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Opportunities and challenges for distributed generation with rooftop photovoltaic (PV) for Uganda: a case study crusader house, Kampala

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ARPL7056: Research report – Schedule of revisions

Student name and number: CEASER MIGISHA (1231324); **Degree**: Master Architecture (SEEC); **Supervisors:** Prof. Daniel Irurah and Ms.Marloes Reinink

Title: OPPORTUNITIES AND CHALLENGES FOR DISTRIBUTED GENERATION WITH ROOFTOP PHOTOVOLTAIC (PV) FOR UGANDA: A CASE STUDY OF CRUSADER HOUSE, KAMPALA

Faculty and School: Faculty of Engineering and Built Environment-School of Architecture and Planning

Section and page number	Examiner's comment	Corrections executed
Minor examiner's detailed report comments, dated; 25 Feb 2018	• I am satisfied that Ceaser has learnt a lot in the last year. "I have re-read the entire thesis and made notes that in my opinion will greatly improve the research…" especially the spelling mistakes, typos and grammatical errors that should be addressed, which are not many. • Query: "On page 40 he explains that i=the relevant discount rate for the investor concerned, and here I highlight the word relevant. On page 122 the discount rate used is 9.5% explained as the Bank of Uganda rate. The inter-bank rate is the risk free rate, in other words what banks charge each other and by implication the lowest risk, meaning that this is not the relevant discount rate for this investor. When banks make loans to the private sector, they look to: 1) make a profit; and, 2) asses project risk, where the higher the perceived risk the high the mark-up. A PV installation, although contrary to what the student may believe, would be seen as high risk in Uganda and a realistic premium would be in the order of 5% (the student can ask Ugandan banks for an estimate), but it must be a reasonable increase (not 0.5% or 1%). The revised rate must then be applied to his models (calculations) which is a straightforward exercise as these are all on excel."	• All spelling mistakes, typos and grammatical errors have been corrected as highlighted in the report by the examiner • The word relevant on page 40 is deleted (see page 41, section 2.5.1.3). 14% discount rate is considered and applied in all model calculations presented in Chapter 6 (see page 125, second last bullet. The discount rate is corrected in the report as 'Discount rate is 14% (Bank of Uganda based on re-discount rate 13.5% +/- as of Jan 2018)'. Thus the Present value factor and the NPV values in Tables 18, 20, 22, 28, 30, 32 and 34 are updated based on the 14% discount rate • More so, on page 128 of the report, the discount rate figure 9.5% is corrected in the narrative to 14% and in the whole report on page 125, section 6.3 and page 128 • On page 129, Table 18, Column B, the values are corrected, where the abbreviation 'd' value is 14% not 9.5%. At the bottom of the Table 18, the figure 0.095 is corrected as 0.14. In light of this, this is applied to Tables 20 on page 133, Table 22 on page 135, Table 28 on page 144, Table 30 on page 146, Table 32, page 148 and Table 34 on page 150,

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		• The narrative of Table 30 on Page 146 is also revised after applying the 14% discount rate in NPV calculations. Lastly, the narrative finding on sub-question 4, page 166, and section 8.2.4 is also updated in reference to the 14% discount rate.
CHAPTER 1 section 1.1.1, page 3, page 7	**Spelling mistakes, typos and grammatical errors** • The word **'the'** is suggested by the examiner to be added after this sentence [Goel (2016) states that the United States…] • The word **'of'** is crossed out by the examiner in the sentence [… are **the** leading solar capacity as **'of'** March…], and suggested the word **'at'** • On page 7, the symbol '©' crossed out by the examiner in this word [Star Energy '©-'rated]	• The word 'the' is corrected as guided by the examiner (see page 3) • The word 'at' is corrected as guided by the examiner (see page 3) • The symbol '©' is deleted (see page 7)
Page 6	• Include GDP growth rate say 2013-2017	• This has been addressed as; (GDP growth rate range for 2013-2017 is 5.0%-7.5%) (See page 6)
CHAPTER 2 Section 2.2.5.2, page 20, page 21, page 29, Page 37 (section 2.5.1), page 45	**Spelling mistakes, typos and grammatical errors** • The word 'let' circled in this sentence bracketed […nine donor agencies 'let' to an offer of a 45% subsidy on solar power equipment.] • Examiner circled the word 'encorage' and also added the preposition 'to' in order to read well the last sentence on page 21 • On page, space between the word 'upto' • On page 37 (section 2.51.1), typo error. (Florio et al. (2008) 'not'…; • Last paragraph on page 45, space between the word market and in order to…	• On page 21, section 2.2.5.2, the word 'let' corrected to 'led' • The spelling of the word 'encourage' is corrected as well as the word 'to' added. See last sentence on page 22, section 2.2.5.3 • On page 29, section 2.4.1, the word 'up to' is spaced • On page 46, section 2.7, space between the word 'market' and 'in order to' is inserted/addressed • On page 39, section 2.5.1.1, this is executed as Florio *et al.* (2008) note that…)

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Page 15, Section 2.2.1	Query on page 15: i) "How is this different to a FIT? A FIT would move different tariffs for incoming/dispatching, whereas net metre offsets"# ii) "You have mixed small and utility. You should distinguish between the two. Very different mechanisms are used for each"	On page 15, section 2.2.1, the paragraph starting with green tags… up to Renewable energy portfolio, has been re-phrased.
Page 16, Section 2.2.3.1	Query: The examiner circled 0.42/kWh in this sentence (…and subsidy of CNY (currency of China called Yuan Renminbi) 0.42 per kWh…) and made this query in quotes. "1CNY=USD?" "+year of FX rate"	This has been explained on page 17, section 2.2.3.1.
Page 30, section 2.4.1.1	Query: Examiner queried if I meant maintenance in this sentence in brackets (Factors that influence the cost of electricity include labour, materials, the location of the project and fuel must be factored into LCOE.). In addition, the examiner inquired; "would this include storage? How is care affected if care has a shorter lifespan than that of PV, would need to be replaced?"	This has been explained on page 30, section 2.4.1.1.
Page 33 section 2.4.4.	Query on page 33, section 2.4.4 as shown in italics. *(Whereas PV systems offer several advantages, Sampaio and González (2017) argue that during the solar PV life cycle and processing, large amounts of energy is consumed. Greenhouse gases are emitted at some stages of manufacturing process of solar cells, assembly of photovoltaic modules and transport of material, among others (ibid., 2017).)* "Of course they would but are these greater than what is displaced? I think you need to make your point here." ii) On page 33 section 2.4.4, the examiner queried and requested that I should remove the words 'economic and financial risks' in this sentence (As a result, they tend to avoid the ***economic and financial risks*** associated in the development of related projects.')	This is executed on page 34, section 2.4.4. ii) This is executed on page 35, section 2.4.4

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Section 2.5.1.3, page 39	Query: "What is the difference between intervention cost and the estimated intervention cost? Explain." In reference to this definition in brackets [ROI= Total cost savings through the life cycle of the intervention minus intervention cost divided by estimated intervention cost and multiplied by 100%.]	On page 41, section 2.5.1.3, the definition is rephrased as the 'total net cash flow divided by total project investment cost expressed as a percentage.' (source: Krarti (2016:65))
CHAPTER 4 Page 76, page 77, page 79, page 81, page 83, page 84, page 85	**Spelling mistakes, typos and grammatical errors** • Grammatical error. [Third parties who would be interested 'on' a partnership…] the word 'interested on' is circled. • On page 77, subsection 4.4 examiner query. "The solar or PV runs 7-10pm? Review the sentence". Supervisor query: Schools do they have battery storage to allow for night use? • This query is on page 76, last paragraph; ['Schools within the city have embraced solar PV installation as an alternative source of power which runs only from 7pm to 10pm…'). • In the second line of page 79, the word 'as' crossed out • In the last paragraph of page 79, examiner suggested to insert the word 'in' [... it was set 'in' 2007…] not [… it was set 2007…] • On page 81, before section 4.6, last line. Space the word 'notsimilar' • On page 83, Examiner crossed out the words ['… it can be externally available at lower interest rates'] and suggested [as 'international finance can be sourced at a lower interest rate] • On page 84, the third last line before section 4.8, the examiner moved/shifted the word 'interviewed' in the sentence in brackets […many tenants (especially those …. 20 years) interviewed expressed their willingness…] and suggested the sentence to read as […many tenants interviewed (especially those… for 20 years) expressed their willingness…]	• On page 77, section 4.3.2, the word 'interested in' is corrected as guided by the examiner • On 77, section 4.4, the sentence has been revised to clarify on the examiner's query. • On page 80, section 4.5, the word 'as' is deleted as guided by the examiner • On page 80, section 4.5, the word 'in' is inserted in the sentence. • On page 82, section 4.5, the word 'not similar' is spaced • On page 84, section 4.7, the sentence has been corrected as guided by the examiner • On page 85, section 4.7, the word interviewed has been shifted as guided by the examiner • This sentence has been revised as shown on page 85, section 4.8 • On pages 85-86, this sentence is revised in response to the examiner's suggestions

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	• On page 84, section 4.8, the examiner comment: "Revise this sentence (in brackets), your point is unclear. Are you saying it is applicable?." [However, the existing policy and legislation permit licenced off-grid/standalone system application for rooftop PV investment on the case study building.] • On page 85, under the sub heading ***challenges,*** in the first bullet, the examiner crossed out the word 'at', and inserted the word 'in'. The word 'level' is also crossed out, added a comma after the word infancy. See sentence in brackets. [The respondents' responses in this chapter clearly indicate that solar business in Uganda is still **at** its infancy **level** despite the 11 cents USD FiT tariff for solar energy generation]	
Page 71, Section 4.3.1	• Query: "It is now 2018, will these be commissioned?"	• Response to this comment has been provided on page 72, section 4.3.1
Page 75	• Examiner comment: "Seem crazy 'let it' "	This is not executed in the report, as it is a complement
Page 86	• Chapter 4 is fine, however, I have two comments i) "The sub-question is legislative and policy but you hear a lot with operational issues (e.g dust, standards, non-skilled workforce) suggest you consider including operational issues in your sub question or at least how policy/legislation impacts things on the ground?" ii) Stronger conclusion. Make your point, cannot export to the grid. So what are you saying? That there is an opportunity to for CHOB to install PV for own use only? With potential for grid export in the future."	Response to this comment has been provided on page 86, section 4.8-conclusion, where the sub question is retained, however, another paragraph for the conclusion has been added.

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CHAPTER 5 Page 90	• Query: The net floor areas(2,281m^2) for the main and net floor area 2,053m2 for the Annex not adding up to 4,164.16m2 the total net floor area of Crusader House office building. • Given that the buildings were built 5 years apart, were they built the same style? i.e are they similar?	• This has been addressed in sub section 5.4, page 92. • This is addressed in section 5.4, page 92.
Page 92, page 100, Page 101, 112	**Spelling mistakes, typos and grammatical errors** • On page 92, section 5.4.1, the preposition 'to control' is circled by the examiner in the sentence in brackets. [Manually controlled internal blinds are used **to control** direct sunlight from north façade windows.] Supervisor suggested the word **'to manage'** • On page 100, the spelling error, 'potable' • On page 101, subsection 5.5.7, the preposition 'on' is crossed out in this sentence in brackets, [… the monthly electricity cost fell on December…]. The examiner suggested the word 'in' in order to revise the sentence. • On page 112, the preposition 'of' is crossed out by examiner in this sentence [The purple colour, the plug loads (computer and equipment) and Yellow colour (external windows) contribute a lot **of** the internal heat gains.]. Revise the sentence with the preposition 'to'. • On page 112, section 5.6.2.6, spelling mistake, 'hyrodro'	• On page 94 section 5.4.1, the sentence is revised as, [Manually controlled internal blinds are used **to manage** direct sunlight from north façade windows] • On page 103, section 5.5.4 the spelling of the word 'portable' is corrected • On page 104, section 5.5.7, this grammatical error on page 101 is corrected as guided by the examiner. • On page 114, section 5.6.2.4, the recommended preposition is inserted in the sentence as guided by the examiner • On page 114, section 5.6.2.6, the spelling mistake is corrected as 'hydro.'
Page 95, Section 5.5.2	• Query: No fridges, no micro wave, no oven, TVs, kettles, oven?	On page 97-98, section 5.5.2, this is executed as an explanation for Table 7
Page 96 section 5.5.2	• Query: The examiner circled the word fridges, as noted, " you have fridges here but not in table 7"	• In reference to page 97-98 executed query, this query is executed on page 97, section 5.5.2.
Page 101, section 5.5.7	• Query: "Is this for main and annex? Clarify I see both"	On page 104, section 5.5.7, the subheading is rephrased

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Page 102, section 5.5.7	• Query on Table 9 caption, "Main and annex?" • Examiner query on why the project manager merged the two building block electricity meter reading devices: "What was the rationale of doing this? It may make the building manager's life easier but makes it harder to isolate areas" • In Table 9, the examiner circled the energy consumption values of 2015 from January to March and queried, "Consumption higher in 2015?" In addition, he circled the energy consumption values of 2016 from May to December, and queried, "consumption higher in 2016 why?"	• On pages 104-105, section 5.5.7 this is addressed. • This is addressed on pages 104-105, section 5.5.7. • On page 105, section 5.5.7, it is described under Table 9, that the electricity escalation was 10%, hence variation of the values between the 2015 and 2016, and that several errors in the process of merging the meter readings were observed as narrated by the manager.
Page 103, section 5.5.7 and section 5.6	Examiner query: • On page 112, grammatical error query in this sentence; 'The gains from external windows can be reduced by introducing longer overhangs (the existing overhangs are 1metre wide, so having 1.5 meters ***will reduce*** some significant amount). Examiner crossed out the prepositions **'will'** and **'some'** • On page 103, "The figure 22 does not correspond to Table 9. It is very unclear" • Query on scales of figure 22. • On page 103, section 5.6, "The examiner does not fully agree with the assumption of having appliances and equipment not running for full 10 hours a day. If not that I should add academic evidence. Or show why it is negligible. His opinion, is that some value should be added.	• On page 115, section 5.6.2.4, this sentence is rephrased as guided by the examiner. • On page 106, section 5.5.7, Figure 22 is re-generated in reference to Table 9 • On page 105, section 5.5.7, the query on scales is addressed. • In reference to page 96-97, section 5.5.2 and as highlighted in the delimitation in Chapter 1 as well as Chapter 6, page 137, section 6.5.1, this is addressed in the over sizing of the PV system where CHOB required 100W solar module but a 250W module was selected.
Page 104, section 5.6.2	• Examiner query on page 104: "What does this mean? is 2002 a date? Be clear people are not familiar with DB	• On page 107, section 5.6.2, this phrase is deleted.
Page 110	• On page 110, section 5.6.2.4, Examiner query: "Optimised for what?"	• On page 113, section 5.6.2.3, Figure 30, this is rephrased in order to achieve the clarity sought in examiner comment.

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Page 111, section 5.6.2.3	• Examiner query on page 111, "But this goes back to your approach of excel electricity items. I am not sure why you used DB when you have actual figures. All it does to create doubt, so you can't just say this is challenging ad not deal with it."	• In reference to section 5.6.2.3, page 114, the sentence is rephrased.
Page 113, section 5.6.2.5	• Query: "is the default setting set to diesel?"	• In reference to section 5.6.2.5, page 115, this has been clarified.
Page 115, section 5.7	• Query: "just one fridge in the both building?" • On page 115, The examiner circled out the words, (can equally justified for CHOB.) in this sentence here below: This implies that the manually calculated optimised energy value can equally justified for CHOB and noted " your statement is not clear"	• This has been adequately addressed on page 97-98 and 103, section 5.5.2. • On page 118, section 5.7.1 (Table 13 explanation) this is addressed.
Page 117, section 5.7.2	• Examiner query on page 117, section 5.7.2: "It is useful to include original value in brackets, to allow the reader to see the difference. No need to keep going back to find the numbers" • Examiner opinion: "8% difference to manual calculations not a big deal don't ignore it"	• On page 120, section 5.7.2, this has been executed as per examiner's suggestion. The examiner could have misunderstood my point. However, for clarity, this is addressed in section 5.6.2.3 pages 112 and 120
Page 118, section 5.7.2	• Examiner query on page 118 and Figure 36: " is there a reason for the large fluctuations from month to month eg Jan- Feb-March-April" this is a simulated Figure 36.	• On page 121, section 5.7.2, this is executed by adding another sentence related to Figure 36.
CHAPTER 6 Page 122, section 6.2	• Risk free rate but the investment is not risk free. So you must add on a premium of 5%	A discount rate of 14% (Bank of Uganda based on re-discount rate 13.5% +/- as of Jan 2018) is considered and revised in all the spread sheets presented in chapter 6. The present value factors and the net present values are revised and based on the 14% discount rate

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Page 125, section 6.3.1	• Examiner circled the word No fridge on Table 17	This has already been addressed and clarified on page 128. See also Chapter 5, section 5.5.2, pages 97-98.
Page 129	• Examiner opinion in the report: "In my opinion, section 6.3.1 is not necessary. Anything within a payback period greater than 8 years is generally not bankable or financially attractive especially if the expected life span of the equipment is 5 years. Your NPV calculations has shown this. I would have saved a lot of time and effort and said that due to long payback period, this is not viable. You can have it in if you like, but it does raise the question as to why you were not aware it was a non-starter from the offset"	On page 128, this section is retained. However, a description of this finding is presented in chapter 8, page 166, and section 8.2.4. More so, at the bottom of the tables after calculating the NPV and PB values.
Page 133, section 6.4	• Examiner advice annotated in the report: "again use discount rate of 14.5%, if still positive then include, otherwise exclude." • On page 133, section 6.4, the examiner stated that the conclusion is Fine but the student needs to double check with a revised discount rate	This is addressed across the whole report and especially in the Chapter 6 tables. A discount rate of 14% based on Bank of Uganda rediscount rate of 13.5% was applied in NPV calculations. See Tables 18, 20, 22, 28, 32, and 34.
Page 134, section 6.5.1	• Query. " check sentence" [In reference to section 6.5, the next step is to determine the PV panel system to supply 361.62 kWh per day, where by divide energy demand per day is divided by sun hours.]	• On page 137, section 6.5.1, the word by divide is deleted.
Page 139	• Examiner query: " what is the benefit of grid interactive with battery if you do not reduce the size of the battery bank" this is examiner query made on table 25 in the report	• In reference to Chapter 4 and Chapter 8 section 8.2.5 (page 167), 8.4 (page 169), this is addressed in the report. Grid interactive with battery mitigates the frequent blackouts faced by CHOB while at the same offering opportunity for supply of surplus power to the grid in future especially when responsive policy changes come into effect.

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Page 131, section 6.3.3	**Spelling mistakes, typos and grammatical errors** • On page 131, spelling mistake, 'Scecanio'	On page 134, section 6.3.3 the spelling mistake is corrected to scenario
CHAPTER 8 Page 153 and 154 and 157	• Query on Table 37, page 153: "ok but who takes the lead? Who puts this together?" • "Who funds this?" • "What about source of finance"	In reference to Figure 40 under section 7.2, page 153-155, a multi-consultancy firm takes the lead. The firm sources funding through search for interested investors and other solar platforms such as crowd-funding.