enrichment technology could be further enhanced with the cooperation of shareholders and external suppliers.¹

As for discount rates, they vary with the credit rating of each country. For Saudi Arabia and UAE, a discount rate of 5% is assumed. Egypt, Jordan and Turkey have weak credit ratings, thus, they are assigned a discount rate of 10%.² Lastly, Iran is assigned a discount rate of 7% mainly due to political risk. The loan payback period is assumed at 30 years. Further, it should be noted that when calculating overnight capital cost, an inflation adjustment rate of 10% was used. This is the accumulated inflation rate of the U.S. dollar since 2008.

With regards to energy costs, two main variables contribute to the energy cost of enrichment, electricity consumption in kilo-watt-hour (kW h) and price of purchased electricity. Electricity consumption is assumed at 62 kW h/SWU based on the figures provided by the American Centrifuge Plant (ACP) and Enrichment Technology Company (Rothwell, 2009). The model assigns a baseline value for electricity price a \$100/MW h. As shown in the results section below, the energy cost element has in fact the smallest share of the total levelized cost (about 5%). Consequently, even if countries in the Middle East would be able to purchase electricity at lower prices, this would not change much the total levelized costs estimated in this paper.

As for labor cost, it depends on the plant's annual enrichment capacity which determines the staff size and the fully burdened salary per employee. Staff size is also estimated using Rothwell's model:

$$L_i = 1.915 \times (SWU_i)^{0.43}$$

where L_i is the number of staff in 100 s, while the “fully burdened” average annual salary per employee was estimated for each of the studied countries. This was done by calculating the ratio of average annual salaries in each country to the average annual salary found in the United States. This ratio was then multiplied with Rothwell's estimated burdened annual salary in the United States of \$ 120,000 to get a rough estimate of fully burdened salaries in the countries studied in this paper.

Throughout this paper, enrichment capacities have been derived from nuclear power capacities. The conversion between the two uses the assumptions listed in Table 1.

3. Proposed nuclear capacity in the Middle East

To estimate the costs of potential national enrichment plants, we first need to assess the region's nuclear power programs. Fig. 2 outlines

¹ It is worth mentioning that there are some uncertainties that are hard to quantify. The comparative economic assessment presented in this paper is based on enrichment plants being located in different countries, built at different times, and possibly with different levels of cost support from governments.

² Egypt, Jordan and Turkey have an S & P credit ratings of B-, BB- and BB, respectively, as of March 2017. Countries with credit ratings below investment grade rating of BBB- of S & P would find it more difficult to borrow funds i.e. are likely to pay higher interest rates and consequently suffer a higher cost of finance

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