Afghanistan Resource Corridor Development: Power Sector Analysis

Executive Summary

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John Irving & Peter Meier

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1. This report examines the power sector implications of the Resource Corridor Development (RCD) proposal. The mining developments that form the core of the RCD are not just potential consumers of power, but also a potential *source* of power for Afghanistan, since the large generation projects necessary to serve the extraction and processing of ores can readily be sized to meet more than just the mining project demand. Significant deposits of coal and reservoirs of gas make such generation possible.

2. This has potentially important impacts not just on the generation expansion plan, but also on the configuration of the transmission system. In particular it represents an opportunity to integrate with and thereby diversify Afghanistan's power supply mix, which over the past few years has become heavily dependant on imports from the Central Asian States (notably Uzbekistan), as well as from Iran (to serve the demand in the Herat area).

3. Afghanistan's strategic location makes it an important player in the many proposed trade projects to bring energy from the energy-rich countries to its north and west, to the energy hungry countries to its east and south, including major gas pipeline projects as well as electricity trade. These may bring potential transit fee foreign exchange earnings, as well augment Afghanistan's energy supply (of which proposals for increased electricity trade from the CAS to Pakistan are directly relevant to this report).

4. However, the Afghan power sector is faced with a complex set of issues largely associated with the difficult security situation and the country's high dependence on power imports from the larger neighbouring power systems: in 2011, the Northeast Power System (NEPS) that serves the North and Kabul imported 77% of its requirements. The exporting countries include Iran and the four former Soviet Union Central Asian (CAS) countries, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan.

5. The only new domestic generation project in the last five years (the 105 MW diesel project at Tarakhil completed in 2010) has been little used for reasons of high operating cost and fuel shortages. Hydro is a potential supply option, but feasibility and costs are uncertain. The 2004 Master Plan recommended the development of two larger hydro projects (Surobi-II, 180 MW, and Bagdara, 280 MW), but most of the studies for potential hydro candidates date to the 1980s, and some require more comprehensive feasibility studies before costs, hydrology, and environmental impacts can be reliably stated. There is similar uncertainty about the prospects for development of the Sheberghan gas field for power generation: there may be other competing uses for this gas (fertilizer industry, households) if the current estimates of reserves can be confirmed. The gas is sour, requiring treatment before it can be used for power generation: whether CCGT or gas engines is the best technology choice requires further study.

6. The RCD Project may offer Afghanistan an opportunity to generate and transmit power from its domestic coal and gas resources while also undertaking the development of hydro capacity near Kabul. The immediate concern is to ensure that the proposal of MJAM (the Chinese developer of the Aynak copper mine south of Kabul) to build a coal-fired power plant at Ishpushta will make available at least 200 MW capacity for domestic use in addition to its own requirement of about 150 MW. Accordingly it will be necessary for the associated 220 kV line from Ishpushta to the copper mine at Aynak to be appropriately interconnected into the Afghan power system. There is also an opportunity to utilize and extend the new 220 kV lines so they form the basis for a 220 kV ring around Kabul. The MoU with MJAM states that the electricity price for the power project will be by mutual agreement of the Parties, and there are understandings that a PPA should be negotiated, but such negotiations do not seem to have started yet. The expectation is that the cost to NEPS would be significantly below the cost of Uzbek gas-based imports, currently at 7.5 UScents/kWh.

7. The impact of the AFISCO[1] iron ore project is more uncertain. It would not likely build a coal-fire generation project for its own use, and if the project is limited to just ore mining and shipping, its electricity needs would be small (about 50 MW). If steel is to be manufactured, then the project may be either be a net electricity exporter (if it uses the blast furnace conversion process, because town gas from coking and producer gas from the blast furnace can be used for generation) or a net gas importer (if it uses the DRI process), or both (if there were surplus natural gas it might supplement the producer gas from the blast furnace to generate electricity in a CCGT).

8. It is important to recognise that all the neighbouring power systems operate asynchronously, and through their exports oblige Afghanistan to operate six separate power systems each synchronised with its neighbouring supplier. While this has helped Afghanistan grow its electricity sales over the last five years, asynchronous supplies limit the opportunities to interconnect and expand the power network in a rational way. Of the five main geographically separate power networks in Afghanistan, the North Eastern Power System (NEPS) is the largest. They could all be interconnected if the respective CAS country sources decided to operate either in synchronisation or agreed to interconnection with each other through high voltage direct current (HVDC) links. The NEPS currently supplies part of Kabul city over long 220 kV links from Tajikistan and Uzbekistan. Other parts of Kabul are supplied from various local hydro and diesel generators which are currently not synchronised with the NEPS. Under a USAID sponsored project it is expected the NEPS will be interconnected with the Kandahar-based South-eastern Power System (SEPS) in the future.

9. Further investment in transmission cannot avoid the synchronization issue. Afghanistan's contract with Uzbekistan expressly forbids DABS from synchronising domestic generation plant with the Uzbek system. Likewise the contract with Turkmenistan stipulates that HV transmission facilities in Afghanistan must have "identical technical characteristics". In effect this means that the main load centre in Kabul is currently supplied from two separate sources; part from the Uzbek system and part from is own domestic generation. Other smaller load centres adjacent to the Uzbek

[1] Afghanistan Iron & Steel Consortium, led by the Steel Authority of India.

to Kabul transmission lines are similarly constrained to use their own diesel or smaller generation without access to the cheaper Uzbek power. Therefore, in the first instance it is essential that Afghanistan adopts a Grid Code acceptable to the CAS countries to enable Da Afghanistan Breshna Sherkat (DABS, the national electricity utility) to synchronise its in-country generation with the imported power systems.

10. Given the asynchronism issues, the long distances involved (coupled with the inherent operational constraints of long HVAC transmission lines), and the power transit opportunities, there is no doubt that HVDC systems in some form or another will be part of any future Afghanistan transmission system. A current proposal for achieving the interconnection is by installing HVDC Back-to-Back (B/B) systems located in Afghanistan to enable DABS to develop its own synchronous system independently from its neighbours. However this approach is costly and could leave Afghanistan with a significant stranded HVDC B/B asset if the neighbouring systems did eventually resynchronise with each other. Moreover it would not take advantage of the much lower construction cost of HVDC transmission and other technical advantages of operating in parallel with HVAC after having made the significant investment in HVDC/HVAC conversion facilities.

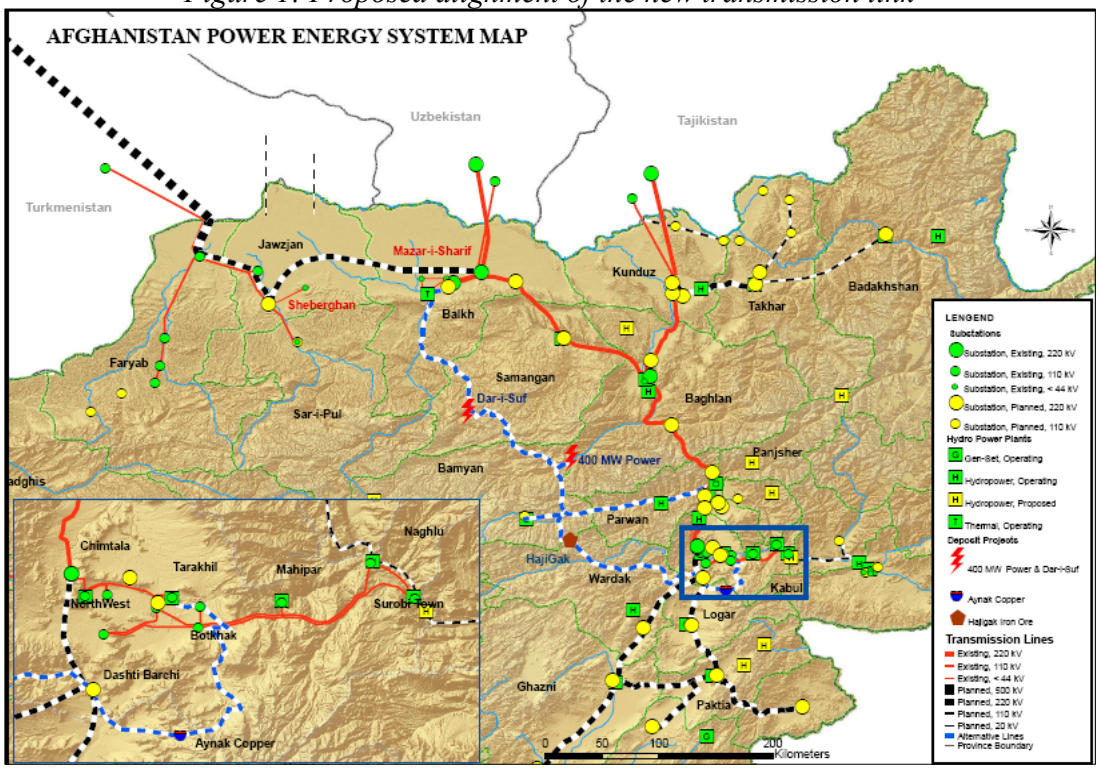
11. Various other HVDC power transit projects have been proposed to bring electricity generated in the Central Asian States to Pakistan, with some proportion made available to Afghanistan at Kabul. The Uzbekistan-Afghanistan-Pakistan Electricity Supply and Trade Project (UAP) would deliver 100 MW (915 GWh) to DABS at an HVDC inverter substation North of Kabul and 900 MW to Pakistan in the Peshawar area. The CASA-1000 project would similarly deliver up to 300 MW of surplus hydro power from Tajikistan and Kyrgyz Republic, also by HVDC to Kabul, and a further 1,000 MW to Peshawar. Both projects offer various technical advantages to Afghanistan particularly in terms of how they may be used to deal with the synchronisation and instability problems, and how they can supply a diversified source of bulk power over long distances to the major load centre in Kabul.

12. However, the financial and economic aspects of these import/transit schemes need further analysis, particularly to ensure equity among the participants. Given the many uncertainties about these projects, there are considerable risks in making power sector investment decisions now that may prove later to be counterproductive. Afghanistan should not be obliged to make significant front-end investment in transmission facilities for power transit operations unless they are backed by legally enforceable long term power purchase and transit contractual agreements.

13. The main recommendation of this report is to forgo at this time the proposal to duplicate the existing 220 kV line from Pul-e-Khumri to Kabul (via the Salang Pass). Instead it is proposed to build a new north-south 220kV line (or possibly a 500 kV line operated initially at 220 kV) from the northern city of Mazar-e-Sharif. (Figure 1). The line would traverse through Bamyan township, connecting to the Ishpushta 400 MW power station en route to Kabul South East substation, and thence to the Aynak copper mine. As the first step in its development it is also proposed to complete the 220kV loop around Kabul by connecting Aynak back to Tarakhil power station to enable the Aynak mine to use Tarakhil for start-up purposes. There should be provision in the

design of the 220 kV north-south line for supplying power to the proposed iron ore mine near Bamyan, and interconnecting other potential coal fired stations in the area in the future. The technical details of such an approach will of course await the outcome of further dialogue with MJAM power designers, but this approach would have the advantage of facilitating additional generation resources at Sheberghan gas fields and providing greater diversity and security of supplies to Kabul as well as relieving potential overloading on the existing Mazar-e-Sharif to Pul-e-Khumri section of the 220 kV transmission line.

Figure 1: Proposed alignment of the new transmission link



14. Our cost estimates for this proposed alignment is shown in Table 1. The total estimate of $184 million, based on costs for lines and substations contracted under ICB procedures, would be offset by the savings from the ADB proposed north-south project.

Table1: Preliminary cost estimates

Phase	Scope of Work	Dependence on other Developments	US$ m
1	MJAM builds 220 kV line from 113 MW Tarakhil DPS to Aynak	This line will would be required to provide the initial power to the Aynak mine possibly from the Tarakhil Diesel power station, though not part of the current contractual obligation of MJAM.. The implementation arrangements, including responsibility for maintenance and the timing of the transfer of ownership the DABS will need negotiation.	32.2
2	MJAM builds the 220 kV line from 400 MW Ishpushta plant to Aynak mine	This line is required under the Ministry of Mines contract with MJAM together with an obligation to supply DABS at both Bamyan and Dashti-Barchi. It is noted the supply to Bamyan would also be required to house the MJAM workforce associated with the Ishpushta mine and power plant	72.4
3	DABS builds line from Mazar-e-Sharif to complete north south route	This project would proceed when either Sheberghan gas fired power plant is available; or if power from Turkmenistan is available under a new import contract	65.9
4	220 kV ring around Kabul completed when/if CASA project proceeds	This project could be built either as part of the CASA project to enable an HVDC converter supply to be interconnected with Tarakhil and Chimtala, or as part of Bagdhara hydro project development.	13.5

15. Transmission alignments need careful assessment. The proposal to build a duplicate 220 kV line across the Salang Pass appears to be motivated by the fact that it is demonstrably possible to do so and would be adjacent to a major road. While the existing 220 kV line is undersized for bulk transit of power, there are alternative routes that have the advantage of providing a more direct source of power from domestic generation plant while providing the Kabul power system greater security through diversity. Thus rather than duplicate the capacity of the line with a parallel 220 kV line along the same route, to reduce congestion it would be better to reserve the route for a future HVDC line (e.g. the CASA project) to provide bulk power to Kabul or transit power en route to Pakistan.

16. On the other hand the UAP project has identified a parallel north-south route which could also be used for new 220/500 kV line providing an opportunity to build substations en route and interconnecting with the proposed MJAM line. It should be recognised that while there are advantages in building transmission lines near roads, cross country alignments can significantly shorten routes and thereby reduce costs. In this regard Afghanistan has unique topographical features that facilitate cross country transmission construction. There is little vegetation, there are many hills offering the prospect of long spans, and cross country access without proper roads is feasible for construction especially when carried out in conjunction with helicopter operations.

17. The resource corridor coal projects will increase carbon emissions, but greenhouse gas (GHG) emissions per capita or per $ of GDP will remain among the world's lowest. By 2025, the resource corridor projects would increase per capita emissions from the present 0.10 tons CO_2/capita to 0.18 tons/capita (based on a 1.5% annual population growth rate): this compares to a 2009 *world* average of 4.4 tons CO_2/capita. Supercritical coal technology would in principle provide higher efficiency (typically 42-43% efficient compared to 36-37% in the sub-critical units that can be expected) and lower GHG emissions, but the minimum unit size is around 600 MW, and therefore not suitable for Afghanistan's incremental power needs at this stage. No supercritical coal project in Asia is smaller than 2 x 500 MW. Efficiency can be incentivised by a normative heat rate requirement in the power purchase agreements for sales to DABS. Moreover, equivalent improvements in GHG emissions can be achieved by reducing technical losses in T&D with far greater benefit for the system as a whole.

18. Finally we note that the present level of T&D losses (estimates range from 30-40%) is unacceptable. Reducing T&D losses, and particularly non-technical losses, remains an immediate priority, with high net economic benefits as well as significant reductions in GHG emissions. The benefits accrue regardless of the choice of supply or transmission options, or of the uncertainties of the load forecast.