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LETTER

An analytic framework to assess future electricity options in Kosovo

Noah Kittner[1,2], Hilda Dimco[3], Visar Azemi[3], Evgenia Tairyan[3] and Daniel M Kammen[1,2,4]

1 Energy and Resources Group, University of California, Berkeley, USA
2 Renewable and Appropriate Energy Laboratory, University of California, Berkeley, USA
3 Kosovo Civil Society Consortium for Sustainable Development (KOSID), Kosovo
4 Goldman School of Public Policy, University of California, Berkeley, USA

E-mail: kammen@berkeley.edu

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Abstract

We have developed an analytic platform to analyze the electricity options, costs, and impacts for Kosovo, a nation that is a critical part of the debate over centralized versus distributed electricity generation and the role of fossil fuels versus cleaner electricity options to meet growing demands for power. We find that a range of alternatives exists to meet present supply constraints all at a lower cost than constructing a proposed 600 MW coal plant. The options include energy efficiency measures, combinations of solar PV, wind, hydropower, and biomass, and the introduction of natural gas. A 30 EUR ton^{-1} shadow price on CO_2 increases costs of coal generation by at least 330 million EUR. The results indicate that financing a new coal plant is the most expensive pathway to meet future electricity demand.

1. Introduction

Kosovo is a critical test case for the future financing of new coal-fired power plants by the World Bank, US government, and international financial institutions. The scheduled decommissioning of the Kosovo A coal-fired power plant in 2017 prompted the international lending and donor community to consider providing a loan guarantee for a new coal-fired power plant to replace expected future missing electricity supply (World Bank 2011a, 2011b). This prompted a systematic analysis of the options that exist to meet electric generation needs compared with a proposed coal-fired power plant. Our analysis examines a suite of alternatives and provides an operational and financial basis for comparison with the coal-intensive proposals. Presenting a unique combination of rising electricity costs, a lack of network connectivity, and the declining cost of renewable technologies over the past five years, Kosovo could be one of several test cases for a country where distributed renewable electricity options become more financially favorable than traditional centralized electricity sector developments (Shirley and Kammen 2015, Molyneaux *et al* 2016).

In 2013, the World Bank issued a policy underscoring its commitment to cease financing new coal projects unless no financially feasible alternatives exist (World Bank 2013a, 2013b, 2013c). Because Kosovo represents a case where new preliminary assessments suggested that financially feasible alternatives may exist (Kammen *et al* 2012), the decision by the World Bank to finance a new plant in Kosovo could set a precedent for future projects that will test the pledge to cease development lending for new coal-fired power plants in other countries. Since the initial plans for a coal-based future energy scenario for Kosovo were announced, the US Department of the Treasury has also announced an end for US support of public financing for new overseas coal projects with the exception of 'very limited circumstances' as part of President Obama's Climate Action Plan (US Department of Treasury 2013). Additionally, the European Bank for Reconstruction and Development (EBRD) policy requires that the infrastructure being financed is the least carbon-intensive of the realistically available options, keeping in line with other multi-lateral development banks (European Bank for Reconstruction and Development (EBRD) 2013). Future coal-fired generation in a proposed 600 MW coal plant will

Table 1. Renewable energy 2020 capacity targets and feed-in tariff levels by technology (ERO 2016).

Renewable energy source (RES)	Capacity in 2014 (MW)	2020 capacity target (MW)	Feed-in tariff application limits (MW)	Level of feed-in tariff, 12 yrs unless otherwise stated (€ MWh^{-1})
Solar PV	3	10	3	85
Solid biomass	2	14	14	71.3
Wind	31.35	150	35	85
New small-hydro power plants (10 yrs)	60	240	10	67.47
Total RES	96.35	414	62	—

undermine the pledges by the US Department of Treasury and the World Bank without fully studying alternatives to meet Kosovar power generation challenges.

The analytic framework presented here could be employed by the World Bank or similar international financial institutions to identify whether to fund conventional power sources compared to alternatives on a first approximation. The World Bank already considers safeguard policies in their Environmental and Social Framework for investment project financing. However, our approach provides a quick and low-budget first-cut analysis for comparison of technical and financial feasibility and cost-effectiveness of alternatives. Cost-effectiveness is determined by the World Bank to include 'capital and operational cost and financial benefits of the options considered over the life of the project', which this framework includes (World Bank 2016). Furthermore, it provides a framework that can readily be adapted to include external costs including CO_2 and air pollution impacts of projects. The framework can be applied across a number of large-scale power investment projects, where scenario analysis can be used to identify the presence of alternative options, and then provide opportunities to investigate different pathways in further detail to explore feasibility of low-carbon, low-cost energy sector investments and loan guarantees.

2. The energy supply and demand picture for Kosovo

Kosovo's power sector currently is not meeting the needs of its population due to frequent blackouts and electricity supply shortages that have required the import of electricity from neighboring countries to serve demand. More than 95% of electric power generation comes from lignite coal in Kosovo. Historically, Kosovo resorted to importing electricity to meet electricity demand needs, therefore placing emphasis on ensuring energy supply security in the future. The political realities of trading electricity supply place Kosovo in a tenuous position, given that a majority of the imports come from Serbia (54% of total electricity imports in 2014 came from Serbia). Serbia does not recognize Kosovo as a sovereign state, and yet exerts significant influence on governance, electricity sales, and water from Gazivoda Lake for cooling Kosovo B (Obradovic-Wochnik and Dodds 2015). From 2000–2014, there has been a consistently large mismatch between electricity generation and demand. Then in 2014, electricity generation decreased even further, by 17%, from 5862 to 4894 GWh, and required an increase in electricity imports to compensate for the artificially capped demand based on physical transmission interconnection and generation constraints (ERO 2014a, 2014b). Serbia will likely remain one of the key trade partners for electricity in the future due to existing physical transmission infrastructure, underscoring the need to address energy independence and political sensitivities.

This dependence on lignite places Kosovo among the highest rates of CO_2 emissions per Euro GDP, with estimates at twice the average level for EU countries, despite a low rate of total CO_2 emissions per capita (Ministry of Environmental and Spatial Planning (MESP) 2014). The UNDP estimated 0.84 tons CO_2/EUR GDP in Kosovo compared to 0.4 tons CO_2/EUR GDP for the rest of the EU (Kabashi *et al* 2011, UNDP 2013). In addition to CO_2 emissions, households in Kosovo also seasonally burn lignite and wood in homes, unfiltered, causing concern for particulate matter and other household air pollution. The UN FAO estimated households consumed an average volume of 8.2 m^3 of wood fuels in rural homes (English *et al* 2015). A survey commissioned by the Energy Community estimated about 2745 GWh of equivalent household heating demand met almost exclusively through biomass consumption (Energy Community 2012). Further, the use of biomass fuels for household heating means there is a large unmet demand for electricity and looming concerns over household air pollution.

3. State of renewables in Kosovo

The Kosovar government plans to generate 25% of its energy from renewable sources by 2020. To support this target, feed-in tariffs have emerged over the past two years as a policy support mechanism. As of May 2016, the Energy Regulatory Office fixed solar and wind feed-in tariffs for 12 year terms at 85 € MWh^{-1}. Small-hydro feed-in tariffs ($<$10 MW systems) remain fixed at 10 year terms at 67.47 € MWh^{-1} (ERO 2016).

The feed-in tariff levels and targets are summarized in table 1.

Although feed-in tariffs are not the only policy option to support renewable electricity in Kosovo, they have emerged as the main policy driver for renewable development to date. Alternative policies include utility procurement of renewables using avoided cost of generation like in the US, competitive bidding, and the allowance of renewable generators to compete in the wholesale market (Cory *et al* 2009, Tongsopit 2015).

Given the prevalence of fossil-fuel based lignite coal in Kosovo's electricity mix, many observers have posed the question of whether it is realistic to expect that renewables can increase capacity in the next few years. A 2013 GIZ study found that there is at least 290 MW of confirmed wind capacity spread across at least seven sites in Kosovo (GIZ 2013). Furthermore, a 2014 study by Economic Consulting Associates and Energy Institute Hrvoje Pozar has cited 246 MW of wind planned for 2020 (KOSTT 2014). In 2015, the first commercial solar producer contracted for power generation in Gjurgjevik with a nameplate capacity of 102 kW and plans to expand to 400 kW (Solar Novus 2015). Due to technology and policy incentive landscapes, renewable-based electricity has been slow to start, but likely to grow in Kosovo. Small-hydro power plants could fill in generation due to the large technical potential along rivers in the country. Finally, the law in Kosovo requires the purchase of domestic production before seeking trading opportunities, which is a boon for any domestic electricity generation source, including renewable and fossil electricity, though it may reduce the allowance of low-cost electricity imports.

An External Expert Panel to the World Bank estimated the LCOE of a new coal power plant in Kosovo at approximately €81.42 MWh^{-1} (Beer *et al* 2012). By the time of completion this cost level will be uncompetitive with renewable generation and the price that electricity is traded within neighboring power exchanges, as electricity traded in the Coordinated Auction Office in Southeast Europe (SEE CAO) hovered between €10–60 MWh^{-1} during 2013 and 2014 (SEE CAO 2015). Kosovo is part of the Energy Community, a shareholder in SEE-CAO, and a part of the ENTSO-E system. If electricity in Hungary is traded at €40–45 MWh^{-1}, it will pressure Kosovar producers to stay at this price level to remain competitive with neighboring power markets. An open regional market could allow for imports of electricity at significantly less than the LCOE of coal based on historical prices in 2013 and 2014. These prices remain consistent with the Hungarian Power Exchange, which maintained base and peak average prices of €40.5/40.6 – €47.02/46.84 EUR MWh^{-1} in 2014 and 2015 respectively and crosses fewer borders than the nearby Energy Exchange Austria (HUPX 2015).

Kosovo is considered a potential candidate to join the EU and already signatory on the EU Energy Treaty (European Commission 2016). Though the drive and ability for Kosovo to join the EU does not directly hinge on the electricity system, meeting climate and energy targets set by the EU could expedite the process (Kammen and Kittner 2015, Kittner *et al* 2016b). Kosovo will likely move into an emerging open regional power market, where it would become part of the European integrated energy market. KOSTT is already a shareholder in the Coordinated Auction Office for South East Europe and a part of the Energy Community Treaty, furthering the rationale for moving toward a single market for energy within the EU (Prange-Gstöhl 2009). The responsibility of trading now falls with the distributor, Kosovo Energy Distribution and Supply Company (KEDS). Therefore, daily, monthly, emergency, and spot pricing will impact the import price for Kosovo. The existing and planned grid interconnections position Kosovo to become a regional power market player. Significant opportunities exist in the region for electricity trading due to differences in resource portfolios and the potential for inter-temporal substitution of electricity from various sources (Hooper and Medvedev 2009).

4. Data

There has been little empirical work studying the power sector in Kosovo and the South East Europe region, despite increasing urgency to decarbonize South East Europe's power sector (Dominkovic *et al* 2016, Kittner *et al* 2016b). Few studies have undertaken detailed systems-scale energy transition analyses due to regional conflict, though KfW and national entities have begun to engage with higher resolution resource assessments (Kammen *et al* 2012, Bjelic and Ciric 2014). Because the power sector faces pressing informational needs due to rising forecasted demand, power generation challenges, and future regional grid integration, providing reliable and secure electricity remains a critical development challenge. The data for this study represent the best available information given the limitations of resource availability assessments in the region, yet provide useful information that can inform electricity capacity planning efforts. The decreased capital cost of key renewable technologies including solar PV and wind within South East Europe provides insights into the cost of developing renewable energy in Kosovo (IRENA 2015, Zheng and Kammen 2014). The European Commission has enacted stricter greenhouse gas emission reduction targets along with increased energy efficiency, renewable generation goals, and plans for expanding regional interconnections. Joining the EU —a goal expressed publicly by all Kosovar leaders— would be a major driver of change in the energy mix to meet the standards imposed by the Industrial

Emissions Directive. Additionally, Kosovo would need to follow the 2030 climate and energy framework, which stipulate a 40% reduction in greenhouse gas emissions from 1990 levels, raising the share of renewable energy generation to 27%, and a 27% improvement in energy efficiency (EU 2015a, 2015b).

The cost data for this study comes from the latest estimates in South East Europe for the levelized cost of energy by leading market research firms and expert elicitation validated by regional governments, private industry, and 17 civil society organizations (Fraunhofer Institute for Solar Energy Systems 2013, Kittner *et al* 2016b). The global reductions over the past five years in the LCOE of renewables open the door for a wide variety of alternative scenarios to investigate further. The cost of generation in our analysis captures capital investment costs, fixed and variable operation and maintenance (O&M) costs, and also the cost of fuel (for coal and natural gas) in table 2. The construction times presented for distributed renewables are based on stakeholder consultation with industry and civil society based in South East Europe. We assume that they are reasonable and should be viewed relative to one another, as solar PV projects are often quicker to construct and deploy than mini-hydropower or wind projects (Kittner *et al* 2016a). Small-scale hydropower and wind projects are often quicker to construct and deploy than large scale coal power plants or natural gas combustion turbines.

5. Methods

We created an annual generation spreadsheet model to estimate electricity generation and the cost of supplying electricity using different technologies. The model is based on an accounting stock of existing infrastructure in Kosovo and explores the cost of meeting energy supply needs through different pathways. This is not an hourly model. Neither does it model to the resolution of capacity expansion models like SWITCH because this model provides a scenario-based framework to address uncertainty under low-data availability (Nelson *et al* 2012, Sanchez *et al* 2015, Ponce de Leon Barido *et al* 2015, He *et al* 2016). The model backcasts annual generation and costs based on different policy parameters detailed in each scenario. Each scenario contains a target capacity of solar, wind, and biomass resources. The model estimates the potential generation based on available resources and policy targets. Also, the spreadsheet calculates life cycle costs of the projects to also estimate the levelized cost of electricity. The spreadsheet first estimates annual generation from each scenario and sums the annual generation across electricity supply technologies. Then the costs of each scenario across the life of the project are calculated using capital investment, fixed and variable O&M, and fuel price estimates to represent the cost of building each scenario in the South East European context. A table of capital investment prices for different generation technologies is used as input parameters for the cost. The costs are then amortized over the life of the project into net present value. The net present value estimations for the different scenarios are used for comparing the scenarios against each other on a cost basis. The spreadsheet does not pick the least cost option; it provides opportunities to examine different pathways of electricity generation.

We apply a 3.2% linear growth rate to forecast electricity demand based on a previous analysis using HOMER, which remains consistent with projected increases in per capita electricity consumption (Kammen *et al* 2012). We assume that each hour in one day has the same peak demand for an entire month, due to the available load shape data as a monthly average, which includes seasonal variation due to increased wintertime electricity demand.

We incorporate previous analyses and parameters of Kosovo's power sector that optimized electricity generation using HOMER (Kammen *et al* 2012). Then we developed realistic scenarios based on varying technology and policy choices that provide a framework to investigate the cost and generation of Kosovo's power sector. The data are from the latest levelized cost of energy projections determined by Fraunhofer and UK DECC 2050 South East Europe Carbon Calculator, representing prices within South East Europe. Investment and capital costs are included in this calculation, as the LCOE comprises total capital cost, fixed and variable O&M, fuel price, and construction time

$$\mathrm{LCOE} = \frac{\{\text{capital investment cost} \times \text{capital recovery factor} + \text{fixed O\&M})}{8760 \times \text{capacity factor}} + (\text{fuel cost} \times \text{heat rate}) + \text{variable O\&M}.$$

We base capacity factors for different technologies on previous reports that estimate resource availability for renewable technologies and historical generation from existing power plants using information from KOSTT. We simulate electricity generation for each technology type and the cost to build each scenario using capital fixed costs, operating costs, and amortize until 2025. We do not model ramping constraints. Electricity imports fill the missing generation to satisfy demand. Distributed generation and intermittent renewable electricity have substantial implications for grid operation. The model presented here deals with these implications as added costs to individual technologies, which may be optimistic since it does not incorporate real power flow. Each scenario represents

Table 2. Lower and upper bound capital investment costs for new generation capacity in 2016 in Kosovo.

Technology	2016 Capital costs (EUR kW^{-1}) Investment low price	2016 Capital costs (EUR kW^{-1}) Investment high price	Variable OM costs (EUR kWh^{-1})	Fixed OM Costs (EUR kW^{-1} yr^{-1})	Lifetime (years)	Capacity factor	Construction time (years)
Brown lignite	1600	2300	0.1	17	40	85%	3
Hydropower run-of-river	1300	3300	—	85	50	55%	2
Wind onshore	1100	1340	—	31	25	25%	2
Solar PV residential	1100	1300	—	8	30	18%	1
Solar PV commercial	1000	1200	—	7	30	18%	1
Solar PV utility scale	1000	1100	—	7	30	18%	1
Biomass (steam turbine)	2300	4400	0.4	15	30	25%	2
Waste-to- energy (steam turbine)	4000	4400	0.1	20	25	75%	2
Conventional natural gas combined cycle	670	1200	0.1	20	25	75%	3

Table 3. A selection of the multiple pathways examined in this paper that economically and reliably meet Kosovo's projected future electricity demand.

Scenario	Name	Notes
1	Base case (coal)	TPP C built in 2017, 2–300 MW turbines
2	Solar prices reduce to SunShot levels	Solar at €0.9 W^{-1} by 2020; €30 ton^{-1} of CO_2
3	Euro 2030 path: aggressive energy efficiency measures (27% increase), 27% CO_2 reduction, 27% renewable consumption along with expanded open regional market via a power exchange	1 kWh energy avoided displaces 1 kWh coal-fired generation
4	Regional transmission network allows for expanded electricity imports	Solar at €1 W^{-1} by 2020 and imports dominate from Hungarian Power exchange
5	Introduction of natural gas via TAP by 2018 with aggressive energy efficiency measures	Solar at €1 W^{-1} by 2020
6	Including a carbon shadow price	€30 ton^{-1} of CO_2 added to cost of coal generation
7	Including storage cost for solar at high deployment levels	Solar at €1 W^{-1} by 2020 and storage is €200 kWh^{-1}
	No natural gas, extra transmission for Albania–Kosovar joint projects	

a different alternative pathway that highlights the numerous opportunities for development in the region. The base case presents a business as usual approach if the World Bank approves financing for Kosovo C. Additionally we estimate the cost difference from the base scenario when introducing a €30 ton^{-1} shadow price of CO_2 when using coal. Lignite coal is one of the lowest quality types of coal and could release 5.8 million tons of CO_2 yr^{-1} in Kosovo's electricity sector (Kammen *et al* 2012). In multiple scenarios, Kosovo A must close down by 2017, as it will approach its end-of-life unless we apply retrofit investments to follow the 'best available techniques' outlined in accordance with the Industrial Emissions Directive. The base case scenario continues operation of Kosovo B beyond 2025. Details of the scenarios are found in the supplementary materials.

6. Results

The results indicate a wide range of options that meet electricity generation requirements at a lower cost than the base case. Table 3 summarizes the scenarios. The Energy Strategy for Kosovo established specific goals for capacity expansion for renewables.

We estimated the cost of different renewable energy technologies and the amount of electricity generated based on different capacities for each technology. Each scenario and cost estimate is summarized in table 4.

The cost assumptions influenced the capacity deployed of each technology in different years. Using resource availability data, we estimated annual generation from each type of electricity and the associated cost, annualized over a twelve-year period. The base case scenario, figure 1, assumes Kosovo C is built in 2017 and 98% of Kosovo's electricity generation comes from brown lignite coal. Figure 2 highlights the scenario where solar prices reduce to SunShot levels of €0.9 W^{-1} by 2020, TPP A ceases production before 2018, there is a €30 ton^{-1} price on CO_2, and we assume a 3% yearly improvement in transmission and distribution losses. Albanian–Kosovar joint projects and small hydropower reserves balance the system and provide flexibility to accommodate intermittent solar as a part of an open regional market. We added a storage penalty to account for the intermittency of solar PV, by appending 10% of system costs per kWh to each kWh of solar generated in scenario 7 (Gur *et al* 2012).

The estimated grid consumption data comes from projections by the Ministry of Economic Development along with expected population growth. Figure 2 exhibits the increased ability of solar PV to meet electricity needs, ramping up in magnitude starting in 2020 if the price of solar reduces to €0.9 W^{-1}, a current policy goal of the US government under the SunShot pricing program, adapted to South East Europe. These prices are reasonable because of the global competitiveness of the solar PV market and remain consistent with projections for the cost of solar PV in South East Europe. An aggressive energy efficiency scenario, detailed in figure 3, exhibits the potential to curtail growth in peak energy consumption to 5000–7000 GWh and meeting EU 2030 energy efficiency targets. Figure 4 introduces low-cost energy imports from an open regional market, which allows solar to develop along with available hydropower resources. Figure 5 introduces natural gas to Kosovo's electricity portfolio by 2018 and gas quickly facilitates a rise in solar PV deployment due to the ability to serve as a fast-ramping, flexible generator that compensates for the variability of solar PV due to cloudiness. Given that bringing TAP or IAP is an official policy of the Government of Kosovo, a scenario incorporating natural gas is analyzed. With the introduction of gas, the demand for coal generation disappears by 2022. The results highlight the wide variety of options Kosovo has to meet its future electricity demand at lower cost

Table 4. Total cost estimates of each scenario including business-as-usual case. Technology costs are based on current operating costs (BAU), and renewable energy technology costs as estimated by the GEA (2012) project, Fraunhofer Institute for Solar Energy Systems (2013), Bloomberg New Energy Finance (2016), and regional stakeholder consultations (Kittner *et al* 2016b).

Scenario	Name	Notes	Estimated cost[a]	Average LCOE	Figure
1	Base case (coal)	'New Kosovo' built in 2017; 2–300 MW turbines	€1.96 billion EUR (€2.29 billion EUR with €30 ton^{-1} CO_2 price, €1.86 billion EUR at 500 MW)	€204 MWh^{-1} (€184 MWh^{-1}–€224 MWh^{-1})	Figure 1; appendix table A1
2	Solar prices reduce to SunShot levels	Solar at €0.9 W^{-1} by 2020; €30 ton^{-1} of CO_2	€1.67 billion EUR	€165 MWh^{-1} (€156 MWh^{-1}–€174 MWh^{-1})	Figure 2; appendix table A2
3	Euro 2030 path: aggressive energy efficiency measures (27% increase), 27% CO_2 reduction, 27% renewable consumption along with expanded open regional market via a power exchange	1 kWh energy avoided displaces 1 kWh coal-fired generation	€1.57 billion EUR	€160 MWh^{-1} (€150 MWh^{-1}–€170 MWh^{-1})	Figure 3; appendix table A3
4	Regional transmission network allows for expanded electricity imports	Solar at €1 W^{-1} by 2020 and imports dominate from Hungarian Power exchange	€1.76 billion EUR	€167 MWh^{-1} (€162 MWh^{-1}–€172 MWh^{-1})	Figure 4; appendix table A4
5	Introduction of natural gas via TAP by 2018 with aggressive energy efficiency measures	Solar at €1 W^{-1} by 2020	€1.55 billion EUR	€155 MWh^{-1} (€141 MWh^{-1}–€169 MWh^{-1})	Figure 5; appendix table A5
6	Including a carbon shadow price	€30 ton^{-1} of CO_2 added to cost of coal generation	€1.78 billion EUR	€169 MWh^{-1} (€160 MWh^{-1}–€178 MWh^{-1})	Figure 6; appendix table A6
7	Including storage cost for solar at high deployment levels	Solar at €1 W^{-1} by 2020 and storage penalty at €200 kWh^{-1}, representing 10% of system generation costs	€1.57 billion EUR	€157 MWh^{-1} (€150 MWh^{-1}h–€164 MWh^{-1})	Not pictured; appendix table A7

[a] See supplemental materials for detailed annualized cost estimation. We use currency exchange of 1.1 USD = 1 EUR based on 2016 rates.

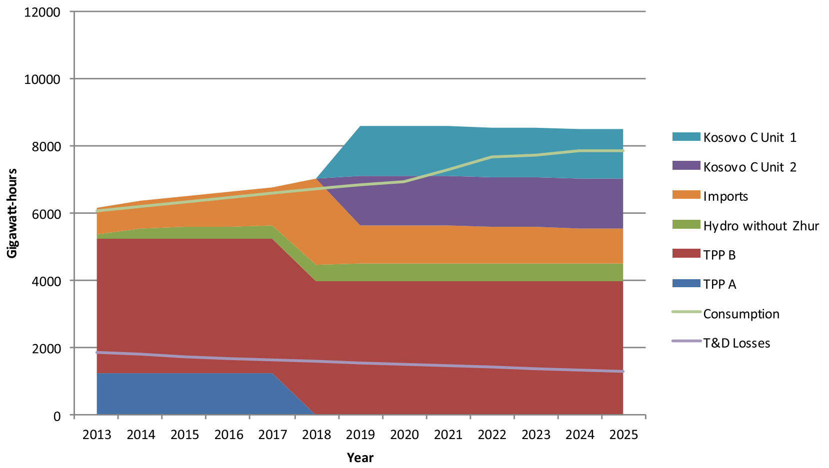

Figure 1. Base case (Kosovo C built in 2017).

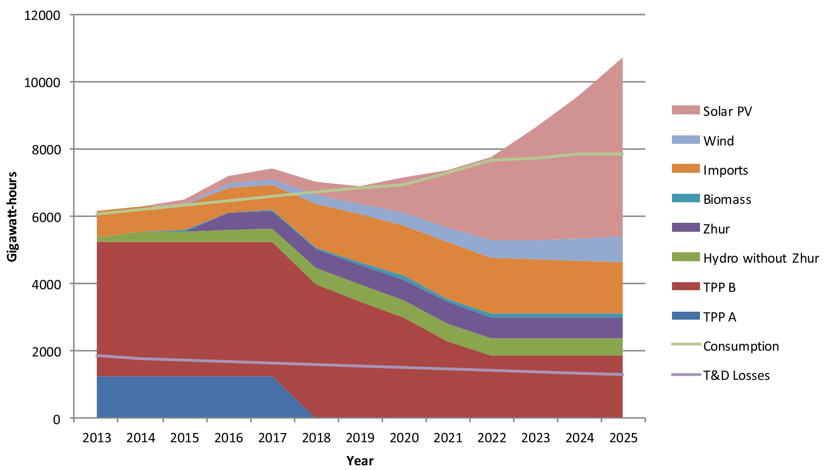

Figure 2. Solar reaches SunShot Prices (€0.9 W^{-1}) by 2020.

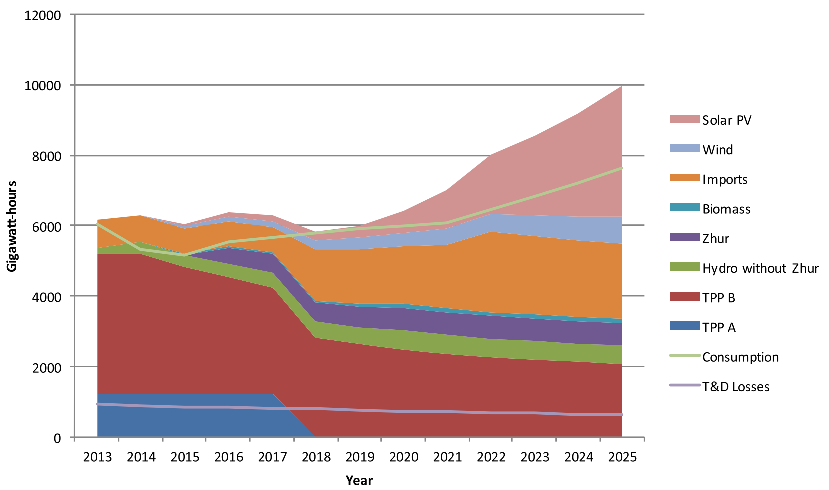

Figure 3. Euro 2030 path: energy efficiency measures (27% increase), 27% CO_2 reduction, >27% renewable consumption, expanded power exchange.

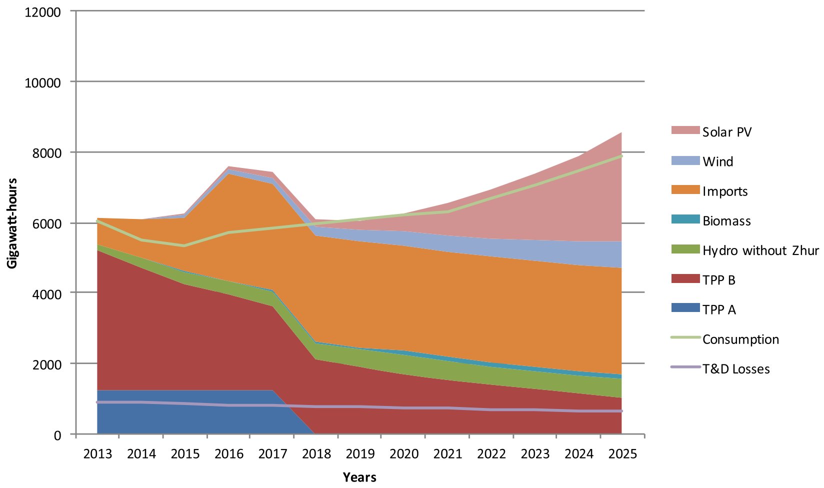

Figure 4. Regional transmission network allows for expanded electricity imports.

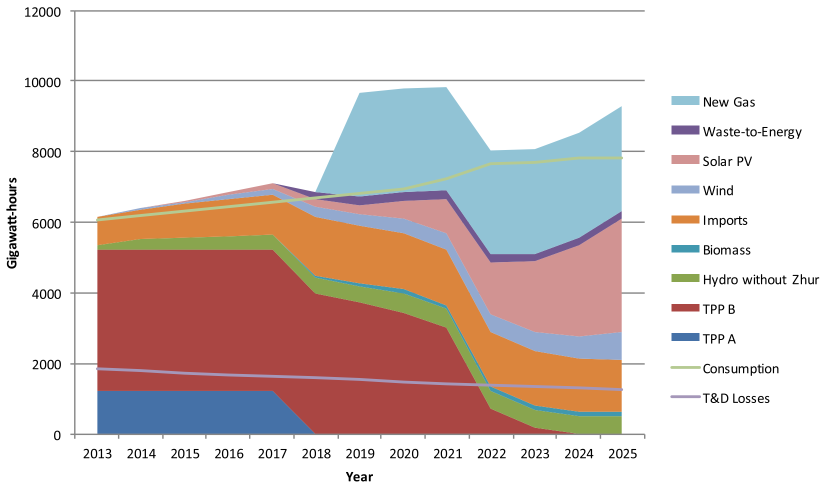

Figure 5. Introduction of natural gas via TAP by 2018 with aggressive energy efficiency measures.

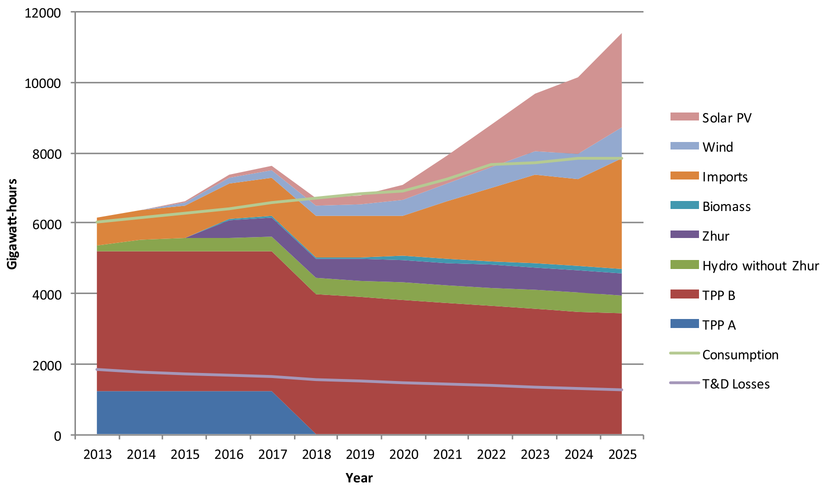

Figure 6. Carbon shadow price of €30 ton^{-1} CO_2.

than building Kosovo C and the opportunities for Kosovo to become an energy hub by exporting electricity to neighboring states.

In figure 6, we test the sensitivity by including a shadow price of €30 ton^{-1} of CO_2 without aggressive cost reductions for solar, as World Bank President Jim Kim has suggested should be accounted for when planning new World Bank projects. We estimate that the construction of Kosovo C could add up to 11.5 million tons of CO_2 per year, adding an additional amortized cost of €330 million for the plant.

Each of the different non-Kosovo C scenarios will provide electricity until at least 2025 at a cost of less than €1.5–1.8 billion euros. This is significantly less than an estimated cost of €1.9–2.2 billion euros to follow a coal-based trajectory. Ongoing international discussions around the Kosovo C option have focused on installing two 300 MW coal-fired subcritical boilers (~37% thermal efficiency) which indicates that (a) the cleanest conventional coal plants are not being considered, largely due to cost concerns, and (b) the human and environmental health impacts of the baseline coal project will be significantly higher than the most recent epidemiological studies on higher ranking bituminous and anthracite coal (Epstein *et al* 2011, Treyer *et al* 2014). Selection of these less societally damaging coal options, which international World Bank policies designed to minimize harms on people and the environment would warrant, increase the price gap between the clean energy cases and the coal scenario further when adding external costs to the analysis. The alternative pathways presented could save the KEDS between €200–400 million euros before considering health, job creation, or societal benefits of a more resilient system. This upper-bound estimate does not include any externalities. If we apply a shadow price of €30 ton^{-1} of CO_2, the difference between each scenario and the base case could double. This is based on estimated costs of capacity expansion only and does not model AC power flow across the grid. We caveat the results that the costs are based on expanding generation capacity.

7. Discussion

Particularly important in this work is the observation that there are multiple, economically realistic scenarios that can provide reliable, low-carbon electricity for Kosovo. Technical and political preferences may lead different analysts to prefer different energy mixtures, but the diversity of viable cases leads to three clear conclusions:

- There is no shortage of low-cost, low-carbon paths that Kosovo and international investment and development partners could follow.
- As a result of the above, a coal-dominated future is neither an economic nor political necessity. In ongoing work, the job creation and both human and environmental health benefits of these non-coal scenarios will be further detailed, which makes the case for a multi-billion dollar coal-based pathway unnecessary.
- A diversity of low-carbon pathways requires further discussion and action; the range of options presented, in fact, may make the pathway to a decision challenging in a contentious environment.

Due to capital constraints within the region, the €200–400 million EUR difference in costs per scenario is not trivial. The health costs of lignite in terms of particulate and sulfur emissions would increase the gap between options that reduce coal generation even further (Ukëhaxhaj *et al* 2013, World Bank 2013a, 2013b, 2013c, Holland 2016).

The capacity for distributed renewables can be increased as needed compared to large centralized projects. For instance, developers can install solar PV incrementally on a per kW or MW scale, whereas a coal plant requires full commitment to hundreds of MW capacity during one investment period. As demand for electricity changes, the deployment of distributed renewables provides investors with increased flexibility to extend capacity in smaller sizes as to not leave the investor with large-scale stranded assets. This also increases domestic electricity production which could become advantageous for Kosovo in a future regional power market.

8. Policy implications

Energy security has emerged as an important policy goal within South East European countries. The different pathways presented in this paper fall within different energy security policy packages including expanding generation capacity within Kosovo and access to electricity and simultaneously responding to looming threats of global climate change. Coal specifically poses certain security challenges including the tradeoff of being plentiful, yet finite in supply. The resource curse of coal could constrain Kosovo's future economic development, as diversity and availability of resources remain key components of any national energy security plan (Sovacool and Brown 2010, Sovacool and Saunders 2014, Tongsopit *et al* 2016). The alternative pathways detailed in this analysis highlight the range of domestic renewable resources that would reduce government debt and improve energy security. A focus on managing risk through diversification of resources, where Kosovo currently relies on 98% lignite could reduce the recent price surges consumers have faced due to unreliable generation capacity from Kosovo A and Kosovo B.

Decentralized and domestic run-of-river hydropower, solar electricity, and biomass resources open up opportunities for regional power trading. An open market could enable Kosovo to become an energy producer of surplus electricity and sell to neighboring countries, since nearly all countries in the region (Albania, Bulgaria, Serbia, and Macedonia) suffer from energy supply shortages on a frequent basis. This would improve the situation from the current reliance on imports from Serbia by facilitating future mutual electricity exchanges that could benefit grid integration, operations, electricity costs, and the environment.

The ripple effects of decisions on Kosovo's power sector will hold a large influence over the future debates to construct new coal-fired power plants in sub-Saharan Africa, India, and Pakistan by setting a precedent for multi-lateral lending institutions. The lending policy opens the conversation for how constrained an economy must be to qualify for the exception in the World Bank's policy, as technically Kosovo resembles a middle-income country (officially classified as IDA/Blend) compared to other countries that may lack significantly more economic resources.

9. Conclusions

As demonstrated through the range of alternative energy pathways, the opportunity cost of building a new coal-fired power plant is high. The policy implications of the proposed coal plant are pervasive throughout the economics of coal, multi-lateral development bank finance policy, and energy security as a national development strategy. The scenario results provide a framework to evaluate policy risk from multiple stakeholders, including the Government of Kosovo, the World Bank, and the US Government as a direct benefactor of energy lending to multi-lateral development banks.

We find that a range of technically and economically viable clean electricity paths exists to meet Kosovo's near and long-term electricity needs based on the analytic framework. The scenarios that emphasize a variety of renewable electricity resources—notably solar, wind, and hydropower, in concert with judicious use of fossil fuels that are employed with a clear end game of a decarbonized and reliable electricity grid—afford Kosovo with an array of advantages. Significant in the cases examined is the consistently estimated lower overall net present cost relative to the business-as-usual coal-based pathway. In addition, each scenario emphasizing renewable energy provides more energy than the forecast demand, opening the door for regional power trading and exports, which have significant capacity to build security, regional prosperity, and peace, as well as bringing Kosovo's carbon emissions closer to the EU standard. This report highlights that Kosovo's energy future will not depend on the economy or technology, yet will remain a policy choice with significant implications for the electricity sector, public health, and the environment.

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