Regional Electricity Trade with the Democratic Republic of Congo:

Preliminary Cost and Demand Analysis

University of Cape Town – Energy Systems Research Group, Department of Chemical Engineering

Authors: Bruno Merven & Gregory Ireland

Introduction

Strong regional electricity system interconnections allow for more economical energy resources available in different countries to be developed and shared or traded in a way that benefits all parties, as well as general surpluses or shortfalls of energy in different countries to be balanced in an open electricity trading market. For example, good hydro resources in the DRC, that if developed at scale, could bring low electricity prices but would produce more than the DRC can use for itself in the short term, opening the opportunity for multiple countries to invest together and share the benefits. Otherwise, good solar resources available in Zambia that could supply Zambia and excess sent to some of their neighbours during the day, while wind or hydro could be sent in the opposite direction at night. These objectives are currently being achieved in Africa in some places, but only to a limited extent in the several isolated African Power Pools on the continent. With significant demand and supply growth expected in the continent into the future this requires specific trade opportunities to be investigated and evaluated in more detail to justify investments with evidence.

The preliminary analysis done here investigates regional electricity trade opportunities in the year 2030 for the DRC and its neighbouring countries. The analysis combines data from the multi-region OSeMOSYS model developed in this project (UCT, 2022; RM & UCT, 2020) and the May 2022 version of the IRENA Continental Master Plan (CMP) model (IRENA, 2021 and 2022; AUDA-NEPAD, 2021). This is done using "screening supply curves" - comparing the potential supply options, their costs and energy potential, and the demand expected in the different regions to see which options are likely to meet individual national demands and which might hold the most potential for trade. The modelling here does not construct full least-cost supply models for countries outside of the DRC and does not look at the exact times of demand or generation with full timeseries, but rather looks at the bigger picture of total energy availabilities combined with investigation of day/night differences with respect to the significant solar resources available in the regions. A key assumption is that by 2030 the Southern+Western DRC grids will not yet be interconnected with the Eastern grid of the DRC (Figures shown below). Trade options and regional demands were therefore investigated separately for the two grid regions with their respective neighbouring countries.

Methodology and Assumptions

Overview

Screening supply curves for 2030 are constructed by progressively stacking to the right along the x-axis the current or potential annual energy production from each power plant option which is either existing, committed, or candidate for the country or group of countries under consideration. The stacked energy rectangles are sized upward along the y-axis according the Levelized Cost of Energy (LCOE) that each of the power plant options is expected to produce. The LCOE is the cost that each unit of electricity would need to be sold at to cover all potential costs e.g. capital costs, interest on loans, insurance, installation and logistical costs, fuel, repairs and breakdowns, maintenance, and salaries, etc.) over the life of the project. The specific equations used to calculate the LCOE are shown in the appendix.

The power plants are ranked from lowest LCOE on the far left to the highest LCOE on the far right. Together these add up to create the so-called "cost of supply curve". As the best/cheapest resources are used, the cost of additional supply (or the "marginal cost of supply") becomes more expensive moving to the right to meet increasing demand.

The total demands of the regions or countries in question are added to the charts as vertical lines to show where along the cost of supply curve the demand is. The supply options to the left of the demand lines are those that add up to meet the demand most cost effectively. Furthermore, by plotting either the combined demand of an interconnected region, or the demands of the specific countries, it is possible to see which options in combination from those countries could most economically meet the demand of the region, or allow us to see which resources are most likely to only be enough to meet a country's own local demand.

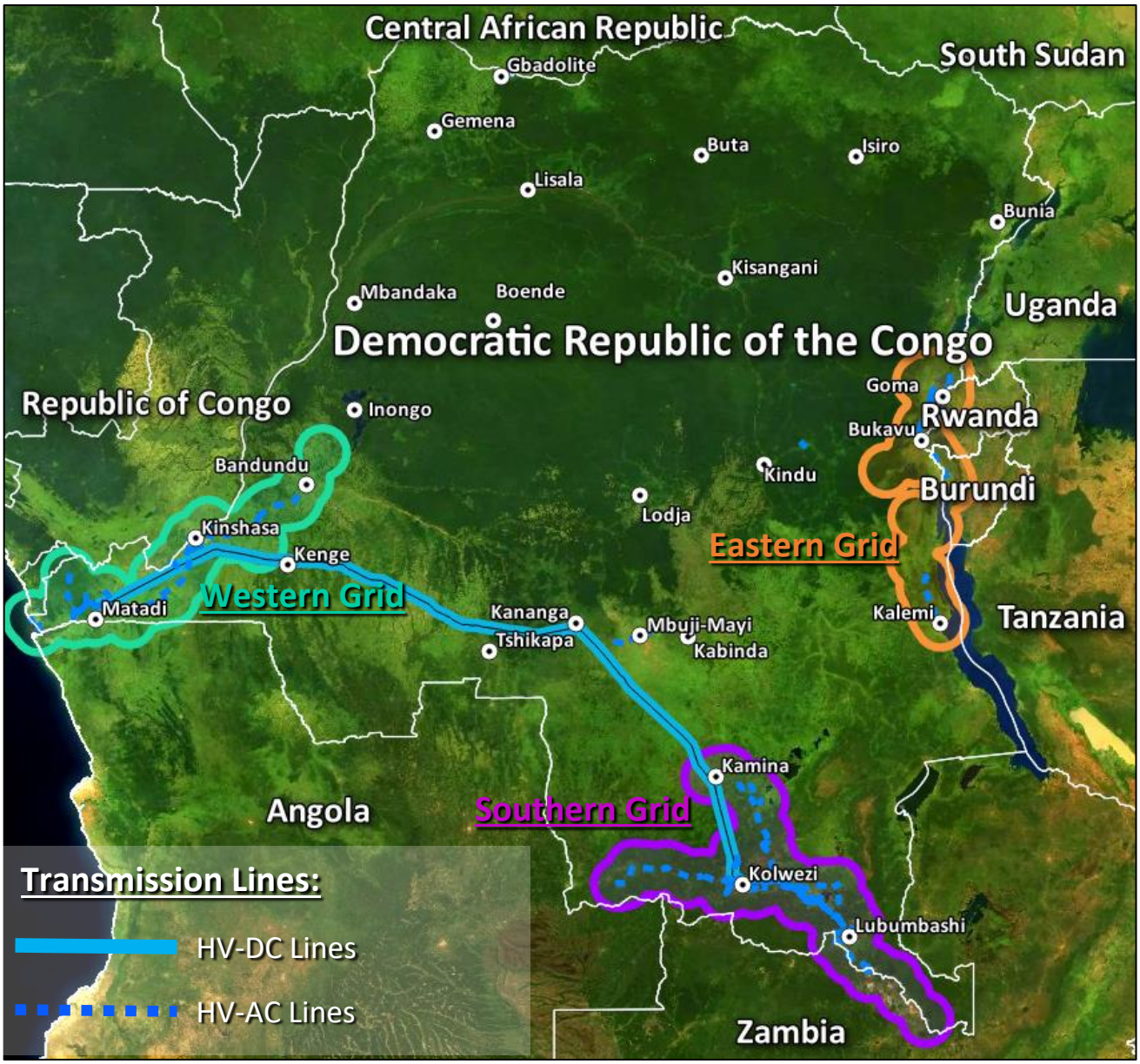

Figure 1: Map of the three major grid networks of the DRC and neighbouring countries. Grid lines are shown in addition to a 50km buffer distance with coloured outlines showing the general coverage of the grids. The Western and Southern grids are interconnected to each other while the Eastern grid is isolated from the rest of the DRC. Other smaller local grids are not shown such as those in many of the labelled provincial capitals. Sources: Open Street Maps, Mapbox, and authors' own GIS analysis.

The combined "Southern+Western grid", and the" Eastern grid" of the DRC are analysed here separately as shown in Figure 1. It is assumed that until 2030, the interconnection of the Eastern DRC grid to the Southern and Western grid is unlikely (with more than 800km at the shortest distance, and over rugged terrain). Thus, to meet growing demand and to electrify the population on or near the Eastern grid it assumed to be more likely that the local domestic energy resources are developed (solar and small hydro), or joint venture projects with DRC's neighbours

(Ruzizi 3+ or others), otherwise imports from other larger projects in Rwanda, Burundi, or Uganda are considered more likely to take place in the medium term than complete internal interconnection of the DRC's major grids.

The Western grid goes from Inga down to Boma and Matadi, and up to Kinshasa and Bandundu, and is connected to the Republic of Congo at Brazzaville, with and the potential and plans to connect to Angola. The Western grid is interconnected down to the Southern mining region via HVDC lines ending in Kolwezi, which then connects onwards to Likasi and Lubumbashi, and finally goes on to connect to Zambia. Both grids have a few additional towns or cities connected to the grid but in general they both have limited coverage. Importantly, the HVDC line that connects Kinshasa to Kolwezi over roughly 1400km does not in fact connect any of the cities or towns that it passes through or nearby, with any electricity available there coming from local mini-networks or an alternatively routed grid.

Some power plants are listed in the analysis with the same name more than once. This is because several projects (for example the Ruzizi projects) are shared by design between several countries with each getting at least a fixed portion of the energy. Additionally, several projects modelled here are refurbishment or expansion projects of existing plants (thus often keeping the same name). The associated costs, energy available for each part of the projects, and shares negotiated to be available for each country are accounted for individually and appropriately.

Inga 3 in this analysis accounts for only the energy negotiated to be available for the DRC domestically and for its own discretion to export to neighbouring countries, but excludes the share of that energy which is intended for export to South Africa as part of the Grand Inga Treaty (2013) between the RSA and the DRC. Other potential exports to South Africa beyond that portion of Inga 3 are not considered in this analysis, neither are imports to the DRC from South Africa, either directly or through joint neighbouring countries in the Southern African Power Pool (SAPP).

Other Assumptions

For set of results presented in this report, the following assumptions are made:

- Cost, lifetime, and availability assumptions for the DRC plant options are the same as used in the 3 region OSeMOSYS model. (UCT, 2022; RM & UCT, 2020)
- Cost, lifetime, and availability assumptions for countries outside the DRC are as per IRENA CMP model May 2022. (IRENA, 2022)
- The discount rate assumed is 10% real and the monetary unit is 2019 USD.
- The year analysed and options available are for the year 2030 - for both demand and supply.
- The analysis excludes plants in the Grand Inga Project beyond Inga 3.
- In 2030 it is assumed that the Southwestern and Southern parts of the DRC are interconnected, but the Eastern part of the DRC is still isolated from the rest of the country resulting in the following regions:
    - DRC-South+West trading with: Congo, Angola, and Zambia
    - DRC-East trading with: Rwanda, Uganda, and Burundi
- Transmission systems required to enable additional trade between countries are not analysed in detail and are assumed to be constructed, upgraded, or refurbished in parallel to the generation projects. For the relatively short distances between the countries/regions analysed here the total cost of transmission is expected to be roughly 5% of the total cost of energy.
- Plants in places may be labelled interchangeably by their number/generation either as I or 1, II or 2, III or 3, and so forth. This is unintentional and a product of the multiple project databases combined to create the final combined set. Double counting has been avoided.
- The environmental, social, or geopolitical impacts of the projects listed here were not all specifically investigated.
- The exact likelihood of construction, timing of completion, or final energy cost of each proposed/planned/candidate plant is unknown and may differ from the assumptions here.
- Lists of definitions and technology/project codes used in this report are included in the appendix.

Results

The DRC Southern and Western Grids and Regional Neighbours

Starting with the combined Southern and Western grids and their neighbours we can see the supply screening curve below in Figure 2, laying out the different supply options and the combined demand as described in the methodology above. Several key projects are labelled in the chart but not all can be labelled at once. The colour coding legend of the different country and power plant type is only included in the first full chart of each region but is the same legend for the related figures following on.

The full table of projects, their modelled costs, and total energy available are ranked in order of cost and given in the appendix - listed separately for the South+West and Eastern grids and neighbours.

The vertical line in black in Figure 2 shows the total combined demand in GWh for the region (~88.3 TWh). It shows that the Inga 1,2 and 3 and other DRC hydro options such as Zongo, Zongo 2, Nzilo, Nseke, Mwadingusha, Pikoa, and Matadi are in the lowest part of the curve, followed by hydro options in Angola, followed by solar in Zambia, solar in Angola, wind in Zambia, solar in DRC South+West, wind in DRC South+West, solar in Congo, then Zambian hydro, coal, diesel, and gas options – in that order.

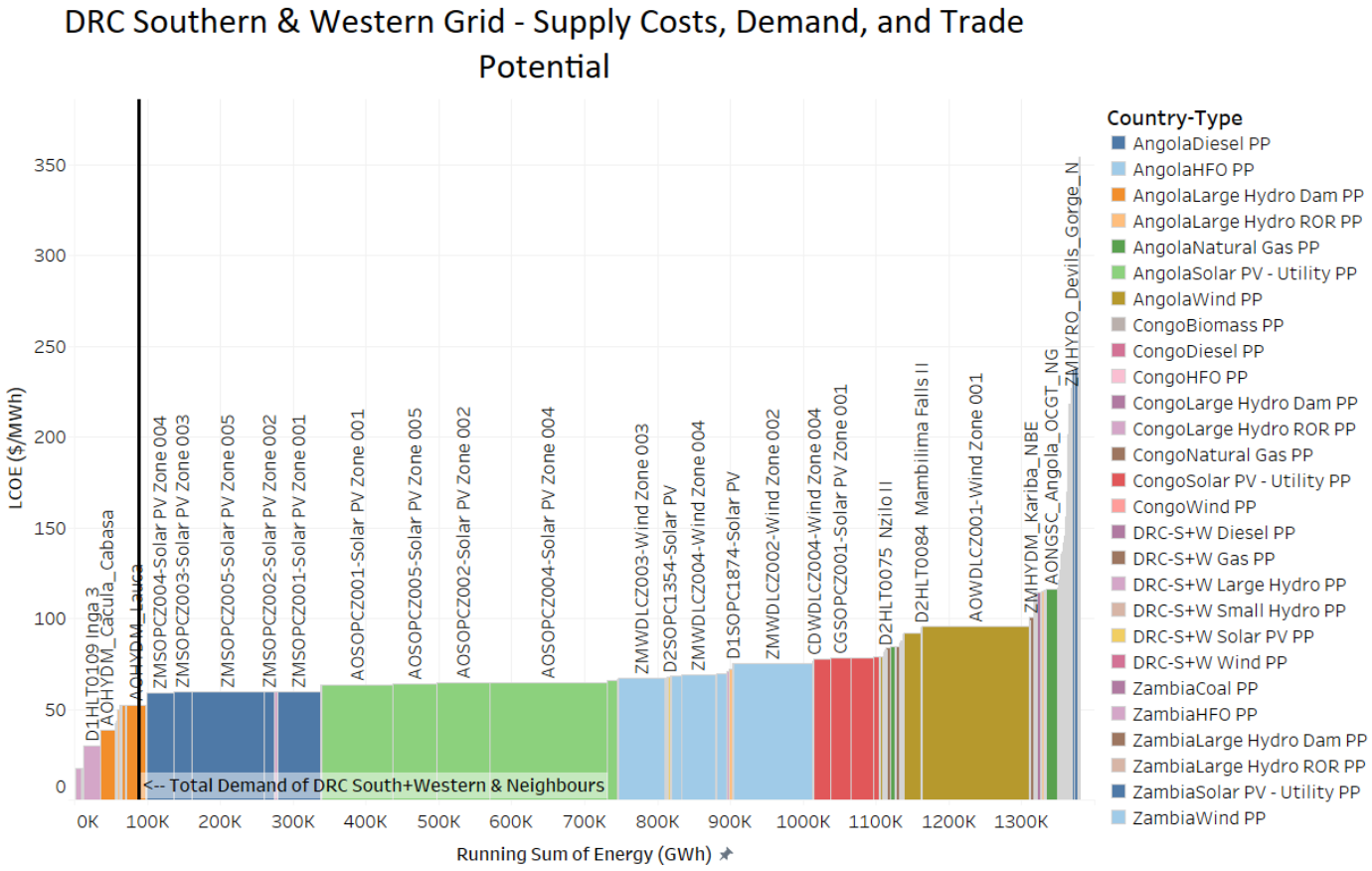

Figure 2 Supply Screening Curve for DRC South+West and Neighbouring Countries (Angola, Congo and Zambia). The black vertical line represents the total expected 2030 demand of the region made up of the DRC South+Western grids together with the immediate neighbours.

By grouping the information by country, and including separate vertical lines to represent the demand of each country we can get a better understanding of which projects are already being used to supply the demand of country they are in, or which projects if developed would first supply demand locally before exporting. Figure 3 shows the same information as Figure 2, but grouped separately by country, and with the vertical lines showing the demand of each country separately.

From Figure 3 we see that if Inga 3 is included in the DRC South+West system, the local demand in the local S+W system could be met with some spare capacity available for exports. The price level would fall below the price level of the cheapest options in the neighbouring countries.

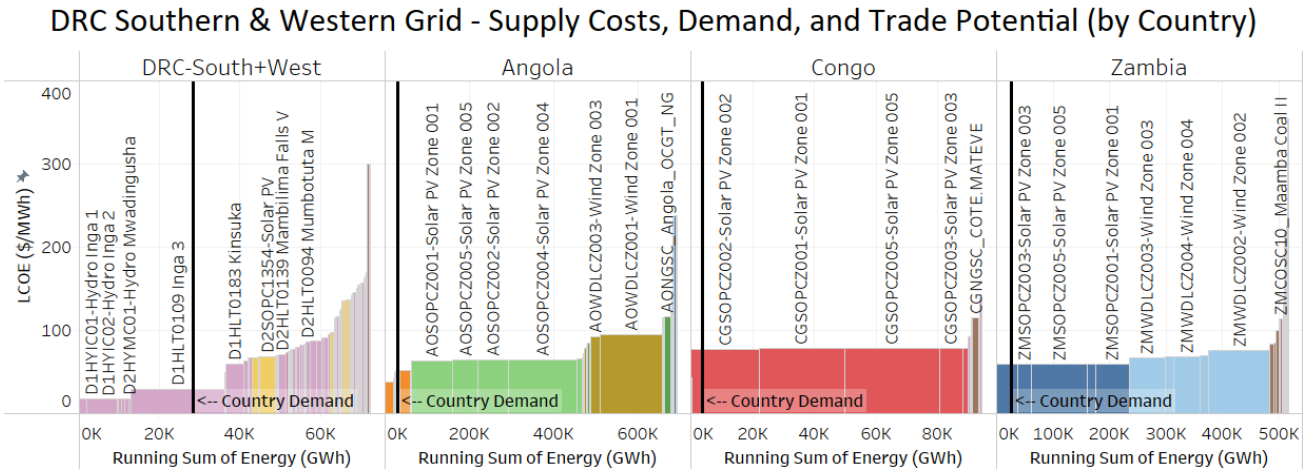

Figure 3 Supply Curve by Country (DRC S+W+Neighbours). Each black horizonal line represents the demand of that specific country. *Note that the axes and scales are not the same for each chart.*

However, should Inga 3 not be considered (see Figure 4 below), either because it does not come online by 2030 or if it's expected final cost of energy becomes much higher, then we find solar and other hydro projects from neighbouring countries becoming economically attractive to import into the DRC (to the left of the vertical line).

The DRC South+West options to the right of the demand curve are no longer competitive in the region limiting the scope for exports from the DRC. Some of the hydro options from Angola could potentially become viable as imports into the DRC should those projects materialise and not already be allocated elsewhere in the region and sufficient transmission capacity is developed to link the countries.

However, the DRC developing specific joint large hydropower projects and transmission systems to import hydro from Angola while the DRC has been championing exporting power from the Grand Inga Project for decades seems politically unattractive. This would more likely be framed as importing potential solar power or oil/gas power from Angola while unlocking power corridors and the eventual export of Inga-based hydro power to the rest of the region.

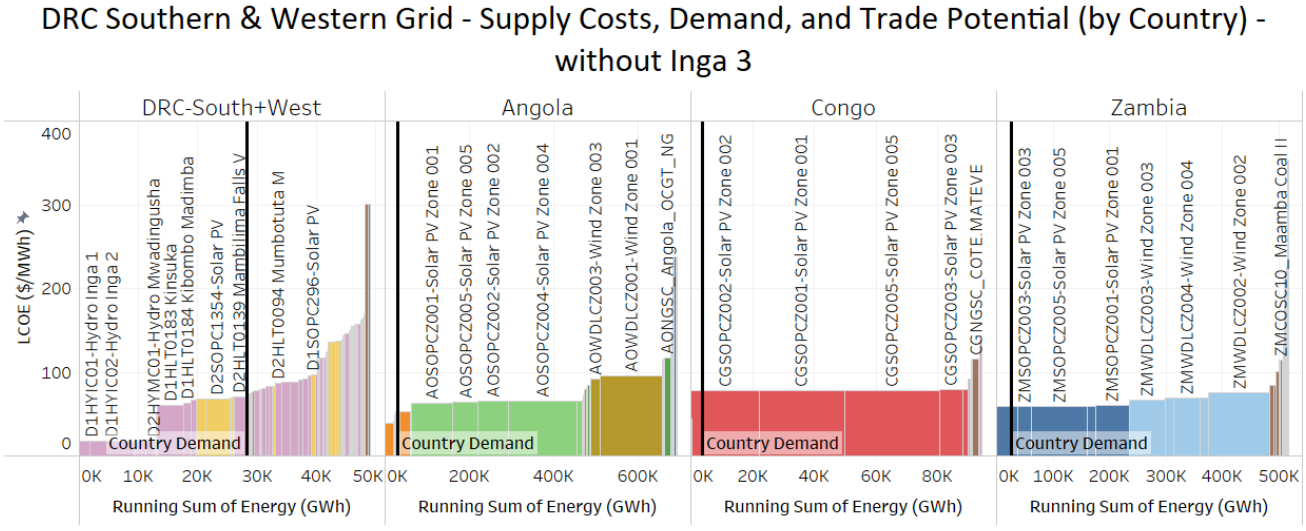

Figure 4 Supply Curve by Country (DRC S+W+Neighbours), but without Inga 3 considered possible or economic in the time frame. Each black horizonal line represents the demand of that specific country. *Note that the axes and scales are not the same for each chart.*

The DRC Eastern Grid Region and Regional Neighbours

Next, we look at the DRC Eastern grid region and its neighbouring countries. Figure 5 below shows the supply screening curve of the region with the full table given in the appendix. The colour coding legend of the different country and power plant type is only included in the first full chart of each region but is the same legend for the related figures following on.

The vertical line in black shows the total demand in GWh for the group of countries in question (~19.6 TWh) which is significantly lower than the S+W interconnected region investigated above. The screening curve shows that Ruzizi 1,2 and 3 are in the lowest part of the curve, followed by hydro in Uganda, then Ruzizi 4 as a joint project of the region, then followed by Solar in Uganda, then Solar in Burundi and Rwanda, and Solar in DRC East. Thereafter, new candidate hydro options in Uganda, wind in Uganda, followed lastly by different gas, coal, oil, and diesel options.

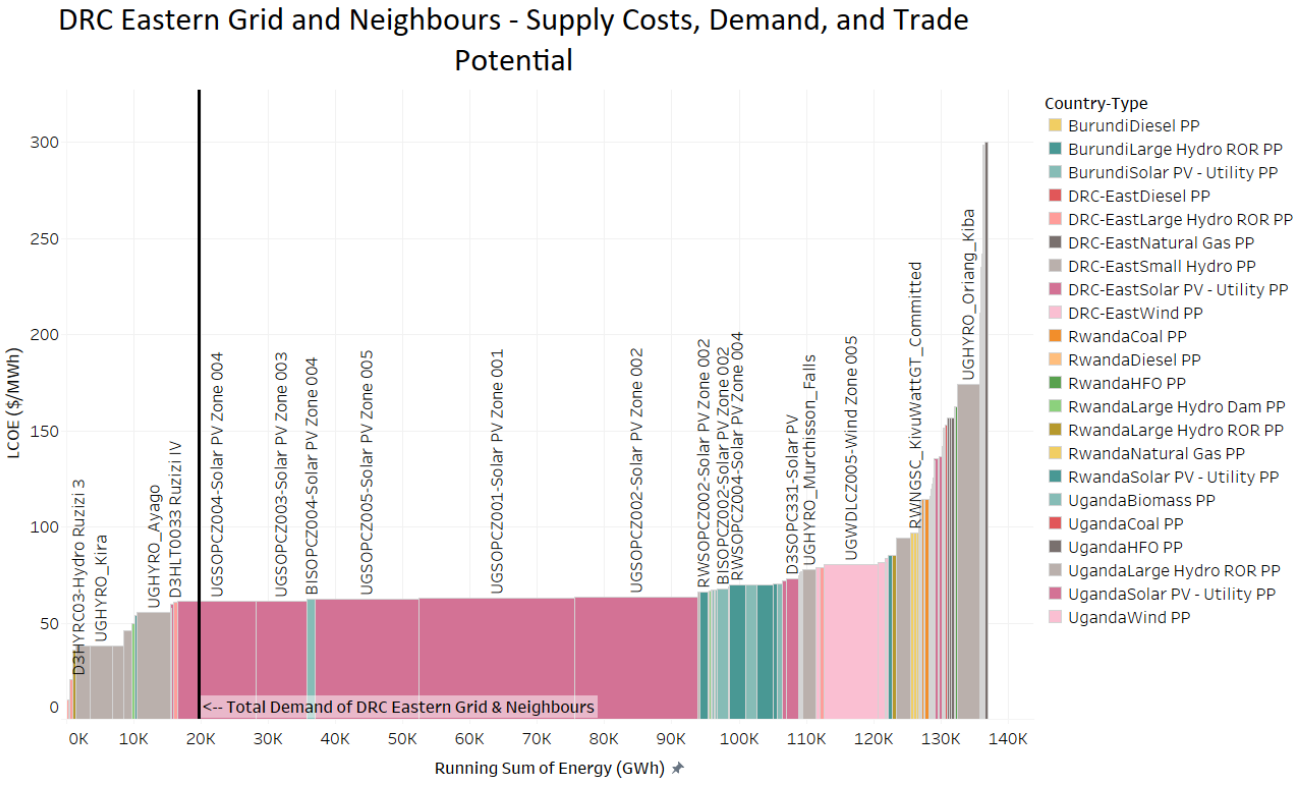

Figure 5 Supply Screening Curve for DRC East and Neighbouring Countries (Burundi, Uganda and Rwanda). The black vertical line represents the total expected 2030 demand of the region made up of the DRC Eastern grid together with the immediate neighbours.

In Figure 6 we have the same previous data but with power plant options regrouped by country. Here we see that the solar options in the East could supply a large portion of daytime electricity demand in each country. In terms of trade, we see that the cheaper hydro options in Uganda are just enough to supply Uganda without much scope for exports to DRC, leaving the larger currently undeveloped projects remaining for consideration.

The expected costs for solar in the countries in this region are mostly quite close to each other so these resources would be more likely to be developed for consumption within each country than exporting bulk energy (which alternatively, might make sense for Zambia in the South for example). The Wind resource in this area is not particularly good but are still cheaper than most of the Oil, Coal, and Gas options, but the difficulty of transporting large wind turbines through several countries and challenging terrain from the seaports of neighbouring countries might make wind power in the region not worthwhile in the medium term. Again, like in the South+West region the DRC importing specific hydro power from its neighbours may be politically unattractive so it may be unlikely for the DRC itself to make joint investments in large projects in other countries beyond its shared rivers.

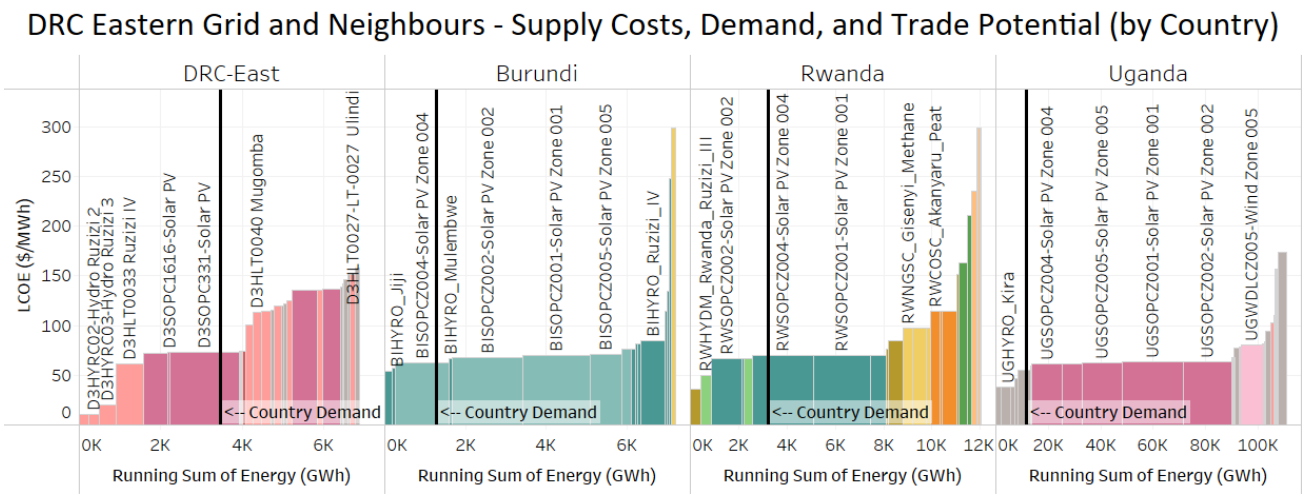

Figure 6 Supply Curve by Country (DRC East+Neighbours). Each black horizonal line represents the demand of that specific country. ***Note that the axes and scales are not the same for each chart.***

Figure 7 below shows the same chart as above but with Solar PV taken out to represent potential night-time supply options. For night-time supply, we see that there would potentially be scope for the DRC to import from Uganda more cheaply than supplying it with its own options. This is contingent on the hydro options being represented adequately and the planned transmission lines being built on time, with sufficient capacity, and the overarching political will required to go forward with the projects.

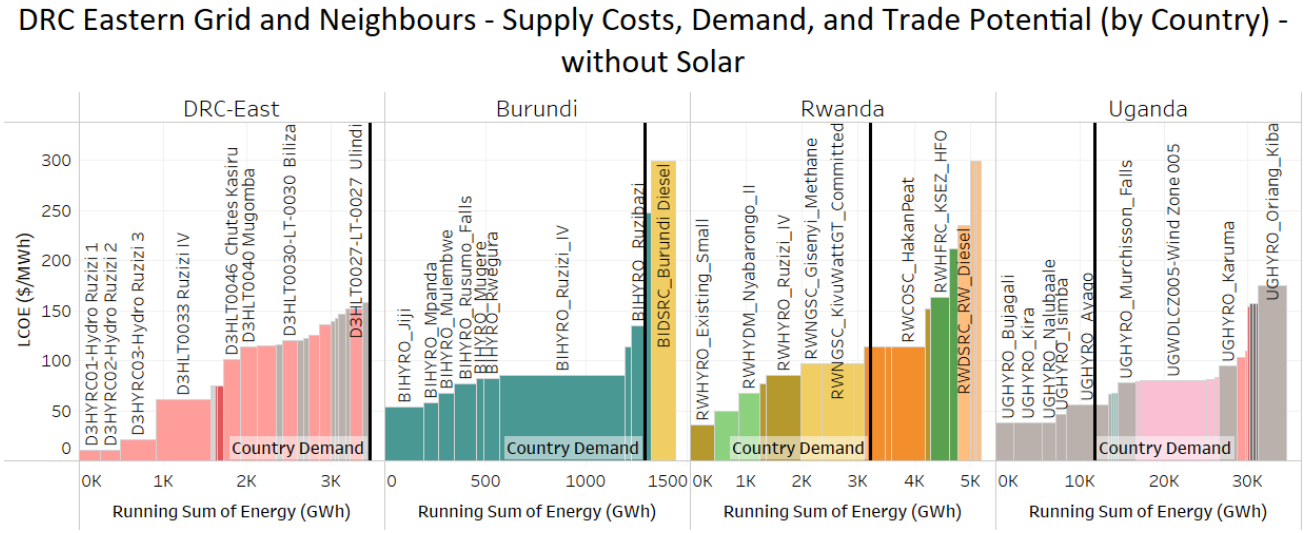

Figure 7 Supply Curve by Country (DRC East+Neighbours) night-time (no solar). Each black horizonal line represents the demand of that specific country. ***Note that the axes and scales are not the same for each chart.***

Costs of the last supply option in the curve that meets demand is a bit higher in the East (at ~60$/MWh or ~6 US cents/ kWh) than what was found in the South+West region and neighbouring countries (at ~50 $/MWh or about ~5 US cents/kWh). If this cost difference continues for the long term and significant amounts of cheap solar or geothermal energy are not developed in neighbouring EAPP countries then it may eventually make economic sense to interconnect the Eastern grid to the Southern and Western grids and join SAPP. Note: This is only the bulk generation cost from the power plants, it does not include the costs for transmission and distribution, technical losses/inefficiency, or theft – so this figure cannot be compared directly to the eventual electricity costs paid by any specific consumer which could be significantly higher.

Conclusions and Future Work

Preliminary analysis shows that if Inga 3 does in-fact materialise by 2030, there would be good opportunity for DRC to export to Angola, Congo, Zambia and to South Africa with the current Grand Inga Treaty. However, should Inga 3 not materialise before Hydro projects in Angola such as Capanda and Lauca, they could provide a lower cost alternative to powering the South+West region.

It shows that in the Eastern parts there is limited trade during the day with all regions able to supply with solar costing more or less the same across the region. However, in combination with developing and refurbishing hydro in the DRC such as the Ruzizi projects, hydro options in Uganda could theoretically provide the Eastern part of the DRC and the region with lower cost power when solar is not available, i.e., during the night.

The analysis conducted above makes several simplifications and to get a better understanding on trade opportunities it would be possible to use an optimization model with explicit detailed representations of countries outside of the DRC. This could be done either by transferring data from the OSeMOSYS 3 region DRC model to the IRENA CMP model or replicating the neighbouring countries from the IRENA CMP model in the OSeMOSYS DRC 3 region model.

The shortcomings that would be addressed, although with perhaps significant effort, include:

- Timing of projects (in terms of the year in which projects become economically viable for the region and/or updates to the realistic times when projects could become operational for the region)
- Time of use considerations: better handling of daily or yearly variability in demand, and RE (solar, wind and hydro) resources variability.
- More explicit costing of trade: for trade to be possible new transmission infrastructure must be built if the current infrastructure is inadequate or non-existent. An optimization model would consider the trade infrastructure costs explicitly, as well as taking energy losses into account when evaluating the feasibility of trade.

Other aspects or topics to consider in more detail include the following:

- Looking beyond the year 2030.
- More detailed representation of trade with South Africa, either directly through HVDC lines or indirectly by South Africa being part of the Southern African Power Pool.
- Investigating scenarios of when internal connection of the major grids within the DRC might become economically viable.

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Appendix

Levelized Cost of Energy (LCOE) Calculation Details

The Energy that each plant can deliver is calculated as follows:

Energy (GWh) = Plant Capacity (MW) x Plant Availability (fraction) x 8.76,

Where the plant availability for thermal units is calculated as follows:

Plant Availability (Thermal) = (1 - Planned Outage Rate) x (1 - Forced Outage Rate)

The plant availability for RE plants (wind, solar and hydro) is calculated by taking the average capacity factor over the year.

The LCOE calculation can be simplified in terms of the OSeMOSYS model inputs as follows:

LCOE($/MWh) = (CRF * Investment Cost ($/kW) + Fixed O&M Cost ($/kW)) / (8.76*Availability) + Variable O&M ($/MWh) + Fuel Cost ($/GJ) / Efficiency * 3.6

Where CRF is the Capital Recovery Factor calculated as follows:

$(r.(1+r)^{N-1})/((1+r)^{N}-1)$, where r is the discount rate and N the life of the plant.

Abbreviations and coding:

D**1** – Democratic Republic of Congo, **Western Grid** (interconnected to Southern DRC Grid, and connected internationally to the Republic of Congo (Brazzaville) with future potential to connect to Angola)

D**2** – Democratic Republic of Congo, **Southern Grid** (interconnected to Western DRC Grid, and connected internationally to Zambia)

D**3** – Democratic Republic of Congo, **Eastern Grid** (isolated from other DRC grids – interconnected internationally to Rwanda and Burundi with future potential to connect with Uganda)

CD – Democratic Republic of Congo (used instead of D1/2/3 for some technologies)

AO – Angola

CG – Republic of Congo (Brazzaville)

ZM – Zambia

UG – Uganda

RW – Rwanda

BI – Burundi

PP – Power plant

CMP – Continental Master Plan

SAPP – Southern African Power Pool

EAPP – East African Power Pool

CAPP – Central African Power Pool

WAPP – West African Power Pool

AfSEM - African Single Electricity Market

IRENA – International Renewable Energy Agency

Hydro – Hydropower electricity generation plant (with or without dam)

ROR – “Run-of-River” a hydropower plant that does not completely block the flow of the river, and instead diverts part of the flow to the power plant. Usually considered less environmentally disruptive but does not allow storage with a reservoir.

PV – Solar Photovoltaic

HFO – Heavy Fuel Oil (Crude oil derivative – less processed than diesel/gasoline)

CCGT – Combined Cycle Gas Turbine (gas turbines with a heat recovery water heating steam cycle added)

OCGT – Open Cycle Gas Turbine (gas turbines with no heat recovery steam cycle)

MWh – Megawatt Hour (unit of energy, not capacity)

GWh – Gigawatt Hour (1000 Megawatt Hours – unit of energy, not capacity)

LCOE – Levelized Cost of Energy

$/MWh – US Dollars (Levelized Cost of Energy) per Megawatt Hour – average sale price per unit of energy required over the project lifetime to reach payback of the project. (divide by 1000 to get $/kWh)

Solar Thermal – Solar power plant that concentrates the heat from the sun to create steam to drive a turbine and generate electricity, unlike a photovoltaic solar panel which converts sunlight to electricity directly.

Wind – On-shore wind power plants using wind turbines of the appropriate “class” for the wind of the area to be constructed (IEC class I or class II or class III – generally with lower classes (I or II) built with shorter towers in higher windspeed areas and usually cheaper to construct with the opposite true for higher classes)

Full Supply Curve for the DRC South+West and neighbouring countries

Project/Technology Code and Name	Country and Power Plant Type	Yearly Energy Potential of Project (GWh)	LCOE ($/MWh) Sorted	Running Sum of Energy (GWh)
D1HYIC01-Hydro Inga 1	DRC-S+W Large Hydro PP	1,845	17	1,845
D1HYIC02-Hydro Inga 2	DRC-S+W Large Hydro PP	7,485	17	9,329
D1HYSC01-Hydro Sanga	DRC-S+W Large Hydro PP	63	17	9,392
D1HYZC01-Hydro Zongo	DRC-S+W Large Hydro PP	394	17	9,787
D1HYZC02-Hydro Zongo 2	DRC-S+W Large Hydro PP	788	17	10,575
D2HYKC02-Hydro Nzilo	DRC-S+W Large Hydro PP	578	17	11,153
D2HYKC03-Hydro Nseke	DRC-S+W Large Hydro PP	1,303	17	12,457
D2HYMC01-Hydro Mwadingusha	DRC-S+W Large Hydro PP	357	17	12,814
D1HLT0132-LT-0132 Pioka	DRC-S+W Large Hydro PP	98	19	12,912
D1HLT0136-LT-0136 Matadi	DRC-S+W Large Hydro PP	59	24	12,971
D1HLT0109 Inga 3	DRC-S+W Large Hydro PP	23,326	30	36,297
AOHYDM_Cacula_Cabasa	AngolaLarge Hydro Dam PP	18,922	38	55,219
AOHYDM_Baynes	AngolaLarge Hydro Dam PP	2,628	42	57,847
CGHYRO_Gamboma	CongoLarge Hydro ROR PP	123	44	57,969
CGHYRO_Mbamba	CongoLarge Hydro ROR PP	53	44	58,022
AOHYDM_Lomaum_II	AngolaLarge Hydro Dam PP	1,402	44	59,424
AOHYRO_Calengue	AngolaLarge Hydro ROR PP	2,540	49	61,964
D2HYKC01-Hydro Koni	DRC-S+W Large Hydro PP	221	50	62,185
AOHYDM_Chicapa_Biopio	AngolaLarge Hydro Dam PP	424	52	62,609
CGHYDM_Moukoukoulou	CongoLarge Hydro Dam PP	648	52	63,258
CGHYRO_N_Komo	CongoLarge Hydro ROR PP	35	52	63,293
AOHYDM_Cambambe_I	AngolaLarge Hydro Dam PP	2,278	52	65,570
AOHYDM_Capanda	AngolaLarge Hydro Dam PP	4,555	52	70,125
AOHYDM_Gove	AngolaLarge Hydro Dam PP	526	52	70,651
AOHYDM_Lauca	AngolaLarge Hydro Dam PP	26,919	52	97,571
AOHYDM_Lomaum	AngolaLarge Hydro Dam PP	438	52	98,009
AOHYDM_Mabubas	AngolaLarge Hydro Dam PP	224	52	98,233
AOHYDM_Matala	AngolaLarge Hydro Dam PP	357	52	98,590
ZMSOPCZ004-Solar PV Zone 004	ZambiaSolar PV - Utility PP	37,327	59	135,917
ZMSOPCZ003-Solar PV Zone 003	ZambiaSolar PV - Utility PP	24,693	60	160,610
ZMSOPCZ005-Solar PV Zone 005	ZambiaSolar PV - Utility PP	99,097	60	259,707
ZMSOPCZ002-Solar PV Zone 002	ZambiaSolar PV - Utility PP	14,097	60	273,803
D1HLT0183 Kinsuka	DRC-S+W Large Hydro PP	4,415	60	278,218
ZMSOPCZ001-Solar PV Zone 001	ZambiaSolar PV - Utility PP	59,162	60	337,380
D1HLT0184 Kibombo Madimba	DRC-S+W Large Hydro PP	1,177	63	338,557
AOSOPCZ001-Solar PV Zone 001	AngolaSolar PV - Utility PP	97,466	63	436,024
AOSOPCZ005-Solar PV Zone 005	AngolaSolar PV - Utility PP	61,525	64	497,549
AOSOPCZ002-Solar PV Zone 002	AngolaSolar PV - Utility PP	72,300	65	569,849
AOSOPCZ004-Solar PV Zone 004	AngolaSolar PV - Utility PP	161,537	65	731,386
AOSOPCZ003-Solar PV Zone 003	AngolaSolar PV - Utility PP	12,972	66	744,357
D2SOPC3750-Solar PV	DRC-S+W Solar PV PP	46	67	744,403

AOHYDM_Jamba_Ya_Mina	AngolaLarge Hydro Dam PP	1,577	67	745,980
ZMWDLCZ003-Wind Zone 003	ZambiaWind PP	63,750	67	809,730
D2HLT0091 Kalengwe	DRC-S+W Large Hydro PP	1,001	67	810,731
CDWDLCZ010-Wind Zone 010	DRC-S+W Wind PP	1,988	67	812,719
D2SOPC1343-Solar PV	DRC-S+W Solar PV PP	1,547	68	814,267
D2SOPC3580-Solar PV	DRC-S+W Solar PV PP	45	68	814,312
D2SOPC1354-Solar PV	DRC-S+W Solar PV PP	3,963	68	818,275
D2SOPC3735-Solar PV	DRC-S+W Solar PV PP	51	68	818,326
ZMWDLCZ005-Wind Zone 005	ZambiaWind PP	15,461	69	833,787
ZMWDLCZ004-Wind Zone 004	ZambiaWind PP	46,611	69	880,397
D2SOPC1281-Solar PV	DRC-S+W Solar PV PP	46	69	880,443
ZMWDLCZ001-Wind Zone 001	ZambiaWind PP	14,153	69	894,596
D2SOPC1333-Solar PV	DRC-S+W Solar PV PP	51	69	894,647
D2SOPC1390-Solar PV	DRC-S+W Solar PV PP	484	70	895,131
CDWDLCZ002-Wind Zone 002	DRC-S+W Wind PP	225	70	895,355
CDWDLCZ007-Wind Zone 007	DRC-S+W Wind PP	419	70	895,774
D2HLT0139 Mambilima Falls V	DRC-S+W Large Hydro PP	1,825	71	897,599
CDWDLCZ006-Wind Zone 006	DRC-S+W Wind PP	241	72	897,841
AOHYRO_Quilengue	AngolaLarge Hydro ROR PP	4,555	72	902,396
CDWDLCZ001-Wind Zone 001	DRC-S+W Wind PP	616	74	903,012
D1SOPC1886-Solar PV	DRC-S+W Solar PV PP	45	74	903,057
D1SOPC1849-Solar PV	DRC-S+W Solar PV PP	45	74	903,102
D1DSBC01-Diesel Bomba	DRC-S+W Diesel PP	176	74	903,278
CGBMST_N-KAYI.MILL	CongoBiomass PP	35	75	903,313
CGBMST_OUESSO	CongoBiomass PP	15	75	903,328
D1SOPC1874-Solar PV	DRC-S+W Solar PV PP	83	75	903,410
ZMWDLCZ002-Wind Zone 002	ZambiaWind PP	109,420	75	1,012,831
D1SOPC1807-Solar PV	DRC-S+W Solar PV PP	66	76	1,012,897
CDWDLCZ008-Wind Zone 008	DRC-S+W Wind PP	1,637	76	1,014,534
CDWDLCZ005-Wind Zone 005	DRC-S+W Wind PP	373	76	1,014,907
CDWDLCZ004-Wind Zone 004	DRC-S+W Wind PP	75	77	1,014,982
CGSOPCZ002-Solar PV Zone 002	CongoSolar PV - Utility PP	22,218	77	1,037,200
D1HSF1004-SF-1004 SF-1004	DRC-S+W Large Hydro PP	849	78	1,038,048
D1SOPC329-Solar PV	DRC-S+W Solar PV PP	116	78	1,038,164
CGSOPCZ001-Solar PV Zone 001	CongoSolar PV - Utility PP	27,394	78	1,065,558
CGSOPCZ005-Solar PV Zone 005	CongoSolar PV - Utility PP	30,750	79	1,096,308
CGSOPCZ003-Solar PV Zone 003	CongoSolar PV - Utility PP	7,544	79	1,103,852
CGSOPCZ004-Solar PV Zone 004	CongoSolar PV - Utility PP	1,591	79	1,105,444
AOWDLCZ005-Wind Zone 005	AngolaWind PP	2,791	79	1,108,235
AOWDLCZ004-Wind Zone 004	AngolaWind PP	1,598	79	1,109,833
D1SOPC1904-Solar PV	DRC-S+W Solar PV PP	198	80	1,110,031
D2HLT0141 Kimimbi-Fuka	DRC-S+W Large Hydro PP	751	80	1,110,782
CDWDLCZ009-Wind Zone 009	DRC-S+W Wind PP	87	81	1,110,868
AONGCC_Angola_CCGT_NG	AngolaNatural Gas PP	931	81	1,111,799
CGHYRO_Mourala	CongoLarge Hydro ROR PP	374	81	1,112,173

D2HLT0075 Nzilo II	DRC-S+W Large Hydro PP	589	83	1,112,762
D1HSF0873-SF-0873 SF-0873	DRC-S+W Large Hydro PP	551	83	1,113,313
CDWDLCZ003-Wind Zone 003	DRC-S+W Wind PP	223	83	1,113,536
D1SOPC1835-Solar PV	DRC-S+W Solar PV PP	263	83	1,113,799
ZMHYDM_Kafue_Gorge	ZambiaLarge Hydro Dam PP	5,784	84	1,119,583
AONGCC_P_Angola_Soyo	AngolaNatural Gas PP	5,585	84	1,125,168
AOWDLCZ002-Wind Zone 002	AngolaWind PP	2,581	84	1,127,749
ZMHYDM_Kafue_Gorge_Lower	ZambiaLarge Hydro Dam PP	4,348	85	1,132,097
D2HLT0094 Mumbotuta M	DRC-S+W Large Hydro PP	1,030	87	1,133,128
D2HLT0140 Mumbotuta CX	DRC-S+W Large Hydro PP	1,472	87	1,134,599
D2HLT0138 Mambilima Falls I	DRC-S+W Large Hydro PP	1,472	88	1,136,071
CGWDLCZ001-Wind Zone 001	CongoWind PP	64	91	1,136,135
D1HSF0980-SF-0980 SF-0980	DRC-S+W Large Hydro PP	596	91	1,136,730
D1HSF1011-SF-1011 SF-1011	DRC-S+W Large Hydro PP	880	91	1,137,610
AOWDLCZ003-Wind Zone 003	AngolaWind PP	23,336	92	1,160,946
CGHYRO_Kouembali	CongoLarge Hydro ROR PP	623	92	1,161,569
CGHYRO_Imboulou	CongoLarge Hydro ROR PP	496	92	1,162,065
D2HLT0084 Mambilima Falls II	DRC-S+W Large Hydro PP	618	95	1,162,683
AOWDLCZ001-Wind Zone 001	AngolaWind PP	147,161	95	1,309,843
D1SOPC296-Solar PV	DRC-S+W Solar PV PP	680	97	1,310,524
D1HSF0997-SF-0997 SF-0997	DRC-S+W Large Hydro PP	325	97	1,310,849
CGHYRO_Liouessa	CongoLarge Hydro ROR PP	75	99	1,310,924
ZMHYDM_Kariba_NBE	ZambiaLarge Hydro Dam PP	5,288	100	1,316,212
AOHYDM_Jamba_Ya_Oma	AngolaLarge Hydro Dam PP	657	108	1,316,869
CGHYRO_Sounda_Gorge	CongoLarge Hydro ROR PP	1,367	112	1,318,236
D2HSF0852-Solar PV	DRC-S+W Large Hydro PP	217	114	1,318,453
ZMCOSC01-Maamba Coal I (St)	ZambiaCoal PP	2,234	114	1,320,687
ZMCOSC10_Maamba Coal II	ZambiaCoal PP	4,468	114	1,325,155
ZMCOSC30-Zambia_Coal	ZambiaCoal PP	1,973	114	1,327,128
D1HSF0698-SF-0698 SF-0698	DRC-S+W Large Hydro PP	164	115	1,327,292
CGNGSC_DJENO.TOTAL	CongoNatural Gas PP	82	115	1,327,374
AOHYRO_Camambe_II	AngolaLarge Hydro ROR PP	2,782	115	1,330,156
AONGSC_E_CIF	AngolaNatural Gas PP	894	116	1,331,050
CGNGSC_COTE.MATEVE	CongoNatural Gas PP	2,234	116	1,333,284
CGNGSC_DJENO.ENI	CongoNatural Gas PP	186	116	1,333,470
AONGSC_Angola_OCGT_NG	AngolaNatural Gas PP	15,638	116	1,349,108
D1HSF1005-SF-1005 SF-1005	DRC-S+W Large Hydro PP	565	117	1,349,673
D2HLT0182 Kambuji	DRC-S+W Large Hydro PP	166	117	1,349,839
D1HSF0994-SF-0994 SF-0994	DRC-S+W Large Hydro PP	339	117	1,350,179
AOHYRO_Cafula	AngolaLarge Hydro ROR PP	1,415	121	1,351,593
D2HSF0910-Solar PV	DRC-S+W Large Hydro PP	202	123	1,351,795
D1HSF0670-SF-0670 SF-0670	DRC-S+W Large Hydro PP	134	125	1,351,929
AOHYRO_Tumuludo	AngolaLarge Hydro ROR PP	1,296	127	1,353,225
CGHYRO_Djoue	CongoLarge Hydro ROR PP	53	130	1,353,278
ZMHYDM_Ithezi_Thezi	ZambiaLarge Hydro Dam PP	446	132	1,353,724

D1SOTS00-Generic Solar thermal with Storage	DRC-S+W Solar PV PP	618	135	1,354,342
D2SOTS00-Generic Solar thermal with Storage	DRC-S+W Solar PV PP	618	135	1,354,960
D1SOTN00-Generic Solar thermal no storage	DRC-S+W Solar PV PP	429	137	1,355,390
D2SOTN00-Generic Solar thermal no storage	DRC-S+W Solar PV PP	429	137	1,355,819
D1HSF0996-SF-0996 SF-0996	DRC-S+W Large Hydro PP	251	137	1,356,070
D1HSF0937-SF-0937 SF-0937	DRC-S+W Large Hydro PP	121	138	1,356,191
CGHYRO_Chollet	CongoLarge Hydro ROR PP	823	139	1,357,014
AOHYRO_Zenzo_I	AngolaLarge Hydro ROR PP	1,296	142	1,358,310
D1HLT0089-LT-0089 Kilemfu	DRC-S+W Large Hydro PP	147	142	1,358,457
D1HSF0889-SF-0889 SF-0889	DRC-S+W Large Hydro PP	169	143	1,358,626
D1HLT0106-LT-0106 Bamba	DRC-S+W Large Hydro PP	108	144	1,358,734
D2HLT0180 Dikolongo aval	DRC-S+W Small Hydro PP	86	145	1,358,821
D1HLT0127-LT-0127 Ruki	DRC-S+W Large Hydro PP	559	145	1,359,380
D2HLT0181 Chutes de Kawa	DRC-S+W Small Hydro PP	88	146	1,359,468
D1HSF0885-SF-0885 SF-0885	DRC-S+W Large Hydro PP	144	149	1,359,612
D1HSF0897-SF-0897 SF-0897	DRC-S+W Large Hydro PP	142	151	1,359,754
D1HSF0741-SF-0741 SF-0741	DRC-S+W Small Hydro PP	75	153	1,359,829
D2HLT0166 Kayo	DRC-S+W Large Hydro PP	167	154	1,359,996
D1HLT0087-LT-0087 Banda	DRC-S+W Large Hydro PP	177	155	1,360,172
D1HSF0987-SF-0987 SF-0987	DRC-S+W Large Hydro PP	187	155	1,360,360
D1HSF0705-SF-0705 SF-0705	DRC-S+W Small Hydro PP	62	156	1,360,422
D2HLT0165 Kabundji	DRC-S+W Large Hydro PP	172	156	1,360,594
D1HSF0988-SF-0988 SF-0988	DRC-S+W Large Hydro PP	190	157	1,360,783
D2HLT0171 Mukuleshi	DRC-S+W Large Hydro PP	172	157	1,360,955
D1HLT0113-LT-0113 Ingende	DRC-S+W Large Hydro PP	397	157	1,361,353
D1HSF0878-SF-0878 SF-0878	DRC-S+W Small Hydro PP	49	161	1,361,402
D2HSF0969-Solar PV	DRC-S+W Large Hydro PP	183	162	1,361,585
D1HLT0107 Dibaya-Lubwe	DRC-S+W Large Hydro PP	177	163	1,361,761
D1HSF0844-SF-0844 SF-0844	DRC-S+W Large Hydro PP	102	165	1,361,863
D2HSF0893-Solar PV	DRC-S+W Small Hydro PP	56	166	1,361,920
D2HSF0779-Solar PV	DRC-S+W Small Hydro PP	46	168	1,361,966
D1HSF0689-SF-0689 SF-0689	DRC-S+W Small Hydro PP	65	169	1,362,030
D2HSF0915-Solar PV	DRC-S+W Small Hydro PP	65	169	1,362,096
D1HLT0185-LT-0185 Kwilu	DRC-S+W Small Hydro PP	88	170	1,362,184
AOHFRC_E_Benguela_(Eng)	AngolaHFO PP	140	171	1,362,324
CGHFRC_POINTE-NOIRE	CongoHFO PP	93	171	1,362,417
ZMHYDM_Lusiwasi	ZambiaLarge Hydro Dam PP	138	186	1,362,554
ZMHYRO_Musonda_Falls	ZambiaLarge Hydro ROR PP	247	193	1,362,801
ZMHFRC10-Zambia_Indola Energy (HFO)	ZambiaHFO PP	147	194	1,362,949
ZMHYRO_Lusiwasi_Extension	ZambiaLarge Hydro ROR PP	212	194	1,363,160
ZMHYRO_Lusiwasi_Lower	ZambiaLarge Hydro ROR PP	217	194	1,363,377
ZMHYRO_Chishimba_Falls_Lunzua	ZambiaLarge Hydro ROR PP	84	201	1,363,461
ZMHYRO_Kabompo_Gorge	ZambiaLarge Hydro ROR PP	225	202	1,363,686
ZMHYRO_Victoria_Falls	ZambiaLarge Hydro ROR PP	243	217	1,363,928

ZMHYRO_Batoka_Gorge_North	ZambiaLarge Hydro ROR PP	2,695	218	1,366,623
ZMHYRO_Mkushi	ZambiaLarge Hydro ROR PP	152	218	1,366,775
ZMHYRO_Devils_Gorge_N	ZambiaLarge Hydro ROR PP	1,353	226	1,368,128
ZMHYRO_Kalungwishi_I	ZambiaLarge Hydro ROR PP	218	227	1,368,346
ZMHYRO_Mambilima_Falls_I-II	ZambiaLarge Hydro ROR PP	704	236	1,369,050
CGDSRC_POINTE-NOIRE.SNE	CongoDiesel PP	61	236	1,369,111
CGDSRC_POINTE-NOIRE	CongoDiesel PP	31	237	1,369,142
AODSRC_E_Cazenga	AngolaDiesel PP	2,643	237	1,371,785
AODSRC_E_Boavista	AngolaDiesel PP	4,331	238	1,376,116
AODSRC_E_Quileva	AngolaDiesel PP	1,582	238	1,377,699
CGDSRC_MPILA	CongoDiesel PP	224	238	1,377,923
D1NGSO00-Solar thermal with Gas	DRC-S+W Gas PP	429	300	1,378,352
D2NGSO00 Solar thermal with Gas	DRC-S+W Gas PP	429	300	1,378,781
ZMHYRO_Lunsemfwa_Kalungwishi_II	ZambiaLarge Hydro ROR PP	119	354	1,378,900

Full Supply Curve for the DRC Eastern Region and Neighbouring Countries

Project/Technology Code and Name	Country and Power Plant Type	Yearly Energy Potential of Project (GWh)	LCOE ($/MWh) Sorted	Running Sum of Energy (GWh)
D3HYRC01-Hydro Ruzizi 1	DRC-EastLarge Hydro ROR PP	245	10	245
D3HYRC02-Hydro Ruzizi 2	DRC-EastLarge Hydro ROR PP	247	10	492
D3HYRC03-Hydro Ruzizi 3	DRC-EastLarge Hydro ROR PP	425	21	917
RWHYRO_Existing_Small	RwandaLarge Hydro ROR PP	429	36	1,346
UGHYRO_Bujagali	UgandaLarge Hydro ROR PP	2,190	38	3,536
UGHYRO_Kira	UgandaLarge Hydro ROR PP	3,329	38	6,865
UGHYRO_Nalubaale	UgandaLarge Hydro ROR PP	1,577	38	8,442
UGHYRO_Isimba	UgandaLarge Hydro ROR PP	1,318	46	9,760
RWHYDM_Rwanda_Ruzizi_III	RwandaLarge Hydro Dam PP	438	50	10,198
BIHYRO_Jiji	BurundiLarge Hydro ROR PP	192	54	10,391
UGHYRO_Ayago	UgandaLarge Hydro ROR PP	5,032	56	15,422
BIHYRO_Mpanda	BurundiLarge Hydro ROR PP	73	58	15,495
UGSOPCZK23-PV Zone K	UgandaSolar PV - Utility PP	400	60	15,896
D3HLT0033 Ruzizi IV	DRC-EastLarge Hydro ROR PP	655	61	16,550
UGSOPCZ004-Solar PV Zone 004	UgandaSolar PV - Utility PP	11,604	61	28,155
UGSOPCZ003-Solar PV Zone 003	UgandaSolar PV - Utility PP	7,530	61	35,685
BISOPCZ004-Solar PV Zone 004	BurundiSolar PV - Utility PP	1,320	63	37,005
UGSOPCZ005-Solar PV Zone 005	UgandaSolar PV - Utility PP	15,350	63	52,355
UGSOPCZ001-Solar PV Zone 001	UgandaSolar PV - Utility PP	23,121	63	75,476
UGSOPCZ002-Solar PV Zone 002	UgandaSolar PV - Utility PP	18,331	63	93,806
UGHYRO_Existing_Small	UgandaLarge Hydro ROR PP	306	66	94,112
RWSOPCZ002-Solar PV Zone 002	RwandaSolar PV - Utility PP	1,268	66	95,380
RWSOPCZ005-Solar PV Zone 005	RwandaSolar PV - Utility PP	76	66	95,456
RWHYDM_Nyabarongo_II	RwandaLarge Hydro Dam PP	381	67	95,837
BIHYRO_Mulembwe	BurundiLarge Hydro ROR PP	79	67	95,917
UGBMST01-Existing Kakira	UgandaBiomass PP	299	67	96,216
UGBMST02-Existing Kinyara	UgandaBiomass PP	205	67	96,421
UGBMST10-Committed Kinyara2	UgandaBiomass PP	246	67	96,668
BISOPCZ002-Solar PV Zone 002	BurundiSolar PV - Utility PP	1,751	68	98,419
UGWDLCZ003-Wind Zone 003	UgandaWind PP	81	69	98,500
RWSOPCZ004-Solar PV Zone 004	RwandaSolar PV - Utility PP	2,495	70	100,995
BISOPCZ001-Solar PV Zone 001	BurundiSolar PV - Utility PP	1,676	70	102,672
RWSOPCZ001-Solar PV Zone 001	RwandaSolar PV - Utility PP	2,375	70	105,046
RWSOPCZ003-Solar PV Zone 003	RwandaSolar PV - Utility PP	626	70	105,672
BISOPCZ005-Solar PV Zone 005	BurundiSolar PV - Utility PP	775	71	106,448
D3SOPC330-Solar PV	DRC-EastSolar PV - Utility PP	592	72	107,039
D3SOPC1616-Solar PV	DRC-EastSolar PV - Utility PP	69	73	107,108
D3SOPC331-Solar PV	DRC-EastSolar PV - Utility PP	1,690	73	108,798
D3DSBC02-Diesel Bandundu	DRC-EastDiesel PP	12	74	108,811
D3DSBC03-Diesel Basankusu	DRC-EastDiesel PP	5	74	108,816
D3DSBC04-Diesel Boende	DRC-EastDiesel PP	6	74	108,822

D3DSBC05-Diesel Bumba	DRC-EastDiesel PP	3	74	108,825
D3DSBC06-Diesel Buta	DRC-EastDiesel PP	14	74	108,839
D3DSBC07-Diesel Butembo	DRC-EastDiesel PP	2	74	108,841
D3DSGC01-Diesel Gemena	DRC-EastDiesel PP	37	74	108,879
D3DSGC02-Diesel Goma	DRC-EastDiesel PP	75	74	108,954
BISOPCZ003-Solar PV Zone 003	BurundiSolar PV - Utility PP	250	76	109,203
BIHYRO_Rusumo_Falls	BurundiLarge Hydro ROR PP	110	77	109,313
RWHYRO_Rusumo	RwandaLarge Hydro ROR PP	110	77	109,423
UGHYRO_Murchisson_Falls	UgandaLarge Hydro ROR PP	2,050	78	111,473
UGWDLCZ004-Wind Zone 004	UgandaWind PP	501	79	111,973
UGWDLCZ005-Wind Zone 005	UgandaWind PP	7,962	81	119,936
UGWDLCZ002-Wind Zone 002	UgandaWind PP	1,024	82	120,960
BIHYRO_Mugere	BurundiLarge Hydro ROR PP	35	82	120,995
BIHYRO_Rwegura	BurundiLarge Hydro ROR PP	79	82	121,073
UGWDLCZ001-Wind Zone 001	UgandaWind PP	417	84	121,491
BIHYRO_Ruzizi_IV	BurundiLarge Hydro ROR PP	622	85	122,113
RWHYRO_Ruzizi_IV	RwandaLarge Hydro ROR PP	622	85	122,735
UGHYRO_Karuma	UgandaLarge Hydro ROR PP	2,108	94	124,843
RWNGSC_Gisenyi_Methane	RwandaNatural Gas PP	372	97	125,215
RWNGSC_KivuWattGT_Committed	RwandaNatural Gas PP	559	97	125,774
RWNGSC_KivuWattGT_Existing	RwandaNatural Gas PP	186	97	125,960
RWNGSC_KP1_Gisenyi_Methane	RwandaNatural Gas PP	13	97	125,973
D3HLT0046 Chutes Kasiru	DRC-EastLarge Hydro ROR PP	196	101	126,169
D3HLT0040 Mugomba	DRC-EastLarge Hydro ROR PP	196	114	126,366
BIHYRO_Kagunizi	BurundiLarge Hydro ROR PP	36	114	126,402
RWCOSC_Akanyaru_Peat	RwandaCoal PP	372	114	126,774
RWCOSC_Gishoma_Peat	RwandaCoal PP	112	114	126,886
RWCOSC_HakanPeat	RwandaCoal PP	596	114	127,481
D3HSF0982-SF-0982 SF-0982	DRC-EastLarge Hydro ROR PP	231	114	127,712
D3HSF0931-SF-0931 SF-0931	DRC-EastSmall Hydro PP	82	116	127,795
D3HLT0030-LT-0030 Biliza	DRC-EastLarge Hydro ROR PP	167	120	127,962
D3HSF0759-SF-0759 SF-0759	DRC-EastSmall Hydro PP	73	120	128,035
D3HLT0031-LT-0031 Kiliba - Katobo	DRC-EastSmall Hydro PP	74	122	128,108
D3HLT0067 Muhuma	DRC-EastLarge Hydro ROR PP	123	125	128,231
BIHYRO_Ruzibazi	BurundiLarge Hydro ROR PP	67	134	128,298
D3SOTS00-Solar thermal with Storage	DRC-EastSolar PV - Utility PP	618	135	128,916
D3HSF0911-SF-0911 SF-0911	DRC-EastLarge Hydro ROR PP	140	136	129,056
D3SOTN00-Solar thermal no storage	DRC-EastSolar PV - Utility PP	429	137	129,485
D3HSF0421-SF-0421 SF-0421	DRC-EastSmall Hydro PP	49	139	129,534
D3HSF0540-SF-0540 SF-0540	DRC-EastSmall Hydro PP	35	142	129,570
D3HSF0939-SF-0939 SF-0939	DRC-EastSmall Hydro PP	87	147	129,657
RWHYRO_Nyabarongo_I	RwandaLarge Hydro ROR PP	94	151	129,751
D3HSF0763-SF-0763 SF-0763	DRC-EastSmall Hydro PP	52	151	129,802
D3HLT0027-LT-0027 Ulindi	DRC-EastLarge Hydro ROR PP	147	152	129,949
UGCOSC10-Committed Kabale_Peat	UgandaCoal PP	246	153	130,195

UGHFRC01-Existing Electromaxx	UgandaHFO PP	350	157	130,545
UGHFRC02-Existing Namanve	UgandaHFO PP	350	157	130,896
UGHFRC10-Committed Albatros	UgandaHFO PP	350	157	131,246
D3HSF0856-SF-0856 SF-0856	DRC-EastSmall Hydro PP	94	158	131,340
CDWDLCZ001-Wind Zone 011	DRC-EastWind PP	35	162	131,375
RWHFRC_KSEZ_HFO	RwandaHFO PP	350	163	131,725
UGHYRO_Oriang_Kiba	UgandaLarge Hydro ROR PP	3,349	174	135,074
RWHFRC_Jabana2	RwandaHFO PP	140	211	135,214
CDWDLCZ002-Wind Zone 012	DRC-EastWind PP	25	216	135,239
RWDSRC_RW_Diesel	RwandaDiesel PP	230	235	135,469
CDWDLCZ003-Wind Zone 013	DRC-EastWind PP	27	242	135,496
BIHYRO_Kabu	BurundiLarge Hydro ROR PP	32	248	135,528
BIDSRC_Burundi Diesel	BurundiDiesel PP	119	299	135,647
RWDSRC_Gikondo	RwandaDiesel PP	70	299	135,717
RWDSRC_Jabana1	RwandaDiesel PP	50	299	135,768
RWDSRC_Mukungwa	RwandaDiesel PP	70	299	135,838
D3NGSO00-Solar thermal with Gas	DRC-EastNatural Gas PP	429	300	136,267