International Growth Centre

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Published on: 20 Oct 2020

Research themes: Energy, State Fragility

Power planning in fragile and conflict-affected states

Traditional methods of energy planning are likely to provide results that may be inappropriate in fragile and conflict-affected countries. The risks of violence and damage, significant delays and cancellations in infrastructure projects, or projects coming in at very high cost, are rife in these states. Security issues can significantly hamper, or make infeasible, the delivery of power system plans.

We look at how traditional power system planning and expansion models could be augmented to better consider the deep uncertainty associated with development in fragile contexts. We find that resilience aspects, combined with modular and incremental benefits of distributed generation technologies and systems, emerge as attractive options if the various risks of infrastructure development are included in modelling techniques. Investing in a diverse mix of supply types in the medium term and building a power system with redundancies or a higher share of local resources in the long term, is an effective approach to reduce vulnerability to conflict and socio-political fragility.

Traditional least-cost planning yields an investment plan that makes perfect technical and economic sense if these projects could be financed, developed in a timely manner, and operated in a conventional way. However, this is generally not the case in fragile states.

Almost all widely-used energy planning models overlook socio-political aspects, including political instability. Least-cost planning methodologies tend toward the economies of scale offered by large-scale, centralised systems and do not consider the uncertainty that abounds in fragile contexts, including the risk of large-scale projects not being eventuated, or delayed, damaged or destroyed. The viability of large-scale, centralised infrastructure is also inherently dependent on functioning systems and institutions, as well as some level of political and social stability – factors that are often absent in fragile contexts.

Considerations for power-planning in fragile states

Any delay in even a single large project can have far-reaching impacts on the business environment and economic growth of very undeveloped countries. Even if the project is successfully financed and developed on time, the operational risk stemming from either extensive damage to the power station or the transmission lines/sub-stations could lead to a collapse of the entire grid.

Taking the stance that investments in large projects should just be postponed until conflict risk is lower is not viable in fragile states. It may take many years to reach a place of adequate stability, and this approach overlooks the key role that energy access plays in kick-starting economic activities needed to create jobs and income-generation opportunities, which are vital to achieving greater social stability – and to moving a country out of fragility.

Conflict affects power system-planning in many ways, and some dynamics to consider in conflict areas include:

- **Forced outages** increase during times of conflict – power system assets, especially transmission lines, are frequent targets of attack. Repair times tend to increase because of labour shortages, site access problems, and unavailability of imported spare parts. Inadequate maintenance of equipment during conflict could also lead to higher malfunction rates.
- **Fuel shortages** are common in conflict zones – including as a result of deliberate attacks on fuel supply lines, disruption of imports and transportation infrastructure, and shortages of labour.
- **Cost changes** during conflict – due to currency exchange rates appreciating or depreciating, unforeseen repair and replacement costs, and extra security measures.
- **Construction time is frequently prolonged** during conflict – due to problems of importing equipment or recruiting workers, site access, sabotage, and temporary or permanent suspension of funding.

New approaches are needed for fragile states

New methods that explicitly recognise and internalise the risks inherent in fragile contexts and integrate them into planning tools are necessary to allow consideration of alternative, more flexible, and incremental options. Prioritising resiliency in the face of severe insecurity might result in very different optimal infrastructure outcomes in fragile contexts.

Some key elements of the new thinking needed for fragile states include:

- **Robust decision-making techniques** that enable planners to explore strategies that perform equally well across a large range of plausible futures, offer much value. Stand-alone systems, like mini-grids, are particularly useful in this regard as they have the benefit of being able to be engineered to be compatible with the grid if or when it arrives.
- Solutions that are **modular, flexible, less capital-intensive and easier/quicker to build and manage** offer useful attributes in conflict-prone areas. For instance, in a particular scenario, building a large hydro plant may well be the least-cost option under certainty and perfect foresight. However, if we start to factor in the quantatitve impact of the risks that the project may be delayed or cancelled or

damaged, or the higher operation and maintenance costs that large-scale projects involve, the risk-adjusted levelised cost may start rising quickly to a point where more distributed choices, including mini-grids, may work out to be cheaper.

- Distributed generation technologies are also more **resilient to risk**. Distributed systems not only spatially distribute the physical hardware, but also the risk of failure. By contrast, large facilities that benefit from economies of scale are also vulnerable to attack and concentrate risk over a much smaller spatial domain. In looking at this issue, Zeriffi et al. (2002) find that, when comparing an electricity system based on distributed natural-gas-fired units to a traditional system based on a large, centralised plant, the distributed system proves to be up to five times less sensitive to measures of systemic attack.
- **Conflict intensity and location changes over time** and approaches must have adaptive strategies that collect data concerning conflict risks, acknowledge improvement or deterioration in conditions in all/part of the country, and adjust management decisions accordingly.
- Distributed generation has **further advantages** in conflict areas, including an increased number of smaller-sized generators, decreased reliance on centralised transmission and distribution, real-time operational advantages, fuel flexibility, and increased fuel storage options.

How can we better model power-planning in fragile contexts?

Can we modify existing least-cost planning tools? Or do the situations in fragile states necessitate a fundamentally new approach? Unfortunately, there is no established methodology to capture the risks associated with fragility and conflict in power-planning, much less a uniformly agreed model. However, there are different ways to think about incorporating fragility risk into planning models (note, these are not mutually exclusive):

- **Least-cost planning models with tailored inputs**, whereby a conscious intervention is made through the choice of model inputs. This could include introducing factors such as higher interest rates, lower available capital, modalities of finance (especially debt vs. equity finance and public vs. private funding), prolonged construction time, and damage cost over the entire planning horizon.
- **Purpose-made models for fragile contexts**, based on models of decision-making under uncertainty. These would explicitly capture the flexibility or ‘option’ value of some of the modular generation and transmission investments. For example, a large number of mini-grids may be more expensive than a single central solar PV plant, but offer significantly higher flexibility to mobilise financing and develop these on an ‘as needed’ basis. If they are backward compatible, i.e. can be hooked into the main grid if and when the grid arrives, the option value of these investments increases greatly.
- Having **temporal, technological and geographical resolution** to models that allow planners to assess relative vulnerability to conflict effects of investments pursued in different years, technologies, and

locations. This could guide the following courses of action:

- Planners can wait for some of the conflict uncertainty to be resolved, deferring certain investments.
- Planners can diversify or change the technological/geographical composition of the investment plan.
- Planners can adjust capacity levels (for example, install redundant capacity as back-ups).

- **Incorporating sensitivity analysis** into models. This is needed to bring in crucial information on conflict impact and consider actions that might mitigate the impact of the uncertainty; for example, adoption of emergency response practices to reduce vulnerability or repair times.

Further reading on power planning in fragile contexts:

- Bazilian, D Chattopadhyay and Ravinder (2016) '**Power politics and energy trade'**, *International Growth Centre.*
- Bazilian and D Chattopadhyay (2015) '**Considering power system planning in fragile and conflict states**', *EPRG Working Paper 1518 / Cambridge Working Paper in Economics 1530.*
- Spyrou, BF Hobbs, MD Bazilian and D Chattopadhyay (2019) '**Planning power systems in fragile and conflict-affected states**', *Nature Energy 4*: 300-310.
- A Korkovelos, M Bazilian, D Mentis & M Howells (2017) '**A GIS approach to planning electrification in Afghanistan'**, IBRD/World Bank.