

SET3901: Graduation Project

National and Global Projection of the Economic
Potential of Ocean Thermal Energy Conversion and
Development of Implementation Scenarios

Appendix

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Table of Appendix Contents

| | |
|--|----|
| List of Appendix Figures | I |
| List of Appendix Tables | IV |
| A. Determination of the Economic Potential of Renewable Energies in Literature..... | 1 |
| B. Different Types of LCOE Calculation | 1 |
| C. Discounted Cash Flow Analysis..... | 2 |
| D. Calculation of Demand Centre Distances Using Trigonometry | 5 |
| E. Microsoft® Excel Sheet for Supply Curve Modelling | 2 |
| F. Supply Curves for Each Tropical Island (Private Projects, Discount Rate 18%)..... | 3 |
| F.1. Barbados | 3 |
| F.2. Cuba..... | 4 |
| F.3. Dominican Republic | 5 |
| F.4. Fiji..... | 6 |
| F.5. Haiti | 7 |
| F.6. Indonesia..... | 8 |
| F.7. Jamaica | 9 |
| F.8. Madagascar..... | 10 |
| F.9. Maldives | 11 |
| F.10. Marshall Islands..... | 12 |
| F.11. Papua New Guinea | 13 |
| F.12. The Philippines | 14 |
| F.13. Republic of Mauritius | 15 |
| F.14. Saint Lucia..... | 16 |
| F.15. Seychelles | 17 |
| F.16. Sri Lanka | 18 |
| F.17. French Polynesia (France)..... | 19 |
| F.18. Guadeloupe (France) | 20 |
| F.19. Martinique (France)..... | 21 |
| F.20. Mayotte (France) | 22 |

| | |
|--|----|
| F.21. New Caledonia (France)..... | 23 |
| F.22. Reunion Island (France) | 24 |
| F.23. Aruba (Netherlands) | 25 |
| F.24. Curaçao (Netherlands)..... | 26 |
| F.25. Cayman Islands (United Kingdom)..... | 27 |
| F.26. Guam (United States of America) | 28 |
| F.27. Hawaii (United States of America)..... | 29 |
| F.28. Puerto Rico (United States of America) | 30 |
| F.29. United States Virgin Islands (United States of America) | 31 |
| G. Supply Curves for Each Tropical Island (Public Projects, Discount Rate 10%) | 32 |
| G.1. Barbados | 32 |
| G.2. Cuba | 33 |
| G.3. Dominican Republic | 34 |
| G.4. Fiji..... | 35 |
| G.5. Haiti | 36 |
| G.6. Indonesia..... | 37 |
| G.7. Jamaica..... | 38 |
| G.8. Madagascar | 39 |
| G.9. Maldives..... | 40 |
| G.10. Marshall Islands..... | 41 |
| G.11. Papua New Guinea..... | 42 |
| G.12. Philippines | 43 |
| G.13. Republic of Mauritius | 44 |
| G.14. Saint Lucia | 45 |
| G.15. Seychelles | 46 |
| G.16. Sri Lanka..... | 47 |
| G.17. French Polynesia (France) | 48 |
| G.18. Guadeloupe (France)..... | 49 |
| G.19. Martinique (France) | 50 |

| | |
|---|----|
| G.20. Mayotte (France)..... | 51 |
| G.21. New Caledonia (France) | 52 |
| G.22. Reunion (France) | 53 |
| G.23. Aruba (Netherlands)..... | 54 |
| G.24. Curaçao (Netherlands) | 55 |
| G.25. Cayman Islands (United Kingdom) | 56 |
| G.26. Guam (United States of America)..... | 57 |
| G.27. Hawaii (United States of America)..... | 58 |
| G.28. Puerto Rico (United States of America) | 59 |
| G.29. United States Virgin Islands (United States of America) | 60 |
| H. Aggregate Supply Curves of 29 Tropical Islands..... | 61 |
| H.1. Privately Funded (Discount Rate 18%) | 61 |
| H.2. Publicly Funded (Discount Rate 10%)..... | 63 |
| I. Sensitivity Analysis..... | 64 |
| I.1. Costs by Lockheed Martin..... | 64 |
| I.2. Costs by Academia and Other OTEC Companies..... | 66 |
| J. List of Remaining Countries Suitable for OTEC | 68 |
| K. Histograms Regarding Power Output..... | 70 |
| K.1. Base Case and Lower Uncertainty | 70 |
| K.2. Upper Uncertainty..... | 71 |
| L. Histograms for LCOE | 72 |
| L.1 Base Case (Lockheed Martin, No Uncertainties) | 72 |
| L.2. Lower Boundary of Uncertainty | 74 |
| L.3. Upper Layer of Uncertainty | 76 |
| M. Global Supply Curves for OTEC | 78 |
| M.1. Privately Funded OTEC (Discount Rate 18%) | 78 |
| M.2. Publicly Funded (Discount Rate 10%)..... | 80 |
| N. Implementation Scenarios and Experience Curves of OTEC..... | 81 |
| N.1. Scenario Design | 81 |

| | |
|--|-----|
| N.1.1. Modest Growth..... | 81 |
| N.1.2. Fast Growth | 82 |
| N.1.3. Rapid Growth | 83 |
| N.1.4. Superaggressive Expansion | 84 |
| N.2. Experience Curves | 85 |
| N.2.1. Modest Growth (Discount Rate 18%) | 85 |
| N.2.2. Modest Growth (Discount Rate 10%) | 87 |
| N.2.4. Fast Growth (Discount Rate 18%)..... | 89 |
| N.2.4. Fast Growth (Discount Rate 10%)..... | 91 |
| N.2.5. Rapid Growth (Discount Rate 18%)..... | 93 |
| N.2.6. Rapid Growth (Discount Rate 10%)..... | 95 |
| N.2.7. Superaggressive Expansion (Discount Rate 18%) | 97 |
| N.2.8. Superaggressive Expansion (Discount Rate 10%) | 99 |
| N.3. Mathematical Expressions of Experience Curves..... | 101 |
| N.3.1. Modest Growth..... | 101 |
| N.3.2. Fast Growth | 102 |
| N.3.3. Rapid Growth | 103 |
| N.3.4. Superaggressive Expansion | 104 |
| N.4. Dynamic Global Supply Curves | 105 |
| N.4.1. Modest Growth (Discount Rate 18%) | 105 |
| N.4.2. Modest Growth (Discount Rate 10%) | 106 |
| N.4.3. Fast Growth (Discount Rate 18%)..... | 107 |
| N.4.4. Fast Growth (Discount Rate 10%)..... | 108 |
| N.4.5. Rapid Growth (Discount Rate 18%)..... | 109 |
| N.4.6. Rapid Growth (Discount Rate 10%)..... | 110 |
| N.4.7. Superaggressive Expansion (Discount Rate 18%) | 111 |
| N.4.8. Superaggressive Expansion (Discount Rate 10%) | 112 |
| List of Appendix References | i |

List of Appendix Figures

| | |
|---|----|
| Figure B.1 Cash Flows over Time..... | 2 |
| Figure D.1 Determination of Distances between OTEC Cell and Demand Centre..... | 5 |
| Figure E.1 Microsoft® Excel Worksheet for Supply Curve Modelling..... | 2 |
| Figures F.1 Supply Curves for Privately Funded OTEC in Barbados..... | 3 |
| Figures F.2 Supply Curves for Privately Funded OTEC in Cuba | 4 |
| Figures F.3 Supply Curves for Privately Funded OTEC in the Dominican Republic..... | 5 |
| Figures F.4 Supply Curves for Privately Funded OTEC in Fiji | 6 |
| Figures F.5 Supply Curves for Privately Funded OTEC in Haiti..... | 7 |
| Figures F.6 Supply Curves for Privately Funded OTEC in Indonesia | 8 |
| Figures F.7 Supply Curves for Privately Funded OTEC in Jamaica..... | 9 |
| Figures F.8 Supply Curves for Privately Funded OTEC in Madagascar | 10 |
| Figures F.9 Supply Curves for Privately Funded OTEC in the Maldives | 11 |
| Figures F.10 Supply Curves for Privately Funded OTEC on the Marshall Islands | 12 |
| Figures F.11 Supply Curves for Privately Funded OTEC in Papua New Guinea..... | 13 |
| Figures F.12 Supply Curves for Privately Funded OTEC in the Philippines..... | 14 |
| Figures F.13 Supply Curves for Privately Funded OTEC in Mauritius | 15 |
| Figures F.14 Supply Curves for Privately Funded OTEC in Saint Lucia | 16 |
| Figures F.15 Supply Curves for Privately Funded OTEC in Seychelles..... | 17 |
| Figures F.16 Supply Curves for Privately Funded OTEC in Sri Lanka | 18 |
| Figures F.17 Supply Curves for Privately Funded OTEC in French Polynesia | 19 |
| Figures F.18 Supply Curves for Privately Funded OTEC in Guadeloupe | 20 |
| Figures F.19 Supply Curves for Privately Funded OTEC in Martinique | 21 |
| Figures F.20 Supply Curves for Privately Funded OTEC in Mayotte | 22 |
| Figures F.21 Supply Curves for Privately Funded OTEC in New Caledonia..... | 23 |
| Figures F.22 Supply Curves for Privately Funded OTEC in Reunion | 24 |
| Figures F.23 Supply Curves for Privately Funded OTEC in Aruba..... | 25 |
| Figures F.24 Supply Curves for Privately Funded OTEC in Curaçao | 26 |
| Figures F.25 Supply Curves for Privately Funded OTEC on the Cayman Islands | 27 |
| Figures F.26 Supply Curves for Privately Funded OTEC in Guam..... | 28 |
| Figures F.27 Supply Curves for Privately Funded OTEC in Hawaii | 29 |
| Figures F.28 Supply Curves for Privately Funded OTEC in Puerto Rico..... | 30 |
| Figures F.29 Supply Curves for Privately Funded OTEC at the U.S. Virgin Islands | 31 |
| Figures G.1 Supply Curves for Publicly Funded OTEC in Barbados | 32 |
| Figures G.2 Supply Curves for Publicly Funded OTEC in Cuba..... | 33 |

| | |
|--|----|
| Figures G.3 Supply Curves for Publicly Funded OTEC in the Dominican Republic | 34 |
| Figures G.4 Supply Curves for Publicly Funded OTEC in Fiji | 35 |
| Figures G.5 Supply Curves for Publicly Funded OTEC in Haiti | 36 |
| Figures G.6 Supply Curves for Publicly Funded OTEC in Indonesia..... | 37 |
| Figures G.7 Supply Curves for Publicly Funded OTEC in Jamaica | 38 |
| Figures G.8 Supply Curves for Publicly Funded OTEC in Madagascar..... | 39 |
| Figures G.9 Supply Curves for Publicly Funded OTEC in the Maldives | 40 |
| Figures G.10 Supply Curves for Publicly Funded OTEC at the Marshall Islands..... | 41 |
| Figures G.11 Supply Curves for Publicly Funded OTEC in Papua New Guinea | 42 |
| Figures G.12 Supply Curves for Publicly Funded OTEC in the Philippines | 43 |
| Figures G.13 Supply Curves for Publicly Funded OTEC in Mauritius..... | 44 |
| Figures G.14 Supply Curves for Publicly Funded OTEC in Saint Lucia..... | 45 |
| Figures G.15 Supply Curves for Publicly Funded OTEC in Seychelles | 46 |
| Figures G.16 Supply Curves for Publicly Funded OTEC in Sri Lanka | 47 |
| Figures G.17 Supply Curves for Publicly Funded OTEC in French Polynesia..... | 48 |
| Figures G.18 Supply Curves for Publicly Funded OTEC in Guadeloupe..... | 49 |
| Figures G.19 Supply Curves for Publicly Funded OTEC in Martinique | 50 |
| Figures G.20 Supply Curves for Publicly Funded OTEC in Mayotte..... | 51 |
| Figures G.21 Supply Curves for Publicly Funded OTEC in New Caledonia | 52 |
| Figures G.22 Supply Curves for Publicly Funded OTEC in Reunion..... | 53 |
| Figures G.23 Supply Curves for Publicly Funded OTEC in Aruba | 54 |
| Figures G.24 Supply Curves for Publicly Funded OTEC in Curaçao..... | 55 |
| Figures G.25 Supply Curves for Publicly Funded OTEC at Cayman Islands..... | 56 |
| Figures G.26 Supply Curves for Publicly Funded OTEC in Guam | 57 |
| Figures G.27 Supply Curves for Publicly Funded OTEC in Hawaii..... | 58 |
| Figures G.28 Supply Curves for Publicly Funded OTEC in Puerto Rico | 59 |
| Figures G.29 Supply Curves for Publicly Funded OTEC at U.S. Virgin Islands..... | 60 |
| Figures H.1 Aggregate Supply Curves for Privately Funded OTEC | 61 |
| Figures H.2 Aggregate Supply Curve for all Five Scales, Privately Funded | 62 |
| Figures H.3 Aggregate Supply Curves for Publicly Funded OTEC..... | 63 |
| Figures I.1 Sensitivity of Supply Curves Based on Costs by Lockheed Martin | 65 |
| Figures I.2 Sensitivity of Supply Curves Based on Costs by Academia and Other OTEC Companies | 67 |
| Figures K.1 Histograms of Real Power Output for Base Case and Lower Uncertainty..... | 70 |
| Figures K.2 Histograms of Real Power Output for Upper Uncertainty | 71 |
| Figures L.1 Histograms of LCOEs for Base Case..... | 72 |
| Figures L.2 Histograms of LCOEs for Base Case..... | 73 |
| Figures L.3 Histograms of LCOEs for Lower Boundary of Uncertainty | 74 |

| | |
|--|-----|
| Figures L.4 Histograms of LCOEs for Lower Boundary of Uncertainty..... | 75 |
| Figures L.5 Histograms of Private LCOEs for Upper Layer of Uncertainty | 76 |
| Figures L.6 Histograms of Public LCOEs for Upper Layer of Uncertainty..... | 77 |
| Figures M.1 Global Supply Curves for Privately Funded OTEC..... | 78 |
| Figures M.2 Global Supply Curve for Privately Funded OTEC for All Scales | 79 |
| Figures M.3 Global Supply Curves for Publicly Funded OTEC..... | 80 |
| Figures N.1 Experience Curves for Modest Growth (Discount Rate 18%). | 86 |
| Figures N.2 Experience Curves for Modest Growth (Discount Rate 10%). | 88 |
| Figures N.3 Experience Curves for Fast Growth (Discount Rate 18%)..... | 90 |
| Figures N.4 Experience Curves for Fast Growth (Discount Rate 10%)..... | 92 |
| Figures N.5 Experience Curves for Rapid Growth (Discount Rate 18%)..... | 94 |
| Figures N.6 Experience Curves for Rapid Growth (Discount Rate 10%)..... | 96 |
| Figures N.7 Experience Curves for Superaggressive Expansion (Discount Rate 18%)..... | 98 |
| Figures N.8 Experience Curves for Superaggressive Expansion (Discount Rate 10%)..... | 100 |
| Figure N.9 Dynamic Global Supply Curves for Private Modest Growth | 105 |
| Figure N.10 Dynamic Global Supply Curves for Public Modest Growth..... | 106 |
| Figure N.11 Dynamic Global Supply Curves for Private Fast Growth..... | 107 |
| Figure N.12 Dynamic Global Supply Curves for Public Fast Growth..... | 108 |
| Figure N.13 Dynamic Global Supply Curves for Private Rapid Growth..... | 109 |
| Figure N.14 Dynamic Global Supply Curves for Public Rapid Growth..... | 110 |
| Figure N.15 Dynamic Global Supply Curves for Private Superaggressive Expansion..... | 111 |
| Figure N.16 Dynamic Global Supply Curves for Public Superaggressive Expansion..... | 112 |

List of Appendix Tables

| | |
|--|-----|
| Table A.1 Literature Review on the Economic Potential of Renewable Energies | 1 |
| Table D.1 Demand Centres Across Tropical Islands | 7 |
| Table J.1 Remaining Countries Suitable for OTEC. | 69 |
| Table N.1 Scenario Design for Modest Growth | 81 |
| Table N.2 Scenario Design for Fast Growth | 82 |
| Table N.3 Scenario Design for Rapid Growth | 83 |
| Table N.4 Scenario Design for Superaggressive Expansion | 84 |
| Table N.5 Mathematical Expressions of Experience Curves for Modest Growth. | 101 |
| Table N.6 Mathematical Expressions of Experience Curves for Fast Growth..... | 102 |
| Table N.7 Mathematical Expressions of Experience Curves for Rapid Growth. | 103 |
| Table N.8 Mathematical Expressions of Experience Curves for Superaggressive Expansion..... | 104 |

A. Determination of the Economic Potential of Renewable Energies in Literature

The literature review resulted in a wide array of publications on the economic potential of renewable energies, both horizontally and vertically. Especially solar power (Fath et al., 2015; Hirvonen et al., 2016; Miranda, Szklo, & Schaeffer, 2015; Purohit & Purohit, 2017), wind power (Hoogwijk, de Vries, & Turkenburg, 2004; Liu, Wang, & Zhu, 2017; McElroy et al., 2009; Nagababu, Kachhwaha, & Savsani, 2017) and bioenergy (Bidart, Fröhling, & Schultmann, 2013; Chen, 2016; Kabyanga et al., 2017; Parker et al., 2017; van Vuuren, van Vliet, & Stehfest, 2009) happen to be popular objects of investigation. Contrarily, ocean technologies are mostly neglected due to lack of experience and relevance (Mercure & Salas, 2012; Osorio et al., 2016). Merely Mercure & Salas (2012) include the economic potential of wave and tidal energy. Regarding OTEC, they only display a range of technical potentials and refer to outdated literature from 1993. Thus, the absence of research about the economic potential of OTEC is detected as a knowledge gap in current literature.

Besides the scrutiny of individual technologies, some scholars take on multiple technologies simultaneously, albeit without the effects of market competition (Blechinger et al., 2016; de Vries, van Vuuren, & Hoogwijk, 2007; Koo et al., 2011; Mercure & Salas, 2012; Nguyen & Ha-Duong, 2009). If the economic potential of one technology is harnessed, the economic potential of other technologies must logically decline as they lose their market share to their competitor. This phenomenon is often left unnoticed and only tackled by few researchers (Blechinger et al., 2016; Hoogwijk et al., 2004; Koo et al., 2011; Mercure & Salas, 2012; Trutnevyte, 2013). Additionally, other dynamic effects like cost reductions via learning and fuel price volatility are not always considered in economic analyses and can thus be seen as a sign of exhaustive methodological quality when encountered (Chen, 2016; Fath et al., 2015; Hirvonen et al., 2016; Koo et al., 2011; Mercure & Salas, 2012; Miranda et al., 2015; Nguyen & Ha-Duong, 2009).

But how did scholars determine the economic potential of one or more renewable energies in the first place? As in the case of the technologies themselves, vast variety also prevails in virtue of the utilised tools and the scope of investigation. Even though these unique research tools are divided by countless criteria, they are united in their roots in mathematical modelling. In this regard, literature discerns between individually designed models and commercially available models known by shrewd neologisms such as HOMER (van Alphen, van Sark, & Hekkert, 2007), TIMES (Park et al., 2017) and SAM (Darling et al., 2011; Purohit & Purohit, 2017). The technology- and spatial-specific inputs required by these mathematical models, then again, predominantly originate from data obtained by geographical information software. Similar to their mathematical counterparts, a whole alphabet soup

of different tools is available, for example IMAGE (de Vries et al., 2007; van Vuuren et al., 2009) or ArcGIS (Blechinger et al., 2016; Liu et al., 2017; Miranda et al., 2015). The scope of the analyses depends on the boundaries set by the researcher and can encompass local and sectoral (Fath et al., 2015; Trutnevyte, 2013), regional (Parker et al., 2017), national (i.e. China (Chen, 2016; Liu et al., 2017; McElroy et al., 2009) or India (Nagababu et al., 2017; Purohit & Purohit, 2017)) and even global levels (Blechinger et al., 2016; Hoogwijk et al., 2004; Mercure & Salas, 2012; van Vuuren et al., 2009). Concerning the latter, Blechinger, et al. (2016) stands out as an interesting paper as it analyses the economic potential of renewable energies (hybrid systems including solar and wind power plus batteries) on small, tropical islands, which coincides with the scope encompassed here. The insights gained are wrapped up and illustrated in Table A.1.

| Author(s) (Year) | Scope | Technology | Methods | Deliverable | Dynamic | Competition |
|----------------------------|------------------------|------------|-------------------------|---------------------------------------|---------|-------------|
| Bidart, et al. (2013) | National (Chile) | Biomass | Math. Model | Cost-Supply Curve | No | No |
| Blechingner, et al. (2016) | Global | Renewables | GIS + Math. Model | Cost-optimal energy mixes | No | Yes |
| Chen (2016) | National (China) | Biomass | Math. Model | Economic Potential | Yes | No |
| de Vries, et al. (2007) | Global | Renewables | IMAGE + Math. Model | Theo. & Tech. Pot., Cost-Supply Curve | No | Yes |
| Fath, et al. (2015) | Local | Solar | 3-D Model + Math. Model | Economic Potential | Yes | No |
| Hirvonen, et al. (2016) | National (Finland) | Solar | Math. Model | LCOE | Yes | No |
| Hoogwijk, et al. (2004) | Global | Wind | Grid Cell Approach | Theo., Tech. & Econ. Potential | No | No |
| Kabyanga, et al. (2017) | National (Uganda) | Biomass | Cost-Benefit Analysis | NPV | No | No |
| Koo, et al. (2011) | National (South Korea) | Renewables | Math. Model | Economic Potential | Yes | Yes |
| Liu, et al. (2017) | National (China) | Wind | GIS + Math. Model | Cost-Supply Curve | No | No |
| McElroy, et al. (2009) | National (China) | Wind | GIS + Math. Model | Cost-Supply Curves | No | No |
| Mercure & Salas (2012) | Global | Renewables | Math. Model | Cost-Supply Curves | Yes | Yes |
| Miranda, et al. (2015) | National (Brazil) | Solar | GIS + Math. Model | Economic Potential | Yes | No |
| Nagababu, et al. (2017) | National (India) | Wind | GIS + Math. Model | Cost-Supply Curve | No | No |
| Nguyen, et al. (2009) | National (Vietnam) | Renewables | Math. Model | Economic Potential | Yes | No |
| Parker, et al. (2017) | Regional | Biogas | Math. Model | Cost-Supply Curve | No | No |
| Purohit & Purohit (2017) | National (India) | Solar | SAM | Tech. and Econ. Potential | No | No |
| Trutnevyte (2013) | Sectoral | Renewables | Math. Model (EXPANSE) | Energy Mixes | No | Yes |
| van Vuuren, et al. (2009) | Global | Biomass | IMAGE + TIMER | Cost-Supply Curve | No | No |

Table A.1 Literature Review on the Economic Potential of Renewable Energies (Own Illustration).

B. Different Types of LCOE Calculation

The costs and revenues of an energy related project occur over several years or even decades as in the case of OTEC. Therefore, the management of these future cash flows embodies one of the most critical choices made when determining the LCOE. In literature, two major options arise and resort to the use of either a *Capital Recovery Factor (CRF)* or a *Discount Rate (DR)*, which are contrasted in equations (i) and (ii), respectively (Blechinger et al., 2016; Visser & Held, 2014).

$$LCOE = \frac{CRF * CAPEX + OPEX + Fuel}{E_{produced}} \quad (i)$$

$$LCOE = \frac{\sum_{t=1}^N \frac{CAPEX_t + OPEX_t + Fuel_t}{(1 + DR)^t}}{\sum_{t=1}^N \frac{E_t}{(1 + DR)^t}} \quad (ii)$$

CAPEX and OPEX represent the capital and operational expenses of an energy project, while E is the real net power output. But what are CRF and DR? Before this question is answered, one must bear in mind that the value of an asset or expense is not constant over time. As a matter of fact, people prefer to enjoy benefits rather today than in the future (Palinko & Szabo, 2012). Thus, the value of one asset declines, the further its benefits lie ahead. The following example shall illustrate these relations. Mr. Ivey receives a loan with the present value P from a bank with an interest rate of i. Due to the accruing interest on the loan, the future value F of Ivey's loan must be somewhat smaller when accounted for the present. If he wants to know, how much F after a period of n is worth today, equation (iii) is applied (Jenkins, 2006).

$$P = \frac{F}{(1 + i)^n} \quad (iii)$$

With equation (iii), Mr. Ivey adjusted the future value of his loan for present circumstances, he discounted F with a discount rate of i. If Ivey now wants to know what constant amount he would have to pay annually to the bank over the same period n, an annuity A is calculated in accordance to equation (iv) (Jenkins, 2006).

$$A = P * \left[\frac{i * (1 + i)^n}{(1 + i)^n - 1} \right] \quad (iv)$$

The term in brackets is the capital recovery factor CRF and equals to the quotient of A and P. Figure B.1 summarises the insights gained so far in the shape of a cash flow diagram, with arrows pointing down resembling expenses and arrows pointing up profits (from the perspective of the bank).

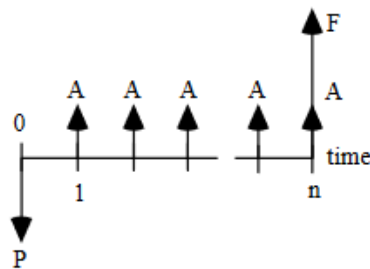


Figure B.1 Cash Flows over Time (Jenkins, 2006).

Now, the nexus between DR and CRF becomes clear. CRF is merely a derivative of DR and draws on the interest rate i as well. With this in mind, it surprises little that both equations (i) and (ii) deliver the same result for the LCOE, although the method using CFR might appear more elegant. While the [International Energy Agency \(IEA\) \(2015\)](#) recommends the use of equation (ii), the [U.S. Department of Energy \(DoE\) \(2012\)](#) advocates the use of CFR as in equation (i). So, it seems that the choice of method depends on personal preference after all. Interestingly, there are patterns observable in literature about which method is applied for which technology. For example, when the LCOE is computed for solar power technologies like photovoltaic, scholars tend to prefer DR over CRF ([Darling et al., 2011](#); [Hirvonen et al., 2016](#); [Ondraczek, Komendantova, & Patt, 2015](#); [Purohit & Purohit, 2017](#)). On the other hand, every publication about the economics of OTEC resorted to some sort of CRF to obtain the LCOE.

C. Discounted Cash Flow Analysis

The LCOE can be calculated via a *Discounted Cash Flow Analysis* (DCF). Here, all cash flows entering or leaving the books of a project are discounted and aggregated to generate a *Net Present Value* (NPV), as displayed in equation (v) below ([Liu et al., 2017](#); [McElroy et al., 2009](#)).

$$NPV = \sum_{t=1}^N \frac{CF_t}{(1 + DR)^t} \quad (v)$$

CF_t represents the net cash flow in year t and consists of both the expenditures and revenues within this time frame. A simplified accumulation of cash flows is shown in equation (vi).

$$CF_t = Revenue_t + Debt_t - CAPEX_t - Loan\ Payment_t - OPEX_t - Tax_t \quad (vi)$$

The revenue produced in year t is the product of the power output E_t and the electricity price p . Generally, a project is financed with a combination of both loans from banks and equity from investors, asset managers, et cetera. If the project is financed with a loan from a bank, the resulting debt counts as a positive cash flow and its amount depends on which proportion of the CAPEX is covered by the bank loan and which one by equity providers. Hence, it can already be observed that the constitution of a project's finance is of fundamental significance in equation (vi). Of course, the bank acts upon *quid pro quo* and expects a margin when providing a loan. Thus, a company generating revenues with a project financed by a loan is obliged to repay this very loan with interest as agreed upon in an underlying contract. Note, that the interest rate of the loan does not necessarily epitomise the discount rate as in the example of Mr. Ivey mentioned in appendix B. But what about equity providers and their returns? It could be assumed that OTEC companies are unquoted and receive equity by high net worth individuals called *Business Angel Investors*. These investors buy shares of the company with the prospect of returns in the future. This can happen by share buybacks by the company or a trade sale for cash as soon as the funded company raised its worth. The details behind these investment mechanisms are not elaborated in any more detail, with more information found in the respective literature (HBAN, 2013). The point is that the profits of equity providers are not part of the cash flow in equation (vi) and thus left out for the remainder of the thesis.

Besides loan payments, another expenditure, at least for private projects, comprises taxes. Corporates are liable to different types of tax, such as an *Enterprise Income Tax* (EIT), shareholder tax and others. Depending on which country is investigated, the tax rates can vary considerably and thus require close attention during data acquisition. Before the tax payments can be calculated, the *Income Before Tax* (IBT) must be found, since expenditures like OPEX, interest payments and depreciation are tax-deductible (Liu et al., 2017; McElroy et al., 2009). Thus, the IBT is obtained using equation (vii).

$$IBT_t = Revenue_t - Interest\ Payment_t - OPEX_t - Depreciation_t \quad (vii)$$

In this regard, depreciation refers to the loss in value of an asset over its lifetime due to fatigue, obsolescence or other reasons (Jenkins, 2006). If a linear depreciation is assumed, its tax deductibility is defined by the division of the CAPEX by the total useful lifetime of the project N . Lastly, the IBT of year t is multiplied with the rate of EIT (Liu et al., 2017; McElroy et al., 2009).

But where is the LCOE in those equations? Right now, the revenue of the project is determined, besides the power output, by the electricity price p . Depending on how p is defined, the NPV of a project can fall or rise, be negative, positive or zero. As already mentioned earlier in chapter **Error! Reference source not found.**, the LCOE is defined as the minimum, average cost of electricity required by an electricity producer to render a project economically feasible. Logically, the NPV must be at least zero in order to not make a loss. Therefore, when NPV in equation (v) is set to zero, p becomes the LCOE, as presented in equation (viii) (Comello, Glenk, & Reichelstein, 2017; Hirvonen et al., 2016).

$$LCOE = \frac{\sum_{t=1}^N \frac{CAPEX_t + OPEX_t + Tax_t + Loan_t - Debt_t}{(1 + DR)^t}}{\sum_{t=1}^N \frac{E_t}{(1 + DR)^t}} \quad (viii)$$

Putting equation (viii) into perspective, this is a more sophisticated version of equation (ii), now taking into account a comprehensive set of financial and fiscal values as described above. While other scholars went even further and added technology-specific aspects to this equation, i.e. a system degradation factor and tax credits for photovoltaic (Comello et al., 2017; Darling et al., 2011), such specialisations are relinquished here and a general shape of the formula is maintained. This equation is also the reason why this thesis does not draw on the use of a capital recovery factor. The adaptation of the DCF methodology naturally lead to an equation akin to (ii).

A remarkable benefit of equation (viii) is that the impact of every expenditure is observable and concomitantly, the effect of policy action against them. For example, one could study the implication of different finance and tax structures, tax credits and subsidies. Additionally, the differences between private and public projects can also be studied, since the latter are not liable to tax payments and use less stringent discount rates as private corporations (Blok & Nieuwlaar, 2016; Boardman et al., 2010).

D. Calculation of Demand Centre Distances Using Trigonometry

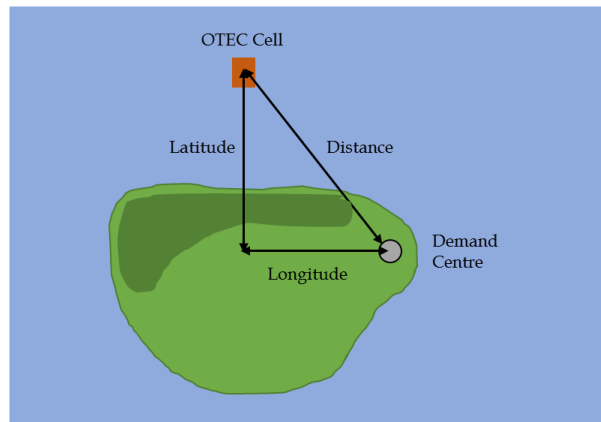


Figure D.1 Determination of Distances between OTEC Cell and Demand Centre(Own Illustration).

Figure D.1 shows a notional island with one distinct demand centre located in the East. As it turns out, there is one practicable location for OTEC, represented by a brown rectangle. The locations of both OTEC cell and demand centre are expressed in geographical coordinates, namely latitude and longitude. The difference in latitude and longitude between the two locations is calculated with equations (ix) and (x) below.

$$\Delta\text{Lat}^\circ = |\text{Lat}_{\text{Dem}} - \text{Lat}_{\text{OTEC}}| \quad (\text{ix})$$

$$\Delta\text{Long}^\circ = |\text{Long}_{\text{Dem}} - \text{Long}_{\text{OTEC}}| \quad (\text{x})$$

These distances are, yet, expressed in decimal degrees and need to be converted to kilometres. To understand the concept of decimal degrees, imagine the Earth as a perfect sphere being sliced into 360 discs of equal thickness.¹ Evidently, the equatorial disc is the largest, while the discs at the two poles converge to a size of zero. If each of the disc's perimeter is then divided into 360 parts as well, one notices that the degree of latitude stays constant for each disc, since they have the same thickness. But in the case of the longitude, this is not the case. The further the discs move from the equator to a pole, the smaller the perimeter of the disc and consequently its 360 compartments. Therefore, while the conversion of the latitude from degree to km is straightforward, it is not for longitudinal coordinates. There, one must bear in mind the latitude of the coordinate as well. For example, while one degree of

¹ Under real conditions, the Earth is not a perfect sphere, but somewhat flattened at both poles. For simplicity, this fact is omitted.

latitude equals to 111,32 km independent on its location on Earth, one degree of longitude only comprises 111,32 km at the equator. On the verge of the tropics, at 23° N/S, one degree of longitude, then, only corresponds to 102,47 km. For the sake of simplicity, it is assumed that the decline in longitudinal length occurs linearly in steps of 0,385 km/deg² as one moves from the equator to the verge of the tropics. Thus, the differences in latitude and longitude, as expressed in (ix) and (x), are converted to km with equations (xi) and (xii) below.

$$\Delta\text{Lat} = |\text{Lat}_{\text{Dem}} - \text{Lat}_{\text{OTEC}}| * 111,32 \frac{\text{km}}{\text{deg}} \quad (\text{xi})$$

$$\Delta\text{Long} = |\text{Long}_{\text{Dem}} - \text{Long}_{\text{OTEC}}| * \left(111,32 \frac{\text{km}}{\text{deg}} - |\text{Lat}^{\circ}_{\text{Dem}}| * 0,385 \frac{\text{km}}{\text{deg}^2} \right) \quad (\text{xii})$$

Before any distance is calculated, close attention is paid to the latitude of each demand centre to adjust the conversion from longitudinal degrees to km accordingly. The distance from OTEC cell to demand centre is eventually computed with a simple trigonometric correlation as shown in equation (xiii).

$$\text{Distance} = \sqrt{\Delta\text{Lat}^2 + \Delta\text{Long}^2} \quad (\text{xiii})$$

| Country | # of Demand Centres | Location of Clusters |
|-----------------------|---------------------|--|
| Barbados | 1 | - |
| Cuba | 4 | Havana, Centre, Santiago de Cuba, Isla de la Juventud |
| Dominican Republic | 3 | Santo Domingo, Puerto Plata, Punta Cana |
| Fiji | 3 | Suva, Ba, Labasa |
| Haiti | 3 | Port-au-Prince, Jacmel, Cap-Haitien |
| Indonesia | 20 | Banda Aceh, Medan, Bukittingi, Jakarta, ... |
| Jamaica | 2 | Kingston, Montago Bay |
| Madagascar | 3 | Toamasina, Mahajanga, Ambowombe |
| Maldives | 2 | Male, Hulhumale |
| Marshall Islands | 2 | Majuro, Ebaye |
| Papua New Guinea | 5 | Port Mosemby, Popondetta, Lae, Madang, Arawa |
| Philippines | 12 | Zamboanga, General Santos, Davao, ... |
| Republic of Mauritius | 1 | - |
| Saint Lucia | 1 | - |
| Seychelles | 1 | - |
| Sri Lanka | 3 | West Coast, East Coast, North |
| French Polynesia | 1 | Îles du Vent |
| Guadeloupe | 1 | - |
| Martinique | 1 | - |
| Mayotte | 1 | - |
| New Caledonia | 2 | (Noumea + Mont-Dore + Dumbea + Païta), (We + Tadine) |
| Reunion | 2 | (Saint-Paul + Saint Denis), (Le Tampon + Saint Pierre) |
| Aruba | 1 | - |
| Curacao | 1 | - |
| Cayman Islands | 1 | - |
| Guam | 1 | - |
| Hawaii (USA) | 4 | Hawai'i, Maui, Honolulu, Kauai |
| Puerto Rico | 2 | (San Juan + Bayamon + Carolina + Caguas), Ponce |
| U.S. Virgin Islands | 1 | - |

Table D.1 Demand Centres Across Tropical Islands (Own Illustration).

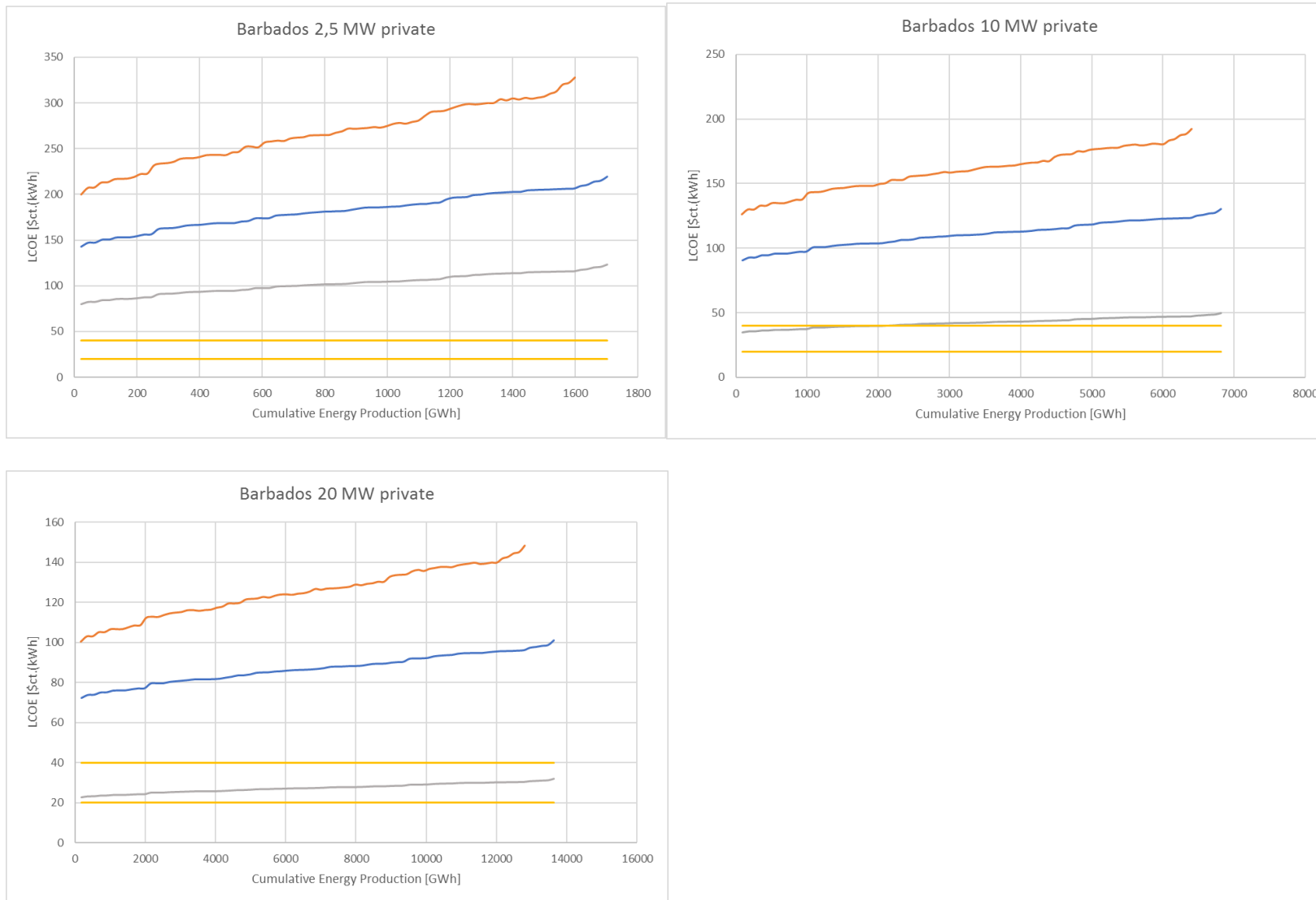
E. Microsoft® Excel Sheet for Supply Curve Modelling

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q |
|----|-------------------------|------------|-------------------|----------|------------|-------------|------------|------|-----------------------|-----------------|----------------|-----------|------------|-----------------|---------------|----------|--------|
| 1 | Indonesia | | OTEC | | | | | | Banda Aceh | North/South [°] | East/ West [°] | | Lampung | North/South [°] | East/West [°] | | Situb |
| 2 | Private Discount Rate | 0,18 | Lifetime | 30 | | | | | | 5,53312 | 95,32870 | | | -4,58013 | 105,40353 | | |
| 3 | Social Discount Rate | 0,1 | Capacity Factor | 0,92 | | | | | Medan | North/South [°] | East/West [°] | | Semarang | North/South [°] | East/West [°] | | Denpa |
| 4 | Reference Cost min | 20 | Uncertainties | | | | | | | 3,590097 | 98,67299 | | | -6,82445 | 110,41008 | | |
| 5 | Reference Cost max | 40 | Unc_CAPEX_w/cable | ± | | 0,56154 | 1,3 | | Bukittingi | North/South [°] | East/West [°] | | Yogyakarta | North/South [°] | East/West [°] | | Mata |
| 6 | Total # Offshore Cells | 1719 | Unc_Distance | + | 0,2 | 0 | 1,2 | | | -0,31279 | 100,37852 | | | -7,94663 | 110,32219 | | |
| 7 | Suitable Offshore Cells | 995 | Unc_OPEX | ± | 0,2 | 0,56154 | 1,2 | | Jakarta | North/South [°] | East/West [°] | | Surabaya | North/South [°] | East/West [°] | | Bima |
| 8 | Total # Onshore Cells | 132 | Unc_Cap.Fac. | - | 0,05 | 0,95 | 0 | | | -6,20227 | 106,81755 | | | -7,25019 | 112,76501 | | |
| 9 | Suitable Onshore Cells | 33 | | | | | | | Manado | North/South [°] | East/West [°] | | Sorong | North/South [°] | East/West [°] | | Jayapu |
| 10 | | | | | | | | | | 1,47809 | 124,84483 | | | -0,87634 | 131,25431 | | |
| 11 | | | | | | | | | | | | | | | | | |
| 12 | OTEC Cell | | | | OTEC Power | | OTEC Costs | | Uncertainty of Inputs | | | | | | Reference | | |
| 13 | OBJECTID | Territory1 | DT1 | Distance | Eff. Cable | Power [kWh] | CAPEX | OPEX | U_distance | U_Cable | U_CAPEX - | U_CAPEX + | U_OPEX - | U_OPEX + | Tariff - | Tariff + | |
| 14 | 1 | Indonesia | 25,01580048 | 9 | 0,9946 | 29348388,78 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 15 | 2 | Indonesia | 25,01280022 | 9 | 0,9946 | 29340212,08 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 16 | 3 | Indonesia | 25,01099968 | 9 | 0,9946 | 29335305,02 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 17 | 4 | Indonesia | 24,98769951 | 9 | 0,9946 | 29271804,34 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 18 | 5 | Indonesia | 24,98089981 | 9 | 0,9946 | 29253272,91 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 19 | 6 | Indonesia | 24,97949982 | 9 | 0,9946 | 29249457,46 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 20 | 7 | Indonesia | 24,93840027 | 9 | 0,9946 | 29137447,57 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 21 | 8 | Indonesia | 24,92889977 | 9 | 0,9946 | 29111555,55 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 22 | 9 | Indonesia | 24,84810066 | 9 | 0,9946 | 28891351,23 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 23 | 10 | Indonesia | 24,83790016 | 9 | 0,9946 | 28863551,49 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 24 | 11 | Indonesia | 24,81559944 | 9 | 0,9946 | 28802774,63 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 25 | 12 | Indonesia | 24,42569923 | 9 | 0,9946 | 27740167,39 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 26 | 13 | Indonesia | 24,41970062 | 9 | 0,9946 | 27723819,19 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 27 | 14 | Indonesia | 24,41340065 | 9 | 0,9946 | 27706649,68 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 28 | 15 | Indonesia | 24,36249924 | 9 | 0,9946 | 27567926,46 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |
| 29 | 16 | Indonesia | 24,24850082 | 9 | 0,9946 | 27257243,02 | 134,75 | 4,3 | 10,8 | 0,99352 | 75,667515 | 175,175 | 2,414622 | 5,16 | 20 | 40 | |

Figure E.1 Microsoft® Excel Worksheet for Supply Curve Modelling(Own Illustration).

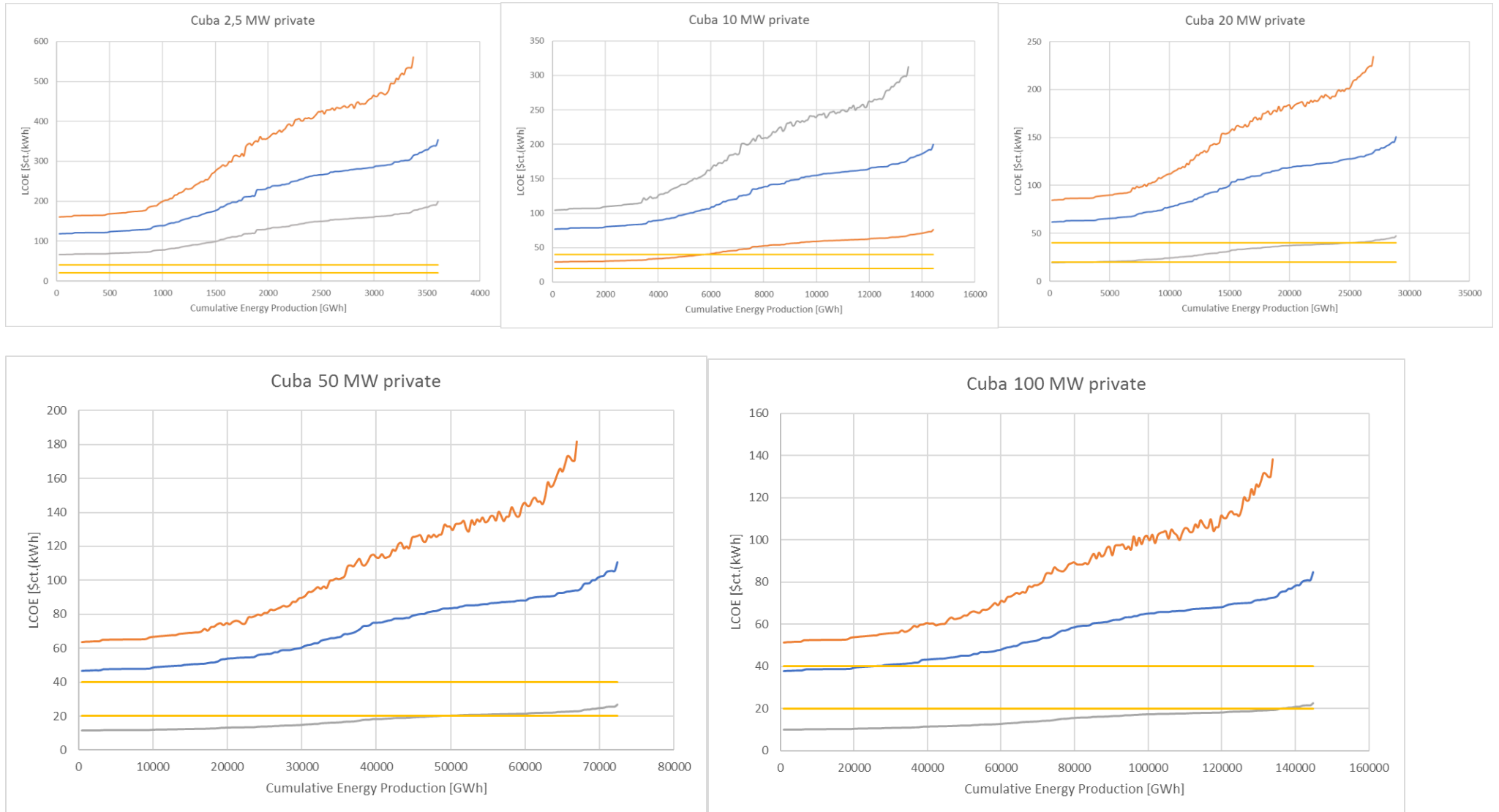
F. Supply Curves for Each Tropical Island (Private Projects, Discount Rate 18%)

F.1. Barbados



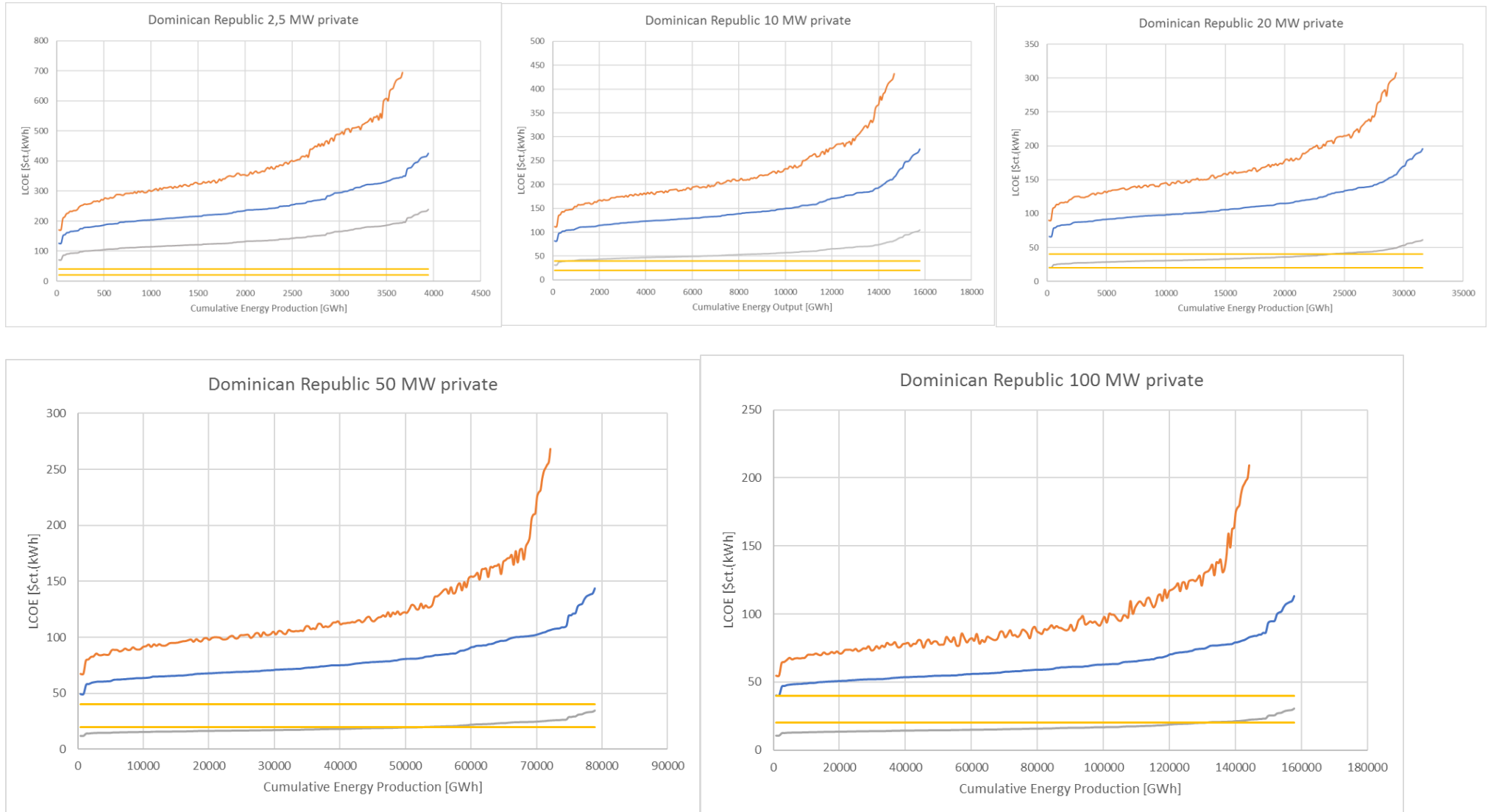
Figures F.1 Supply Curves for Privately Funded OTEC in Barbados (Own Illustration).

F.2. Cuba



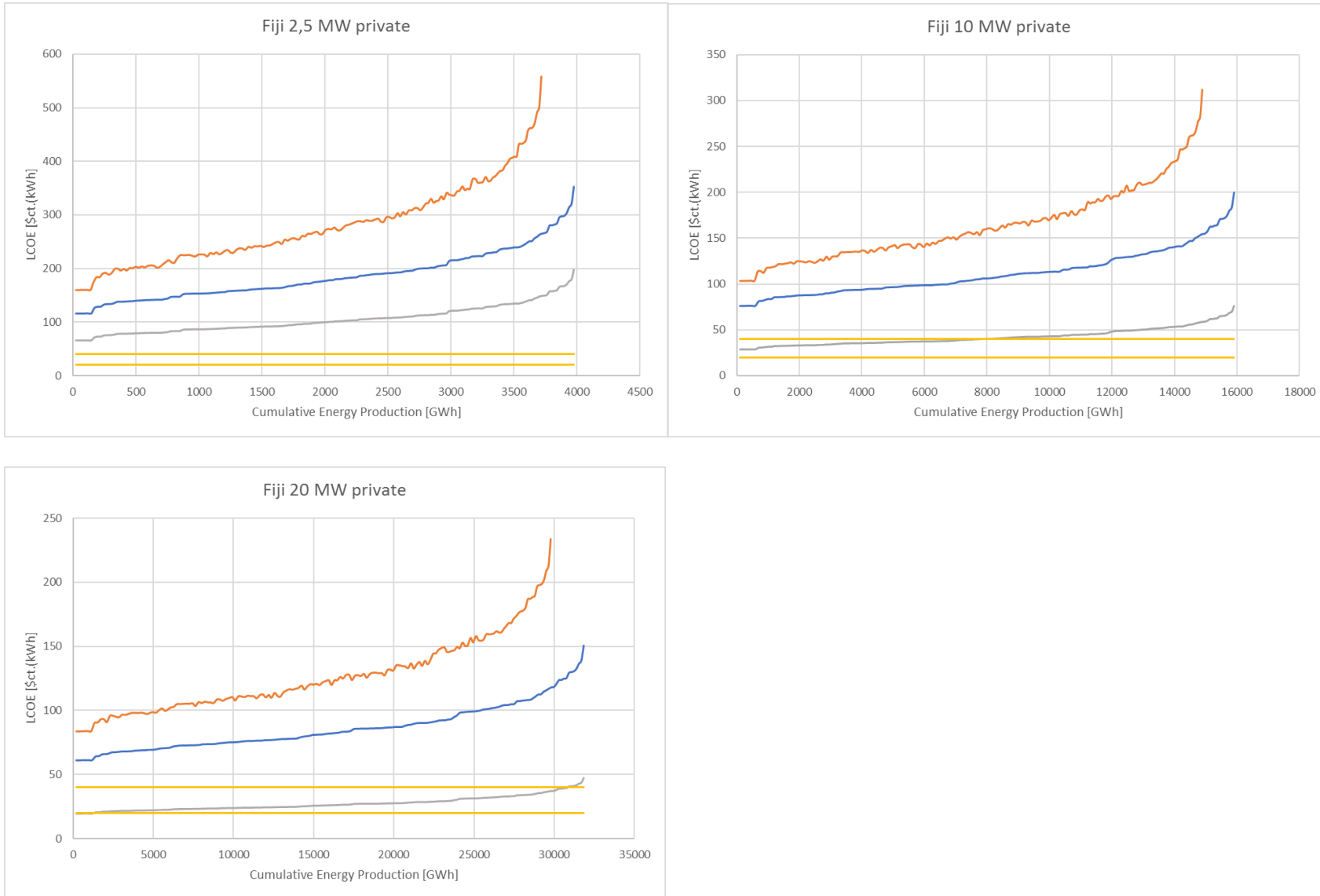
Figures F.2 Supply Curves for Privately Funded OTEC in Cuba (Own Illustration).

F.3. Dominican Republic



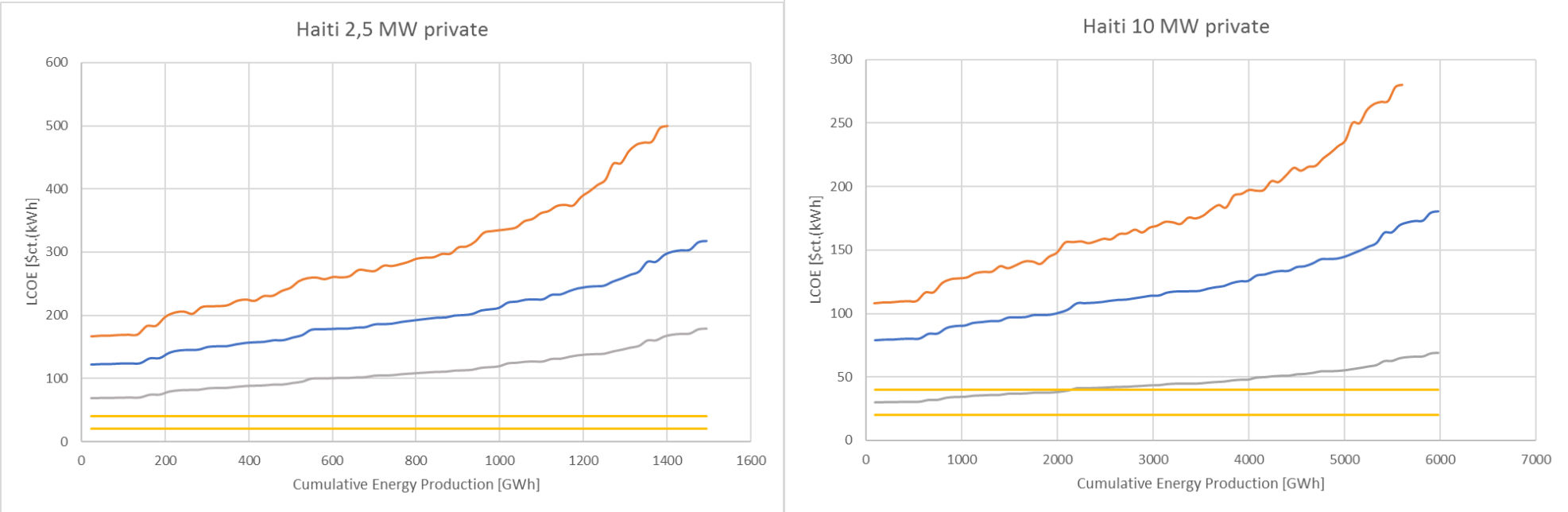
Figures F.3 Supply Curves for Privately Funded OTEC in the Dominican Republic (Own Illustration).

F.4. Fiji



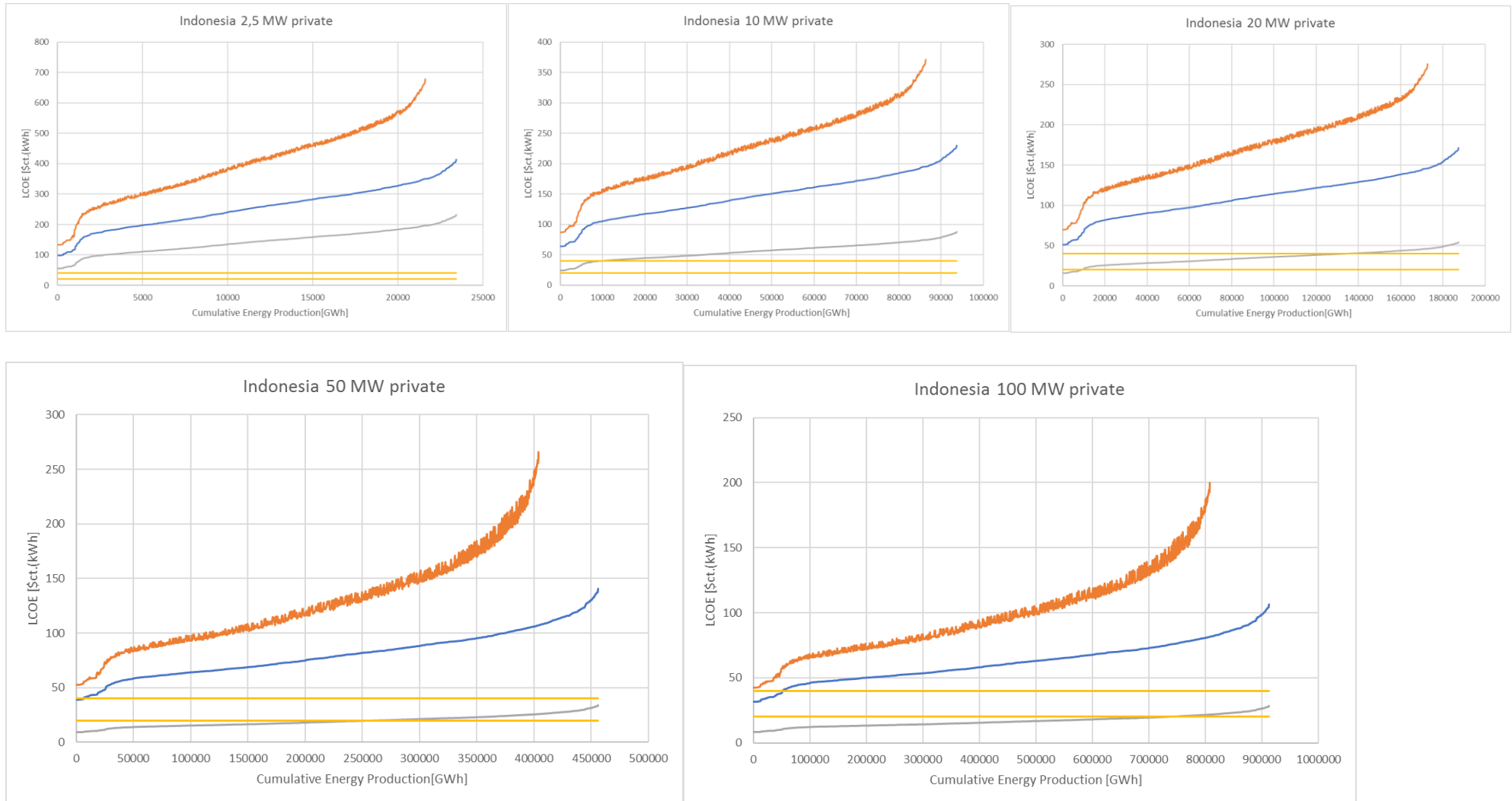
Figures F.4 Supply Curves for Privately Funded OTEC in Fiji (Own Illustration).

F.5. Haiti



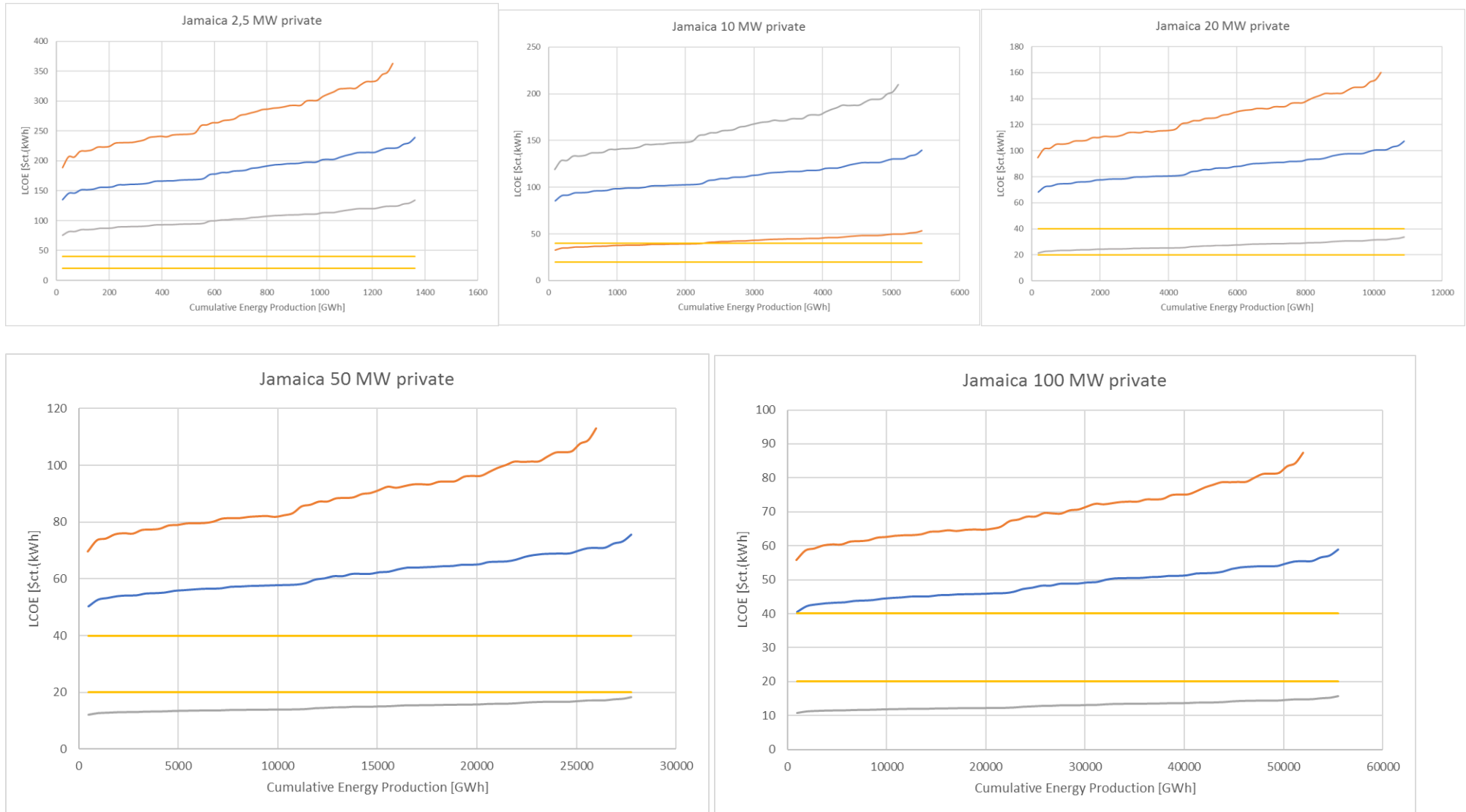
Figures F.5 Supply Curves for Privately Funded OTEC in Haiti (Own Illustration).

F.6. Indonesia



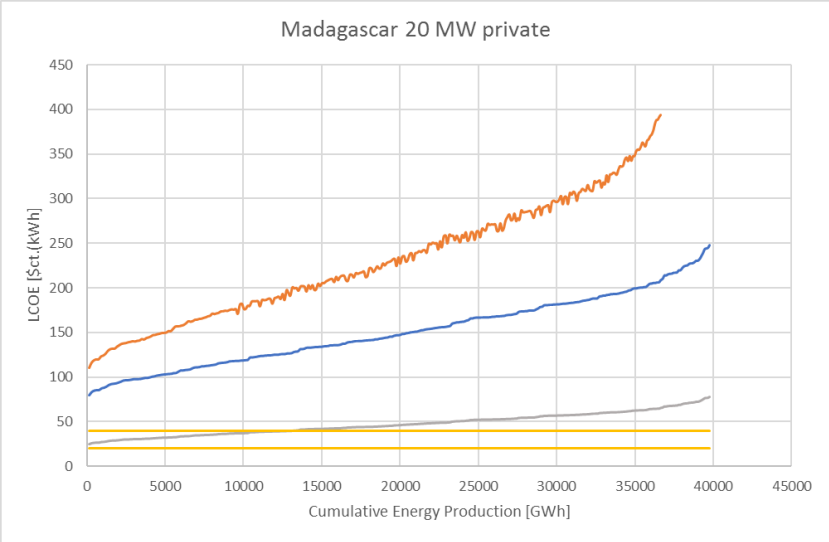
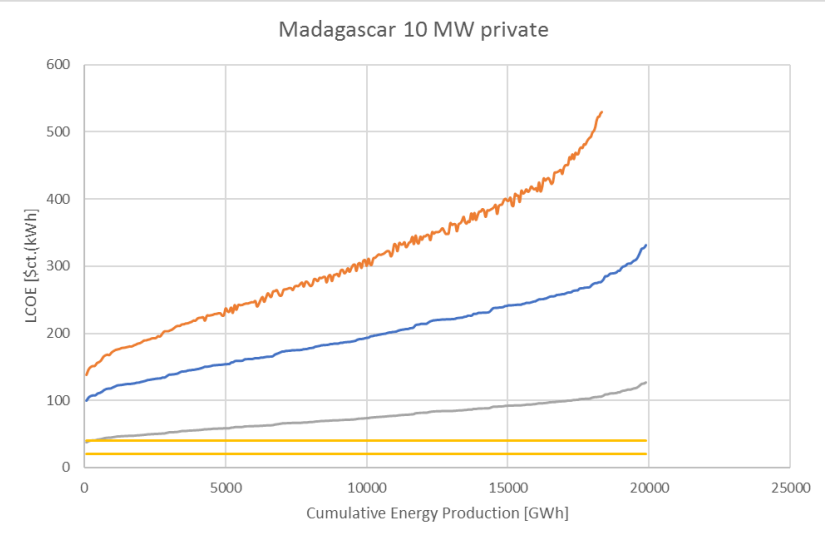
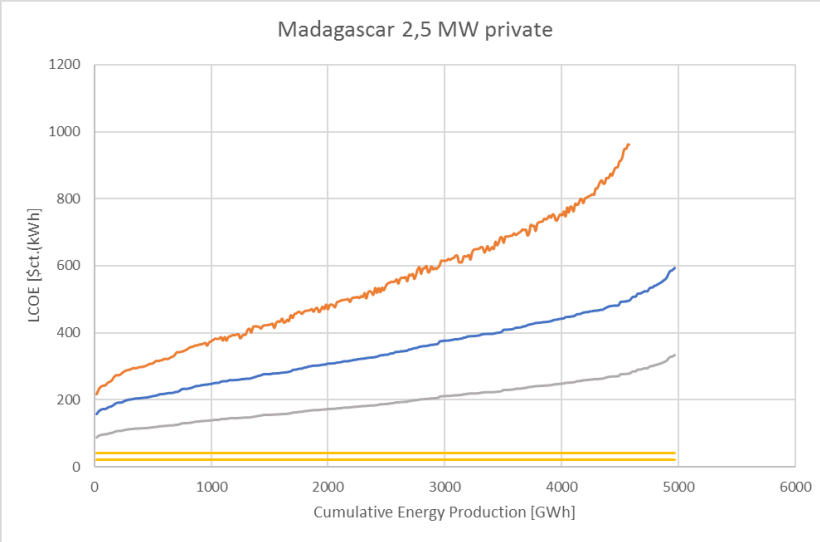
Figures F.6 Supply Curves for Privately Funded OTEC in Indonesia (Own Illustration).

F.7. Jamaica



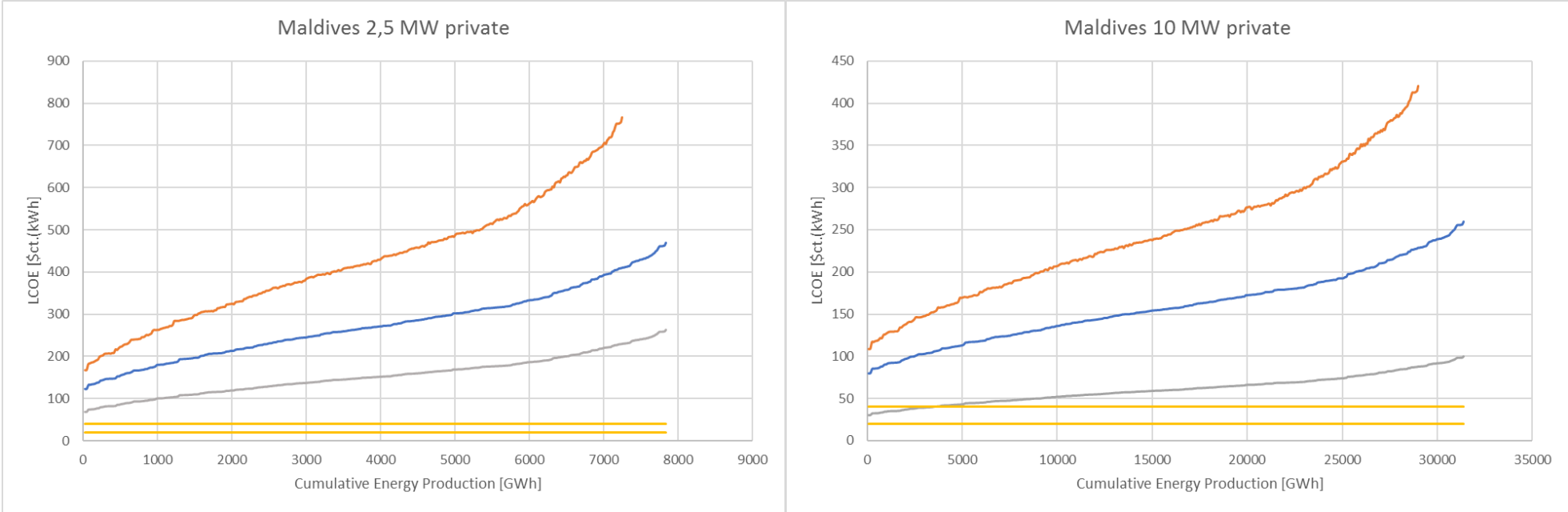
Figures F.7 Supply Curves for Privately Funded OTEC in Jamaica (Own Illustration).

F.8. Madagascar



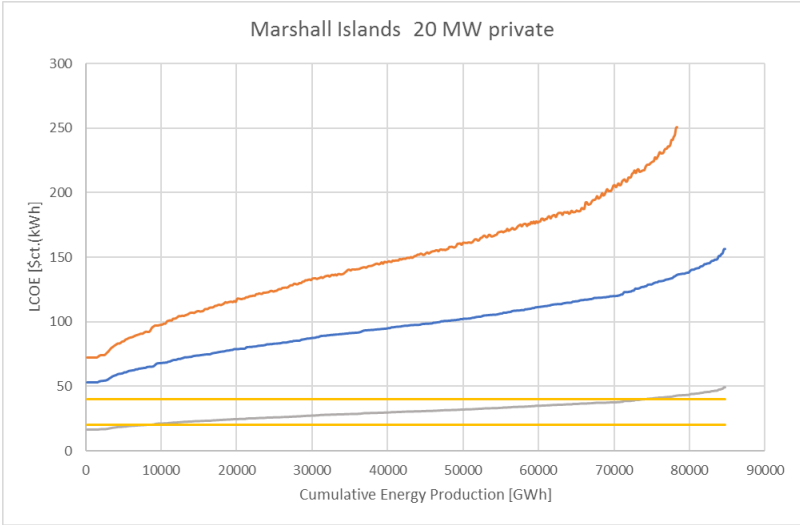
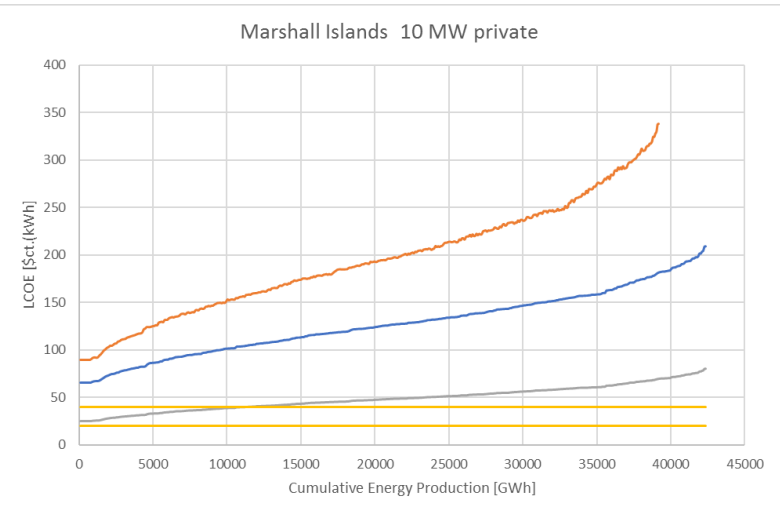
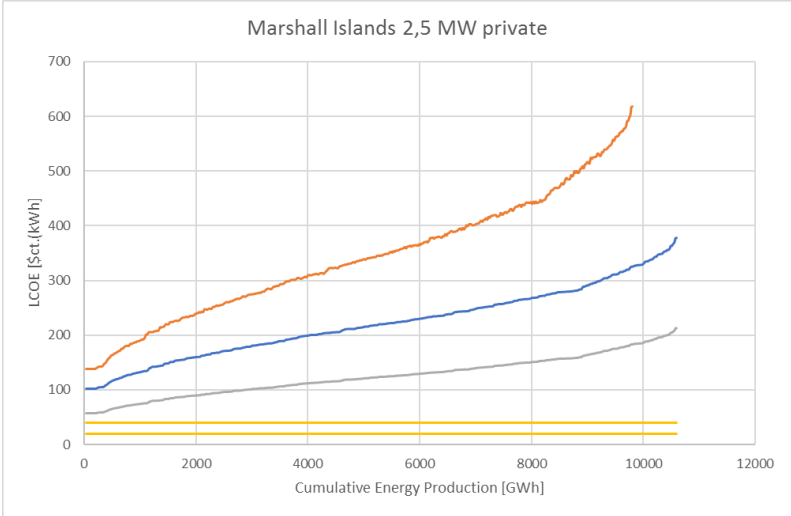
Figures F.8 Supply Curves for Privately Funded OTEC in Madagascar (Own Illustration).

F.9. Maldives



Figures F.9 Supply Curves for Privately Funded OTEC in the Maldives (Own Illustration).

F.10. Marshall Islands



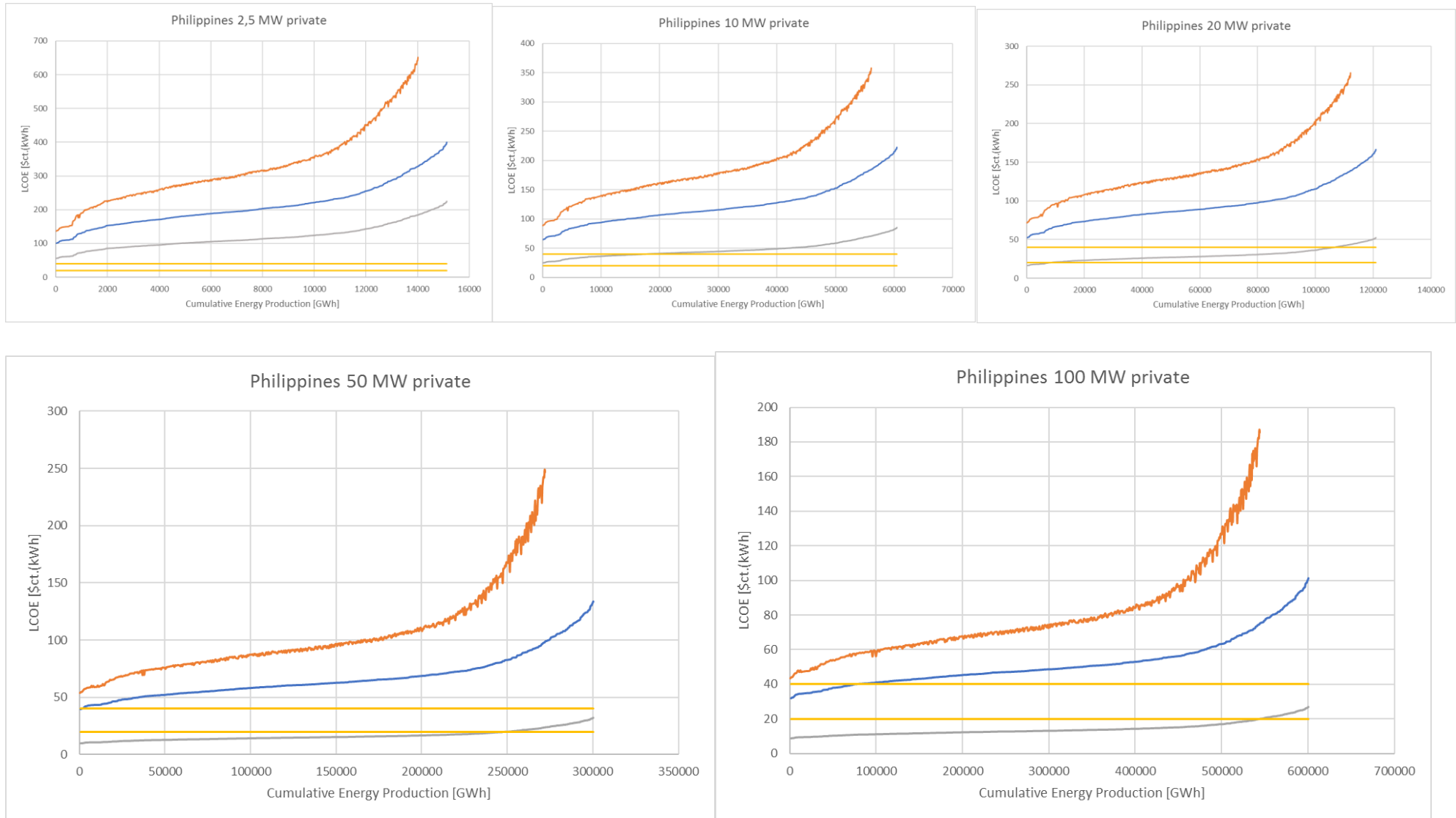
Figures F.10 Supply Curves for Privately Funded OTEC on the Marshall Islands (Own Illustration).

F.11. Papua New Guinea



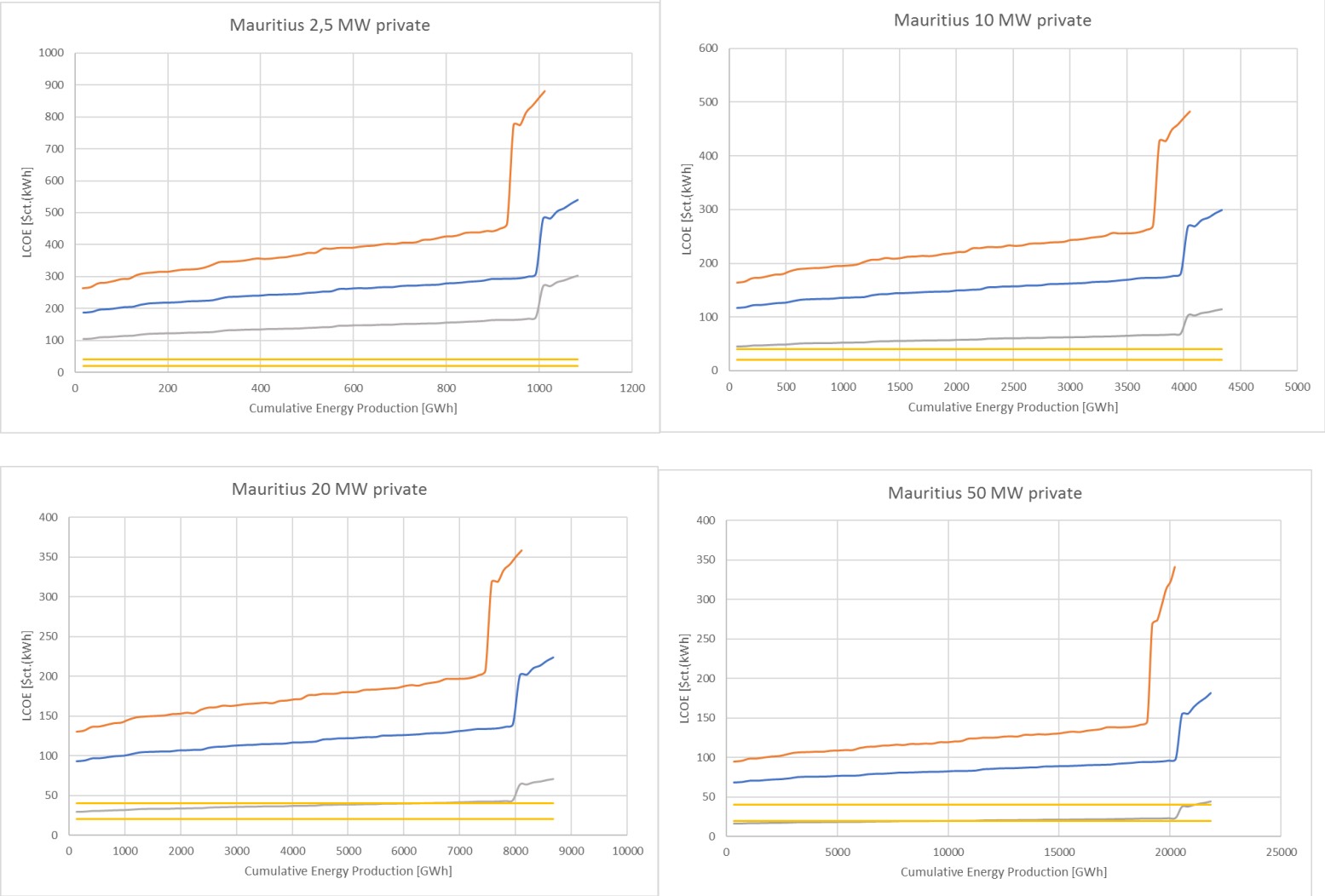
Figures F.11 Supply Curves for Privately Funded OTEC in Papua New Guinea (Own Illustration).

F.12. The Philippines



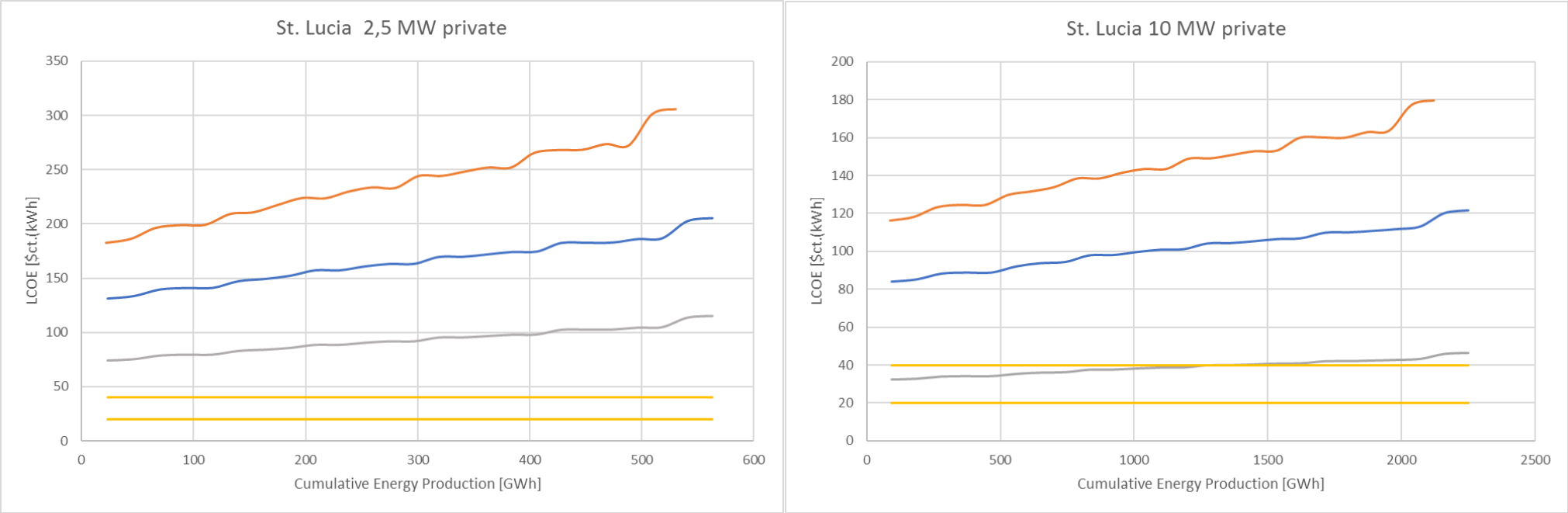
Figures F.12 Supply Curves for Privately Funded OTEC in the Philippines (Own Illustration).

F.13. Republic of Mauritius



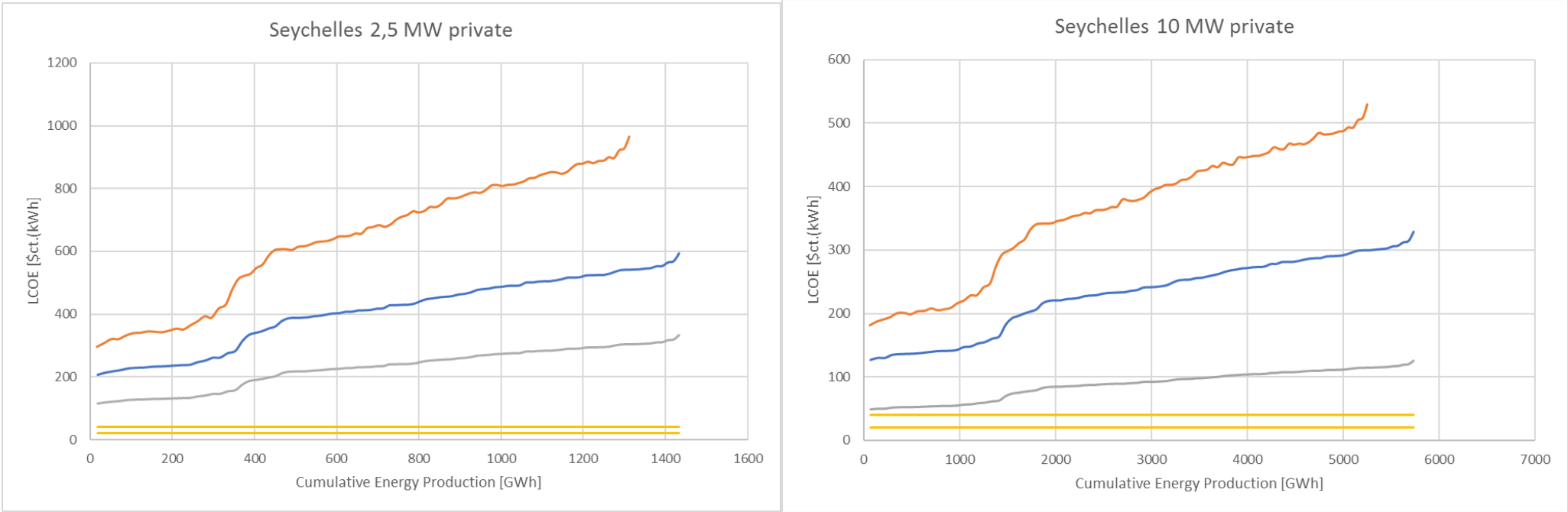
Figures F.13 Supply Curves for Privately Funded OTEC in Mauritius (Own Illustration).

F.14. Saint Lucia



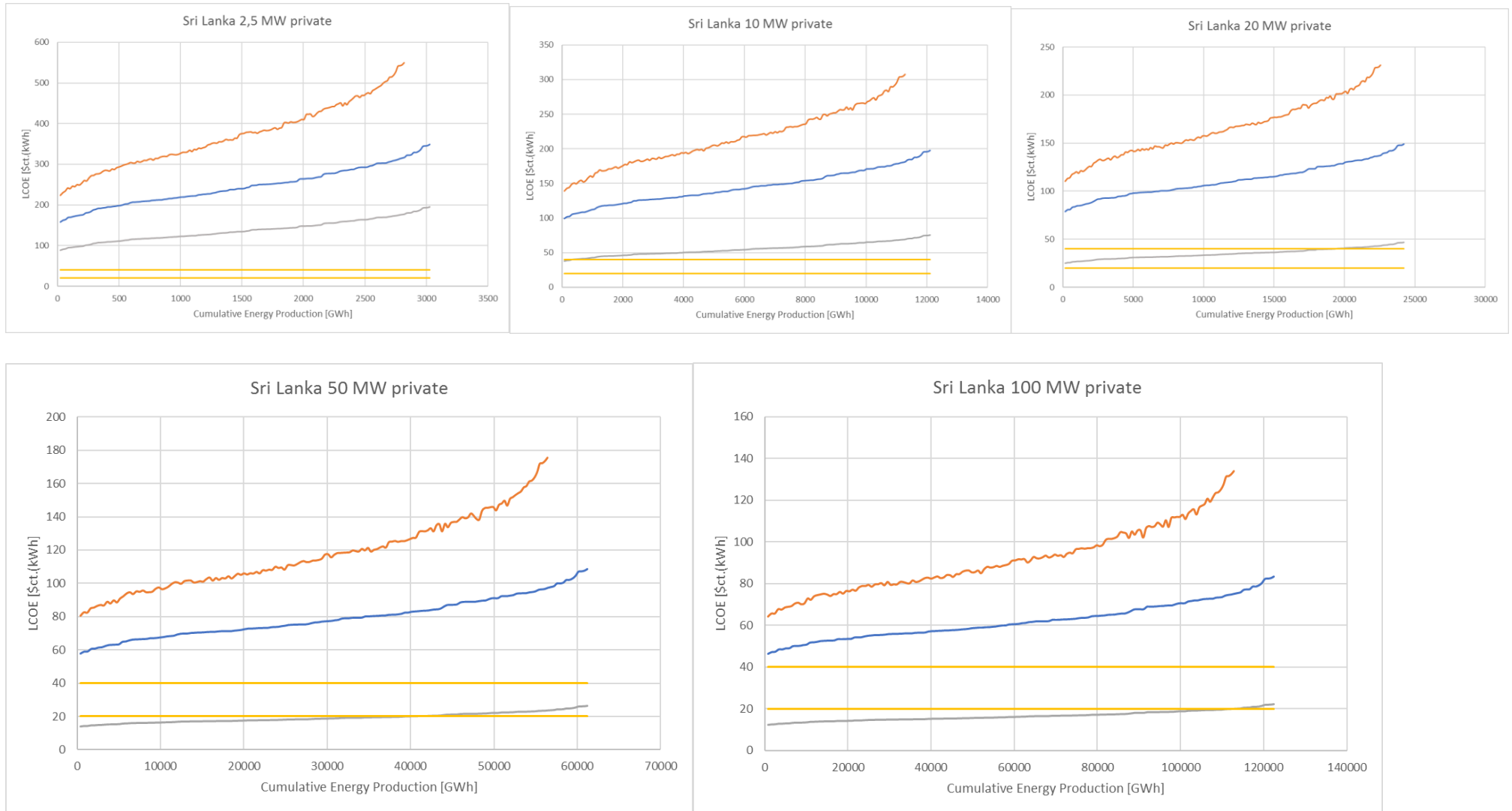
Figures F.14 Supply Curves for Privately Funded OTEC in Saint Lucia (Own Illustration).

F.15. Seychelles



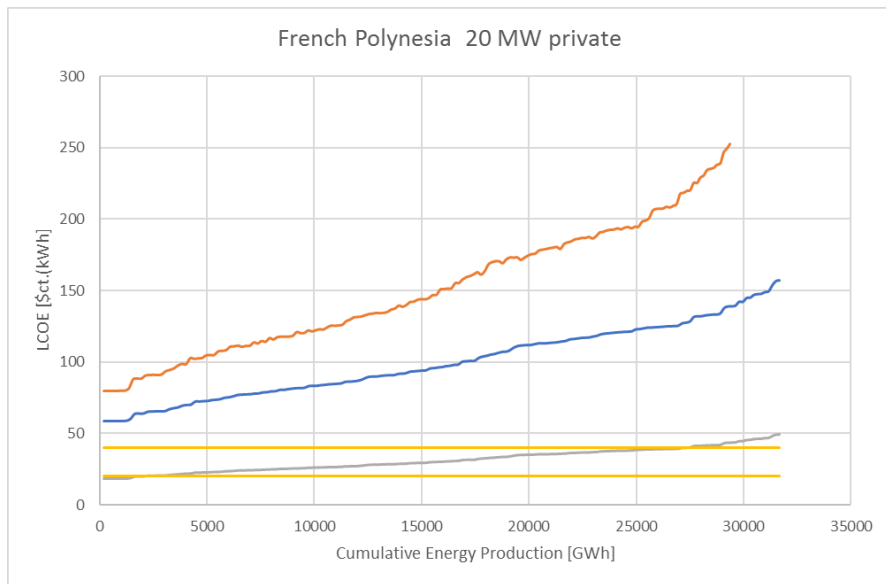
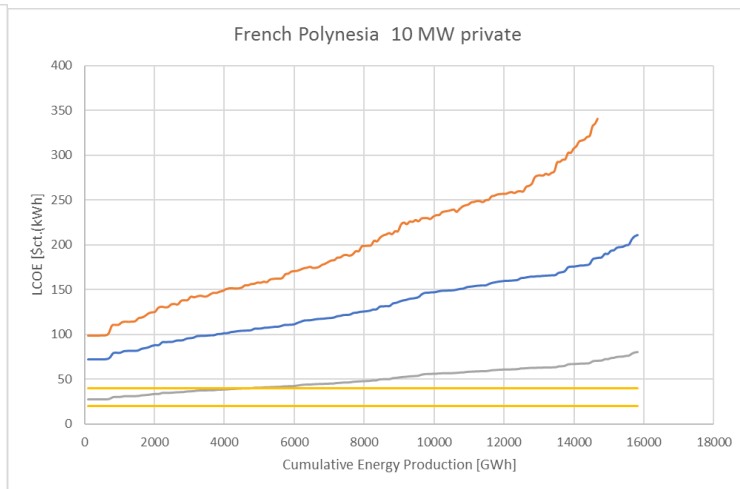
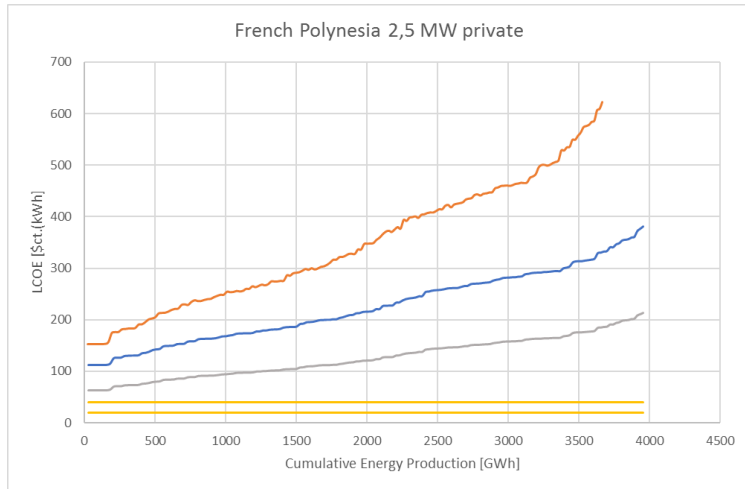
Figures F.15 Supply Curves for Privately Funded OTEC in Seychelles (Own Illustration).

F.16. Sri Lanka



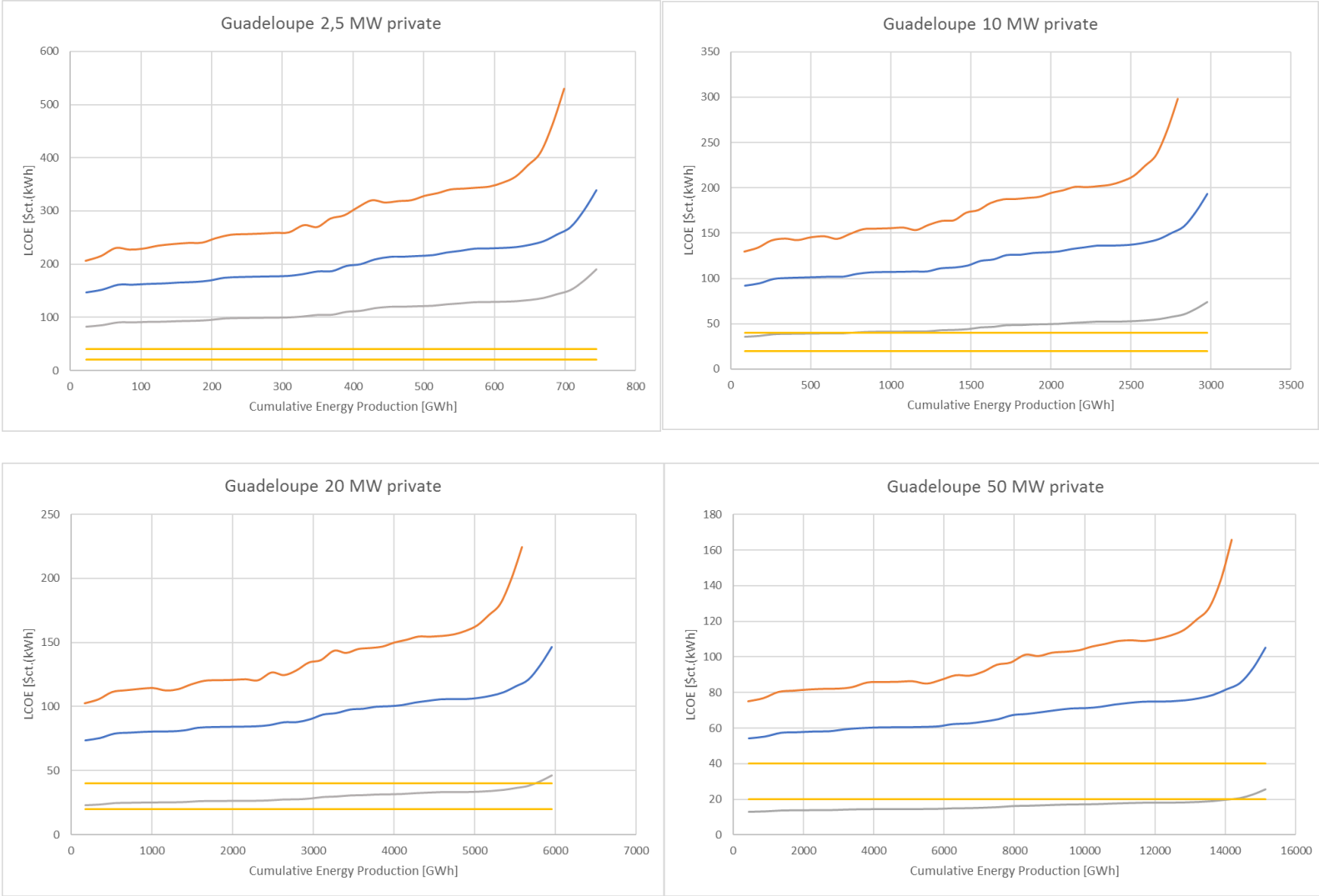
Figures F.16 Supply Curves for Privately Funded OTEC in Sri Lanka (Own Illustration).

F.17. French Polynesia (France)



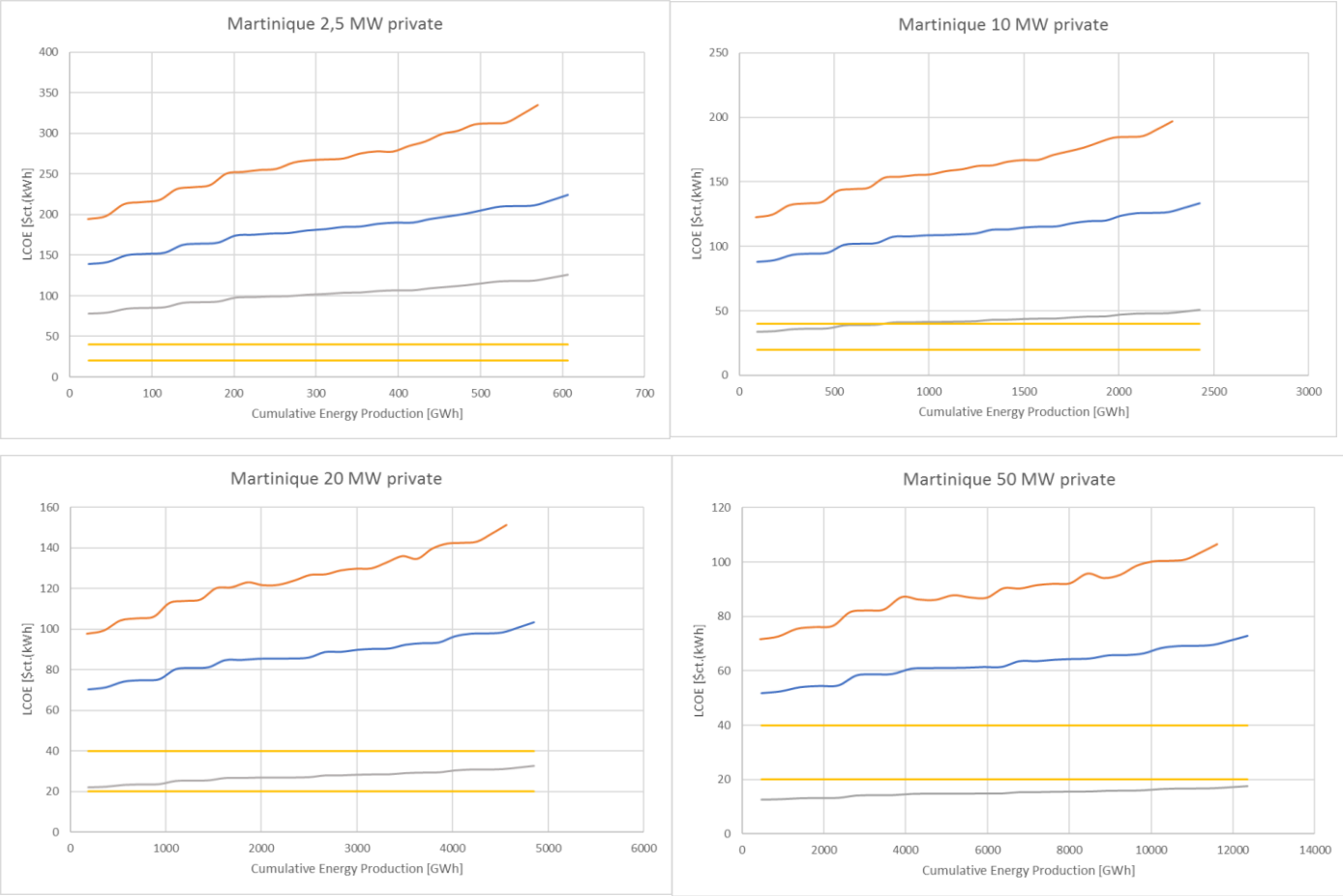
Figures F.17 Supply Curves for Privately Funded OTEC in French Polynesia (Own Illustration).

F.18. Guadeloupe (France)



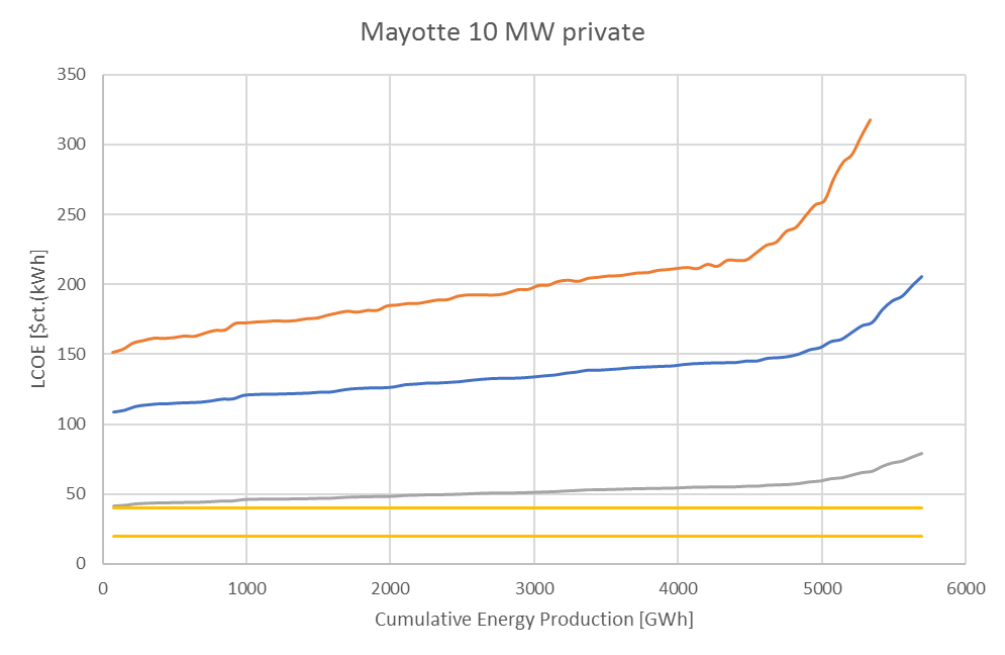
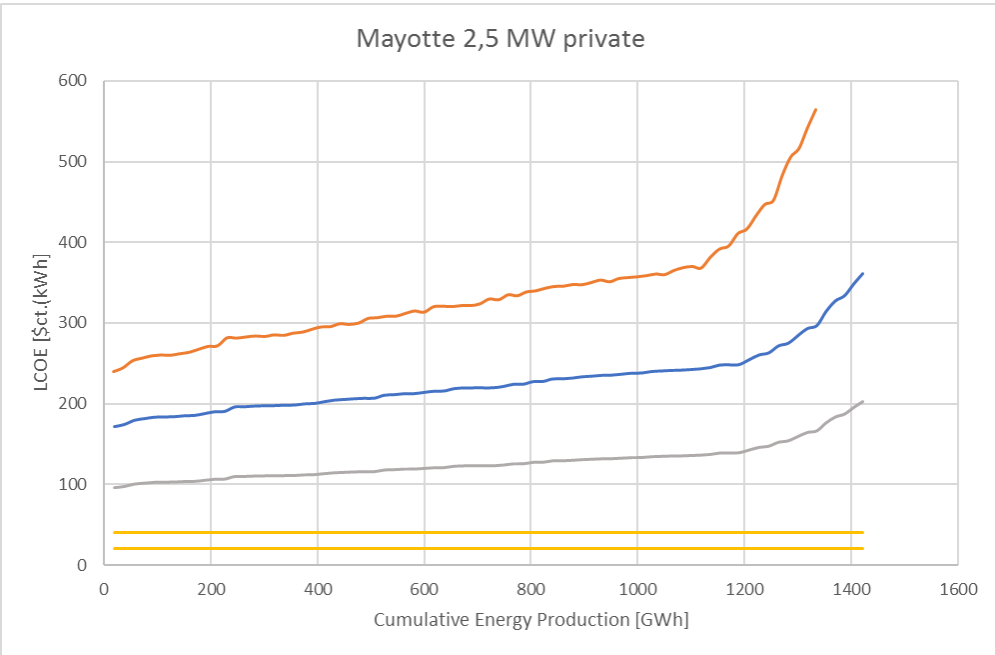
Figures F.18 Supply Curves for Privately Funded OTEC in Guadeloupe (Own Illustration).

F.19. Martinique (France)



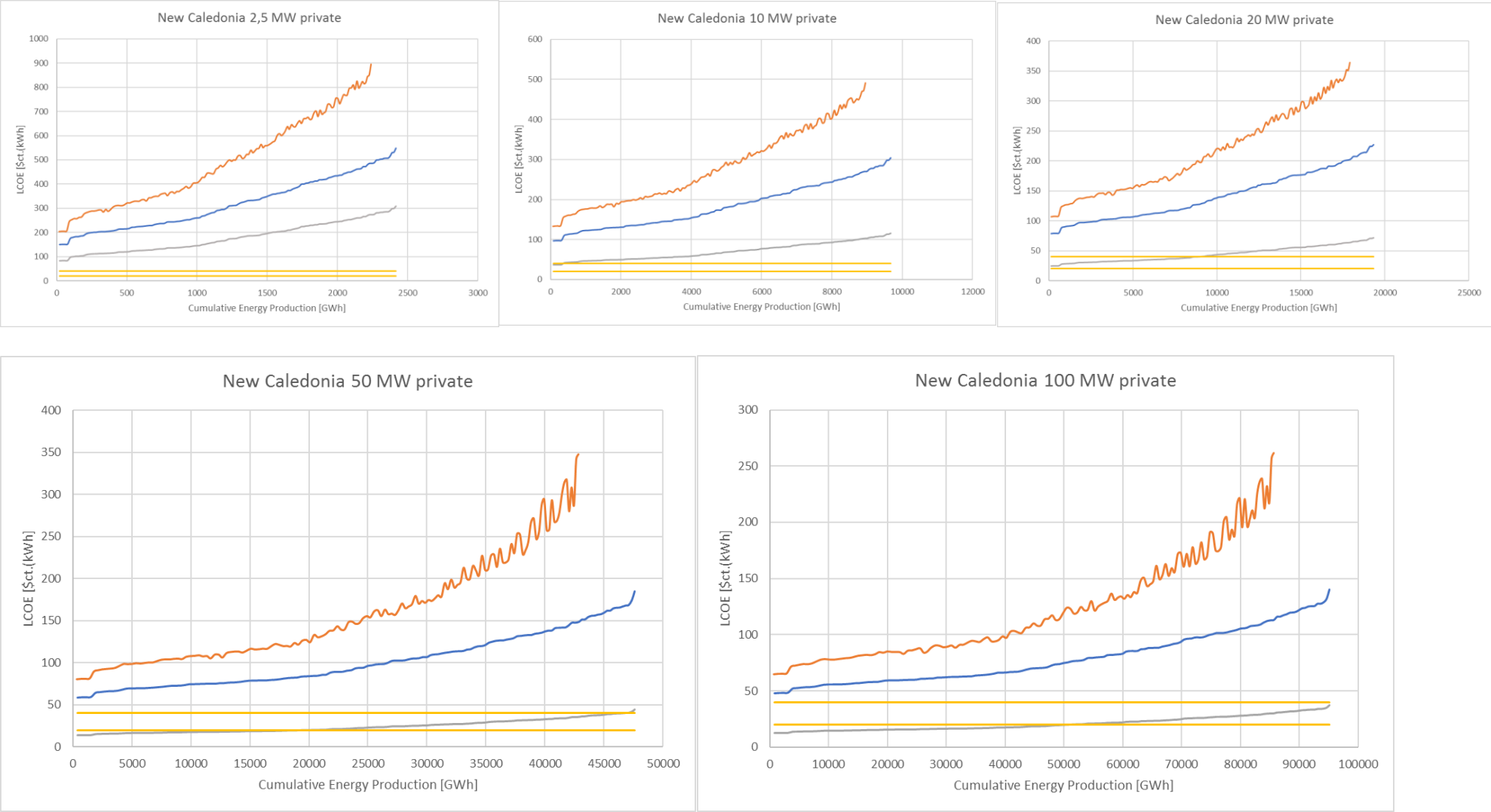
Figures F.19 Supply Curves for Privately Funded OTEC in Martinique (Own Illustration).

F.20. Mayotte (France)



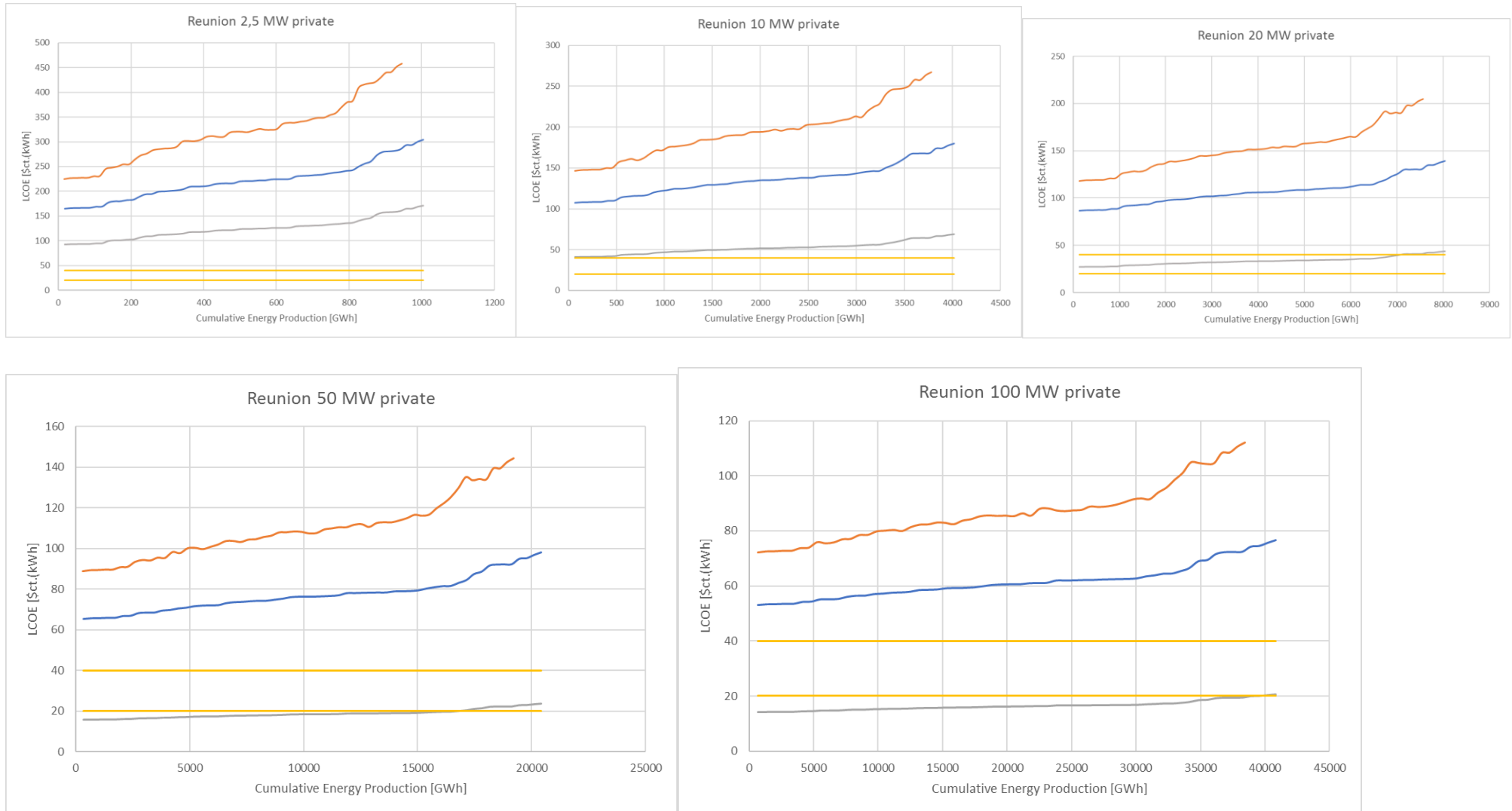
Figures F.20 Supply Curves for Privately Funded OTEC in Mayotte (Own Illustration).

F.21. New Caledonia (France)



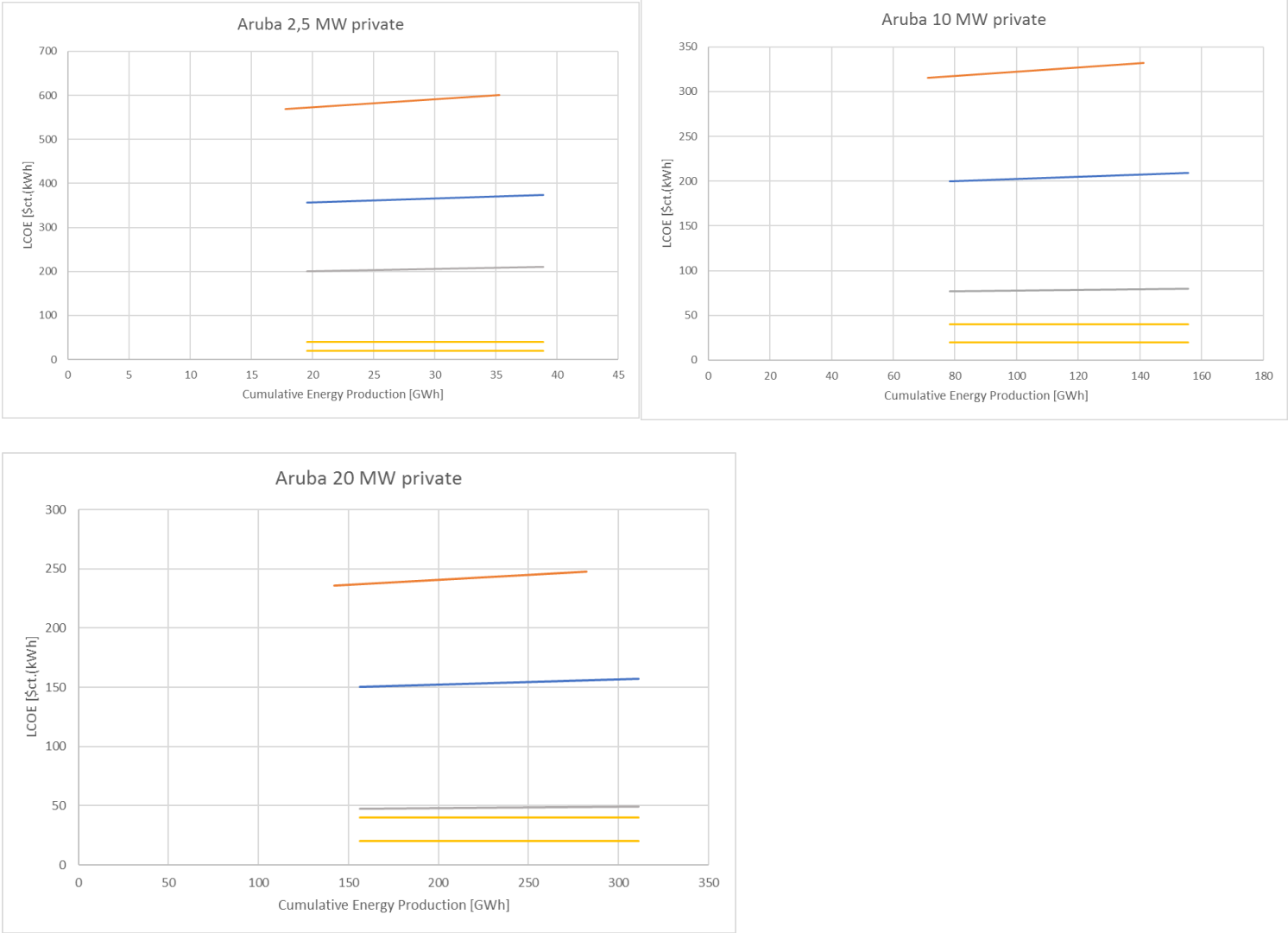
Figures F.21 Supply Curves for Privately Funded OTEC in New Caledonia (Own Illustration).

F.22. Reunion Island (France)



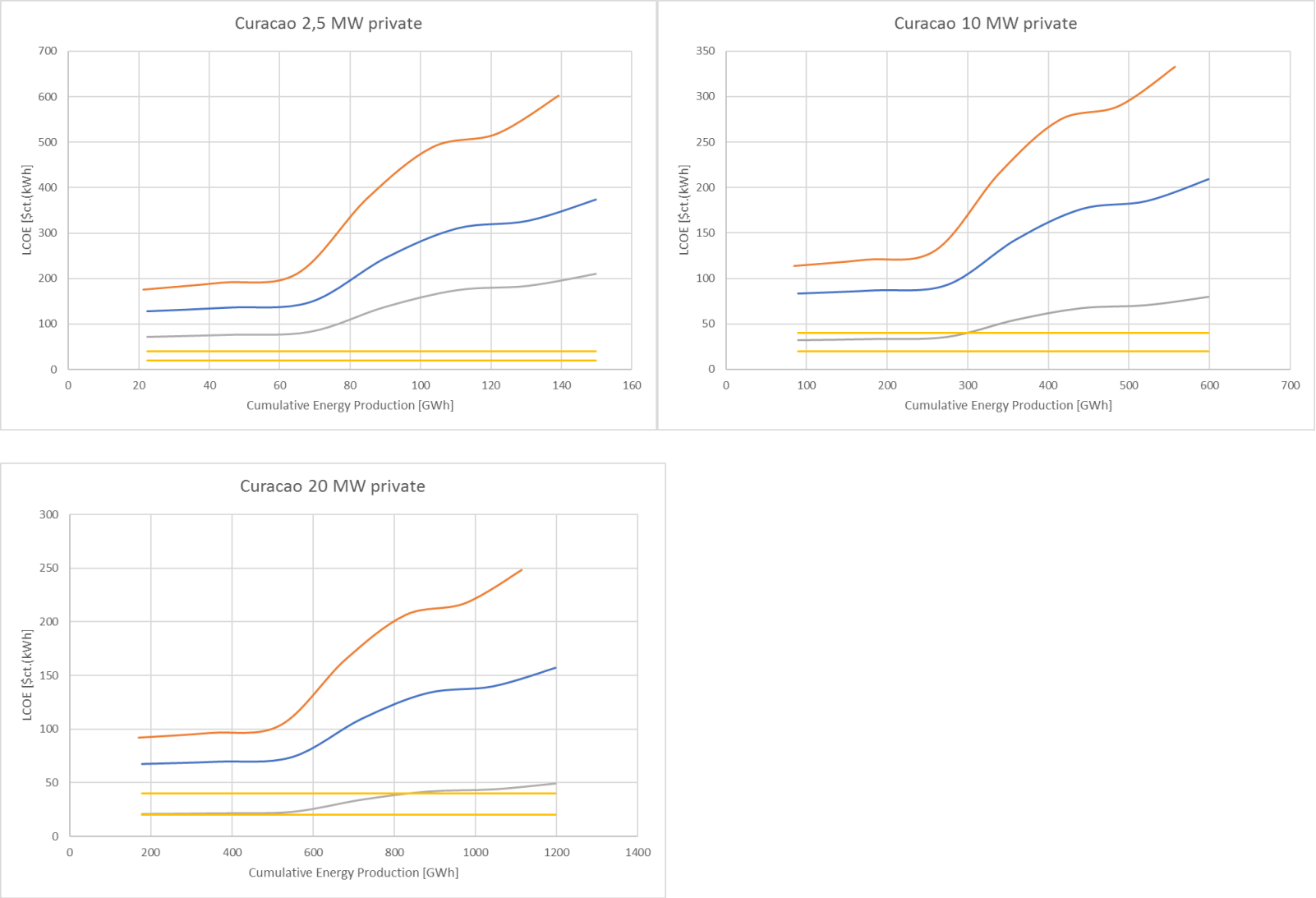
Figures F.22 Supply Curves for Privately Funded OTEC in Reunion (Own Illustration).

F.23. Aruba (Netherlands)



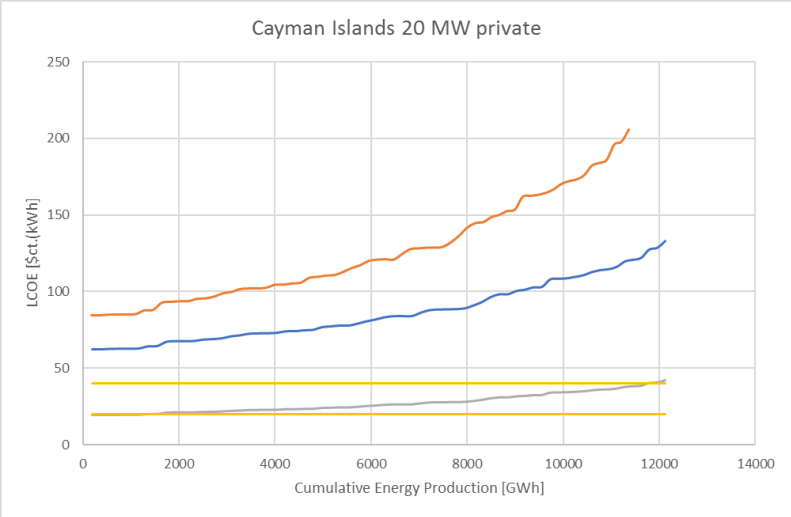
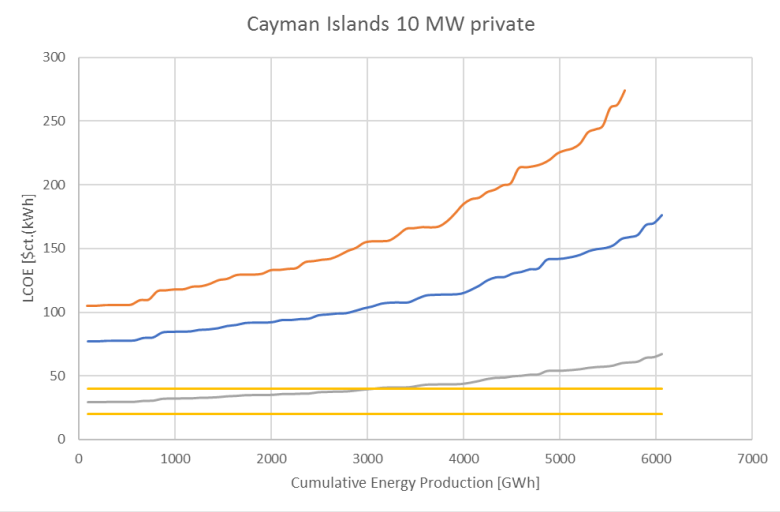
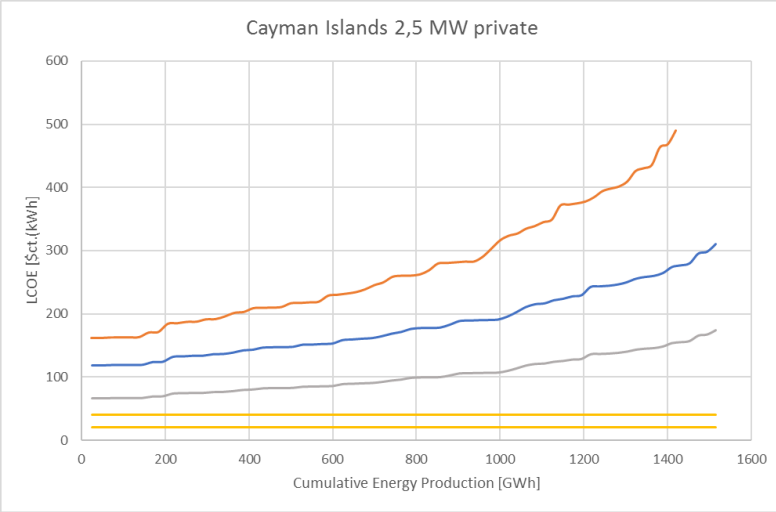
Figures F.23 Supply Curves for Privately Funded OTEC in Aruba (Own Illustration).

F.24. Curaçao (Netherlands)



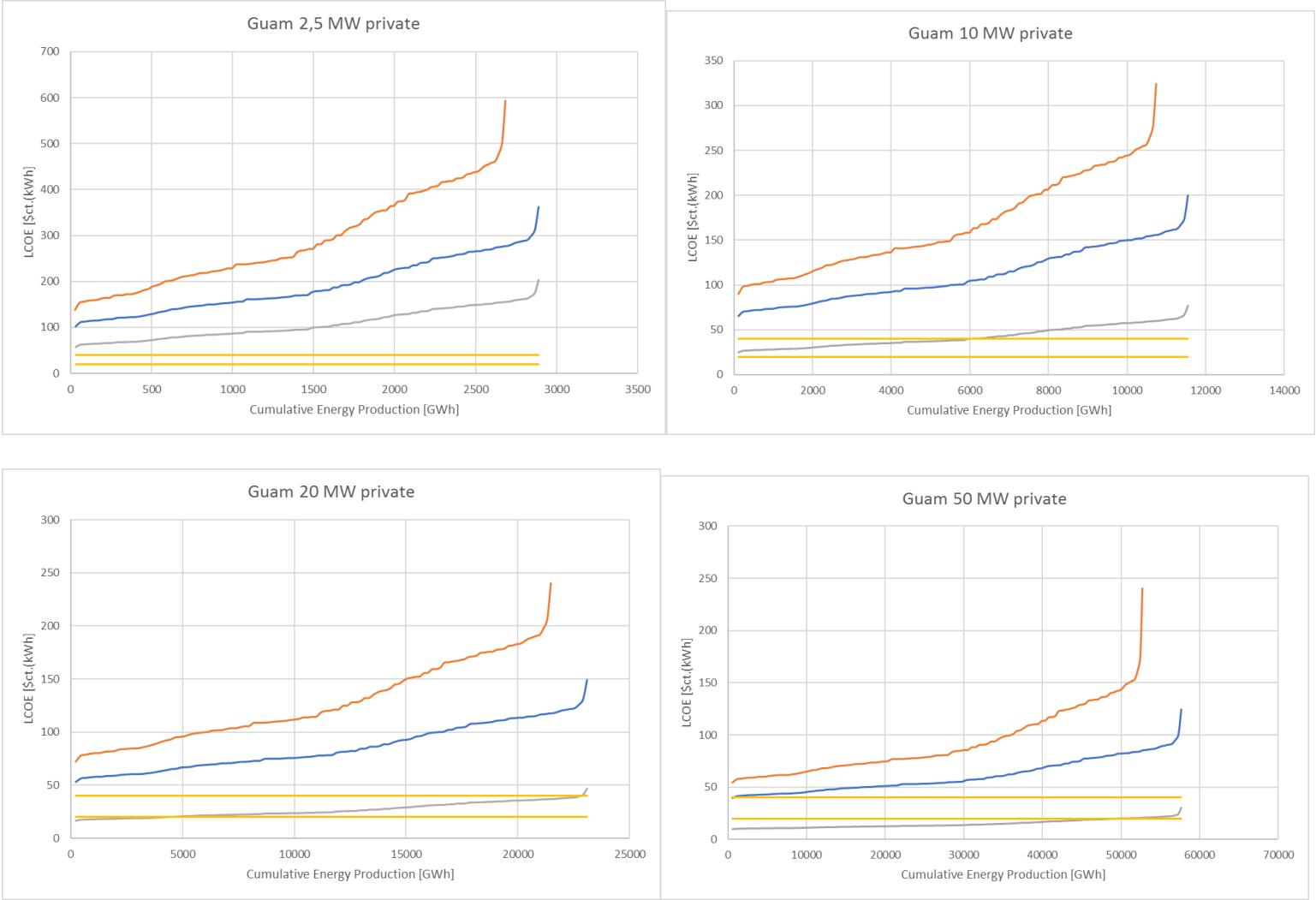
Figures F.24 Supply Curves for Privately Funded OTEC in Curaçao (Own Illustration).

F.25. Cayman Islands (United Kingdom)



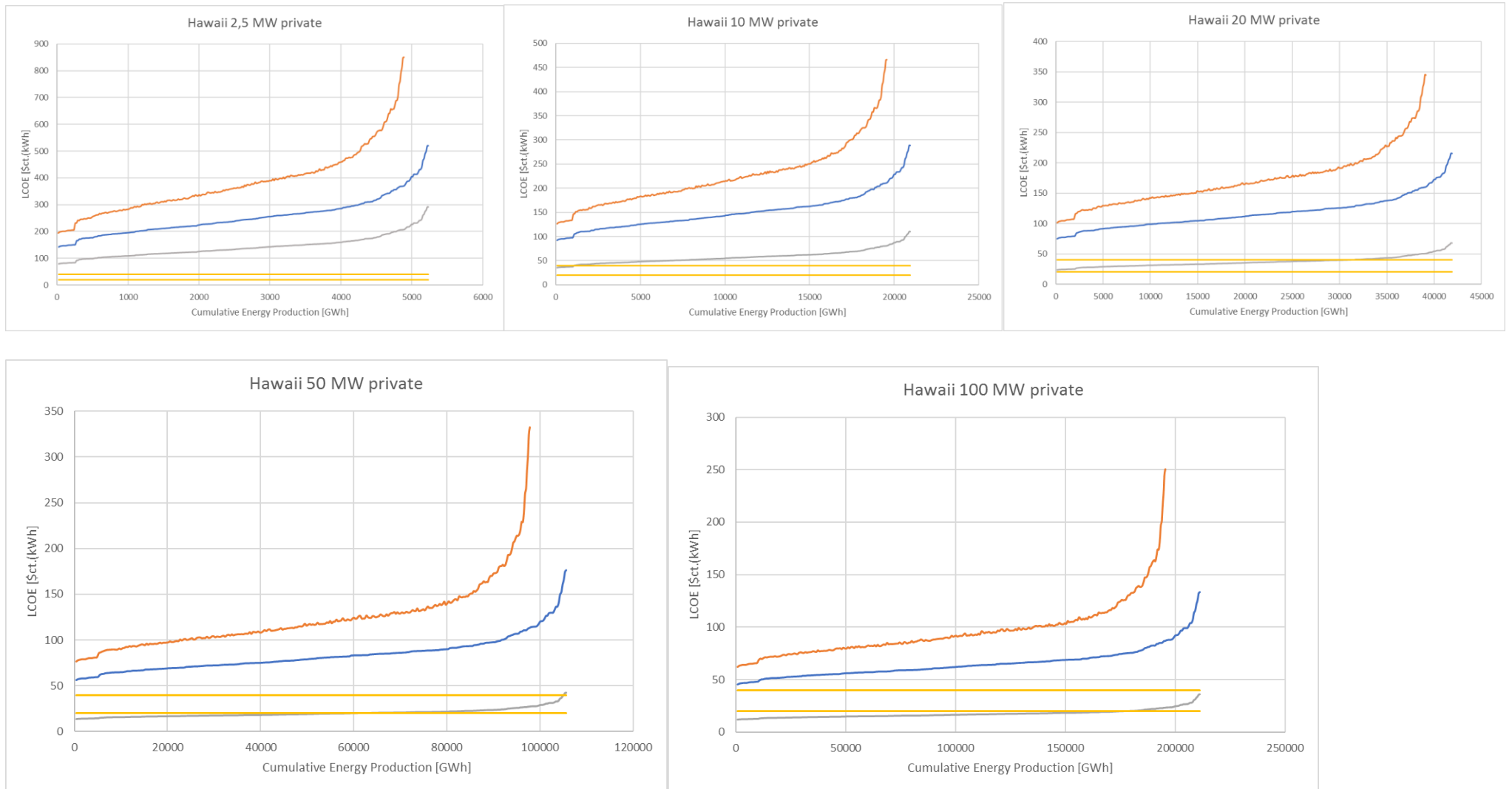
Figures F.25 Supply Curves for Privately Funded OTEC on the Cayman Islands (Own Illustration).

F.26. Guam (United States of America)



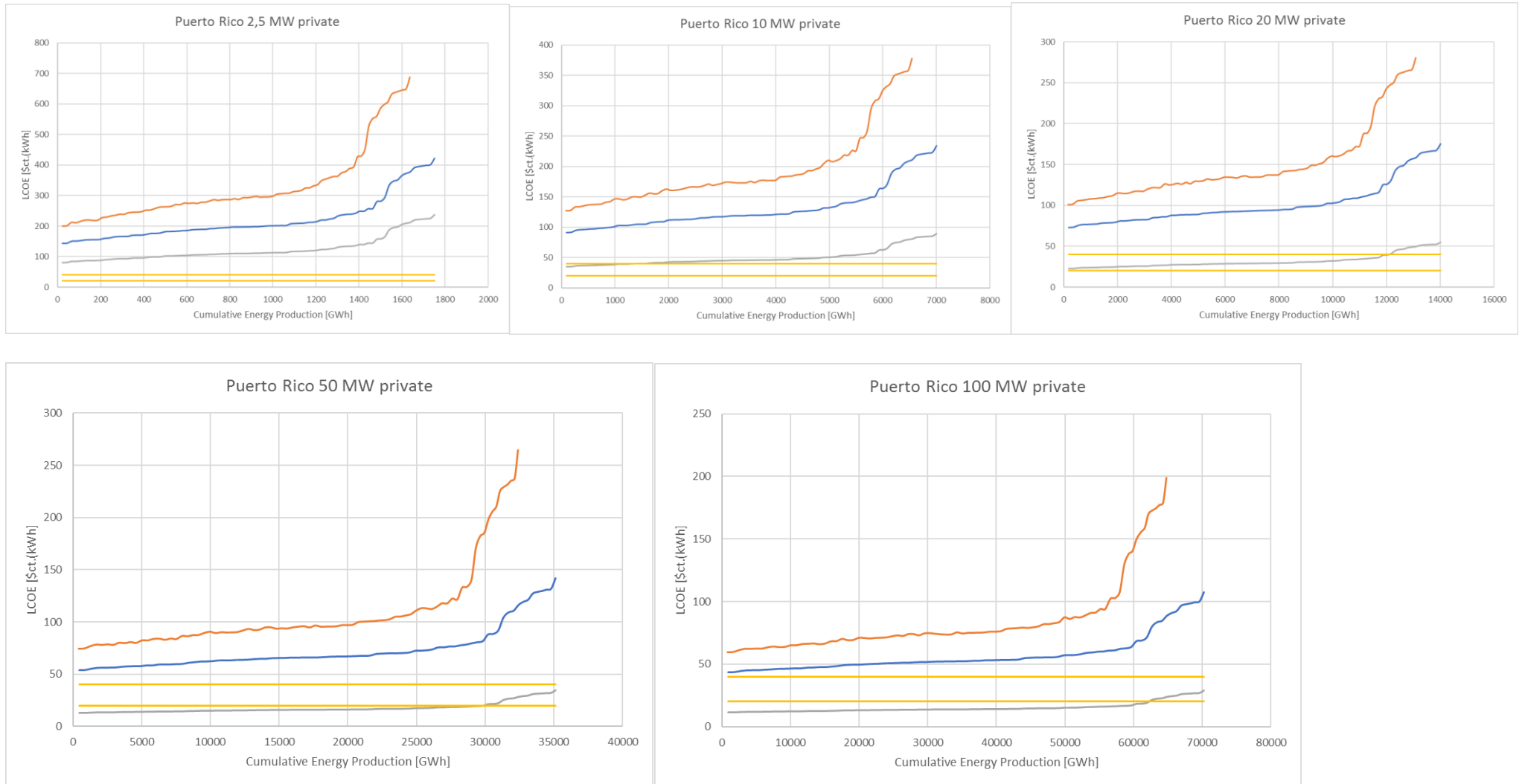
Figures F.26 Supply Curves for Privately Funded OTEC in Guam (Own Illustration).

F.27. Hawaii (United States of America)



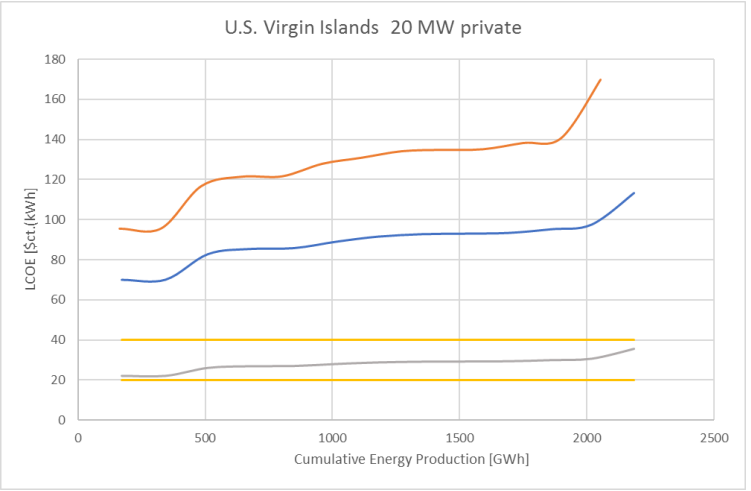
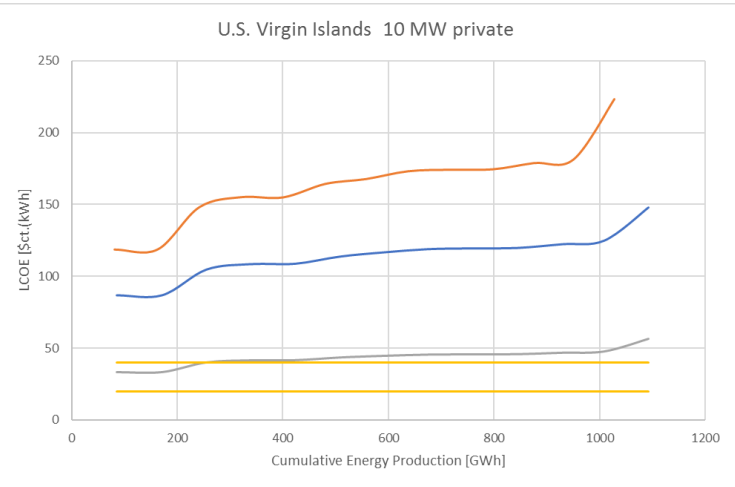
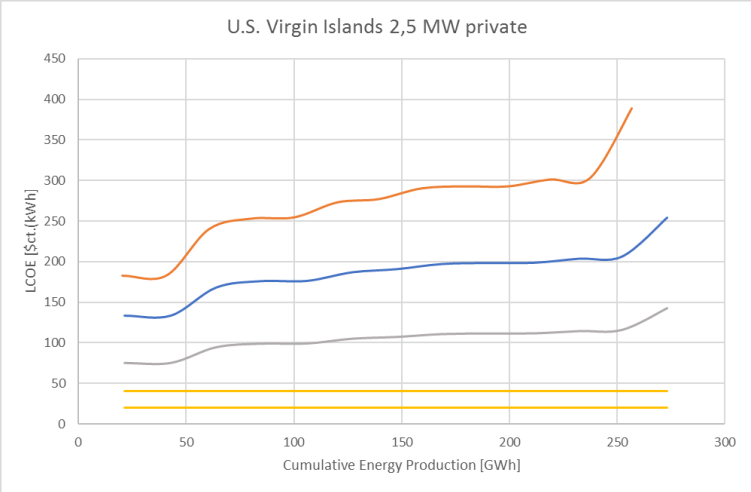
Figures F.27 Supply Curves for Privately Funded OTEC in Hawaii (Own Illustration).

F.28. Puerto Rico (United States of America)



Figures F.28 Supply Curves for Privately Funded OTEC in Puerto Rico (Own Illustration).

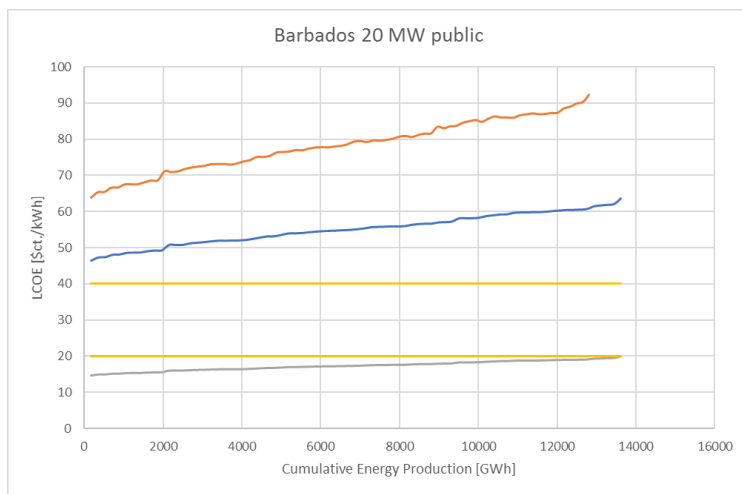
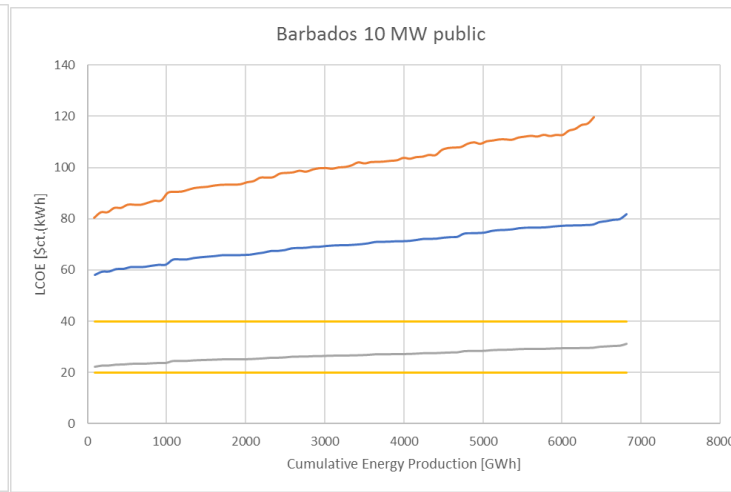
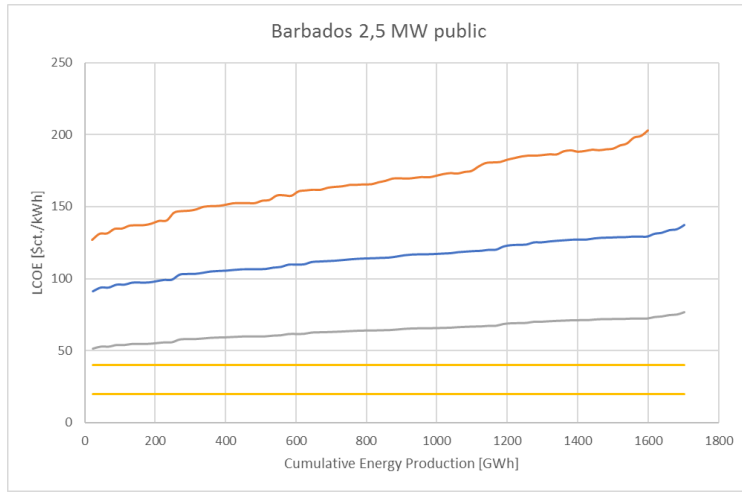
F.29. United States Virgin Islands (United States of America)



Figures F.29 Supply Curves for Privately Funded OTEC at the U.S. Virgin Islands (Own Illustration).

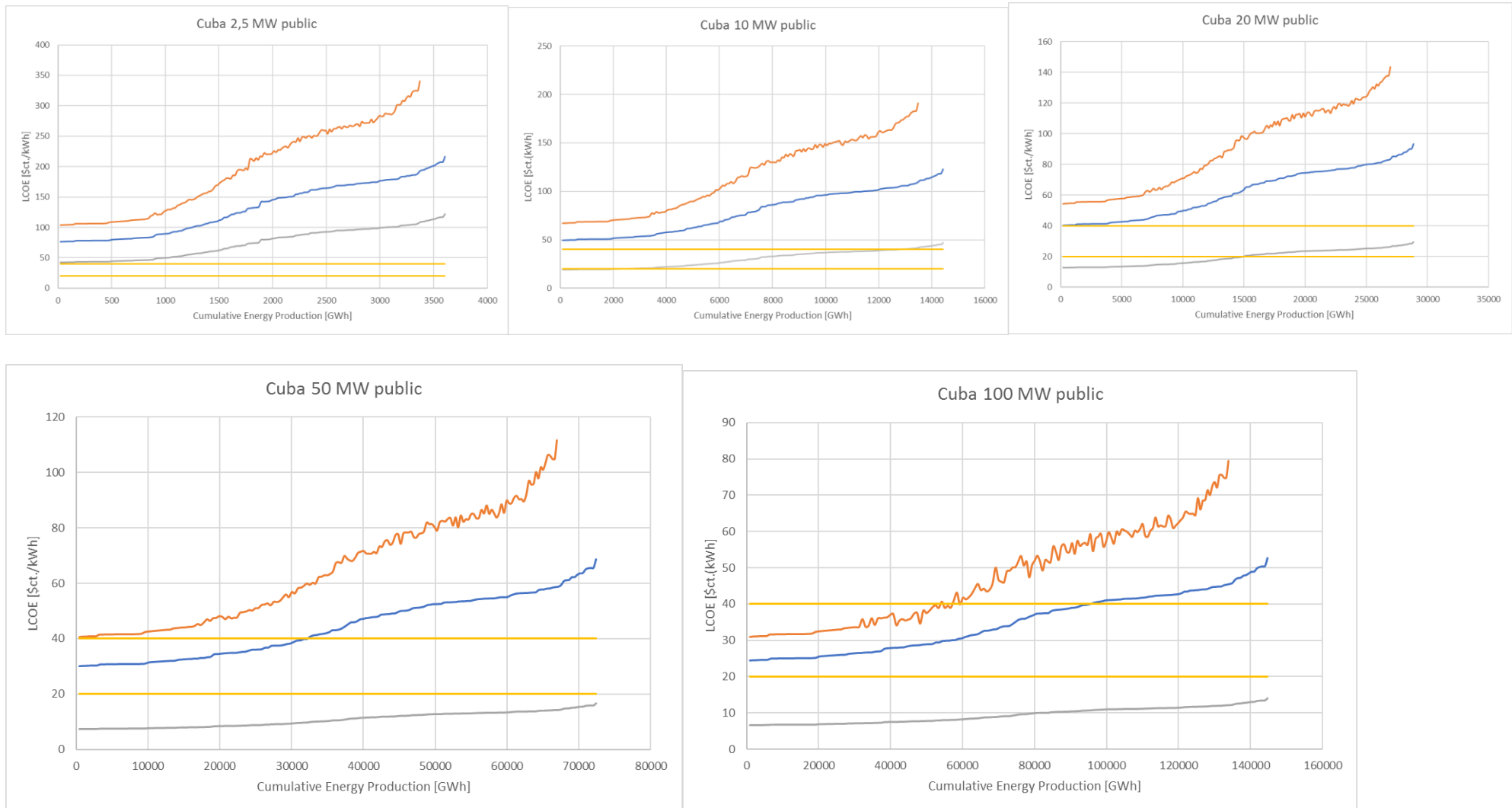
G. Supply Curves for Each Tropical Island (Public Projects, Discount Rate 10%)

G.1. Barbados



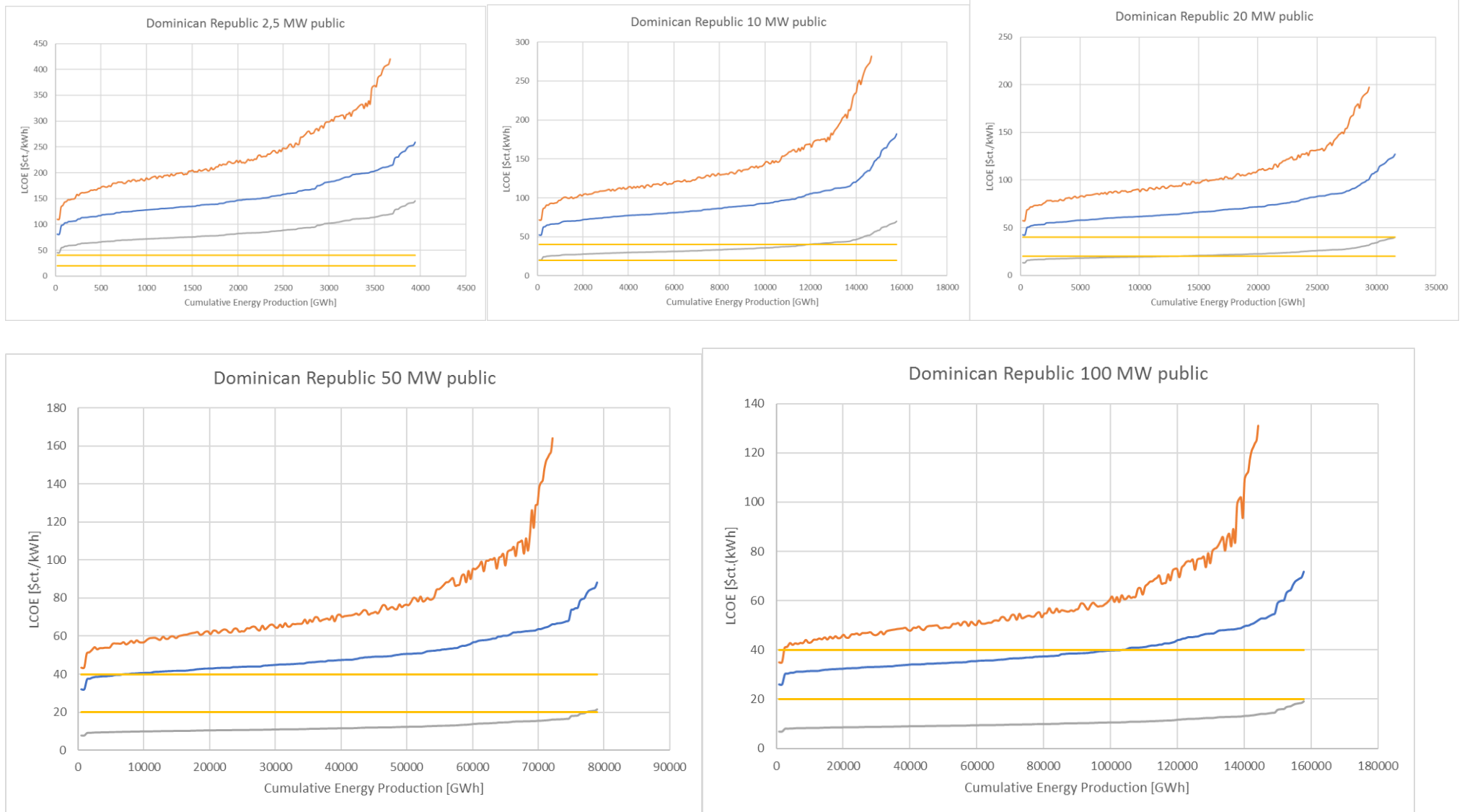
Figures G.1 Supply Curves for Publicly Funded OTEC in Barbados (Own Illustration).

G.2. Cuba



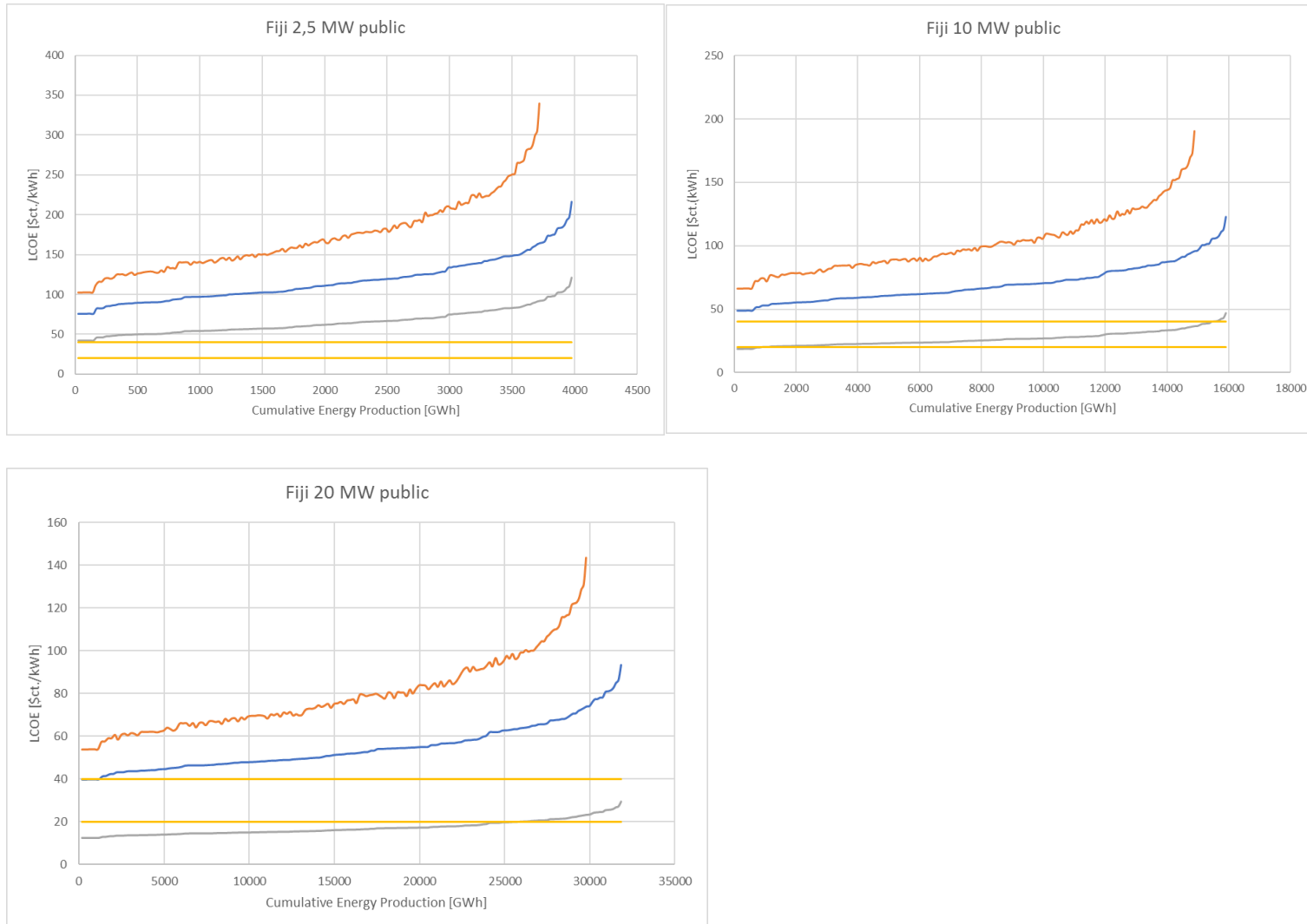
Figures G.2 Supply Curves for Publicly Funded OTEC in Cuba (Own Illustration).

G.3. Dominican Republic



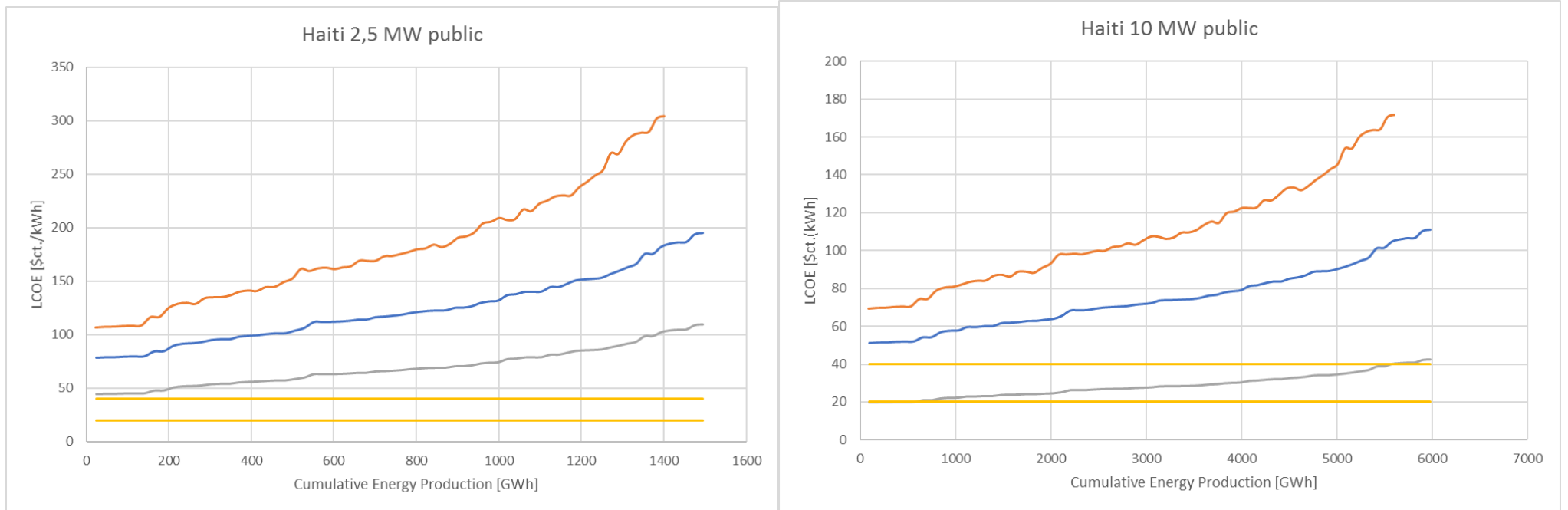
Figures G.3 Supply Curves for Publicly Funded OTEC in the Dominican Republic (Own Illustration).

G.4. Fiji



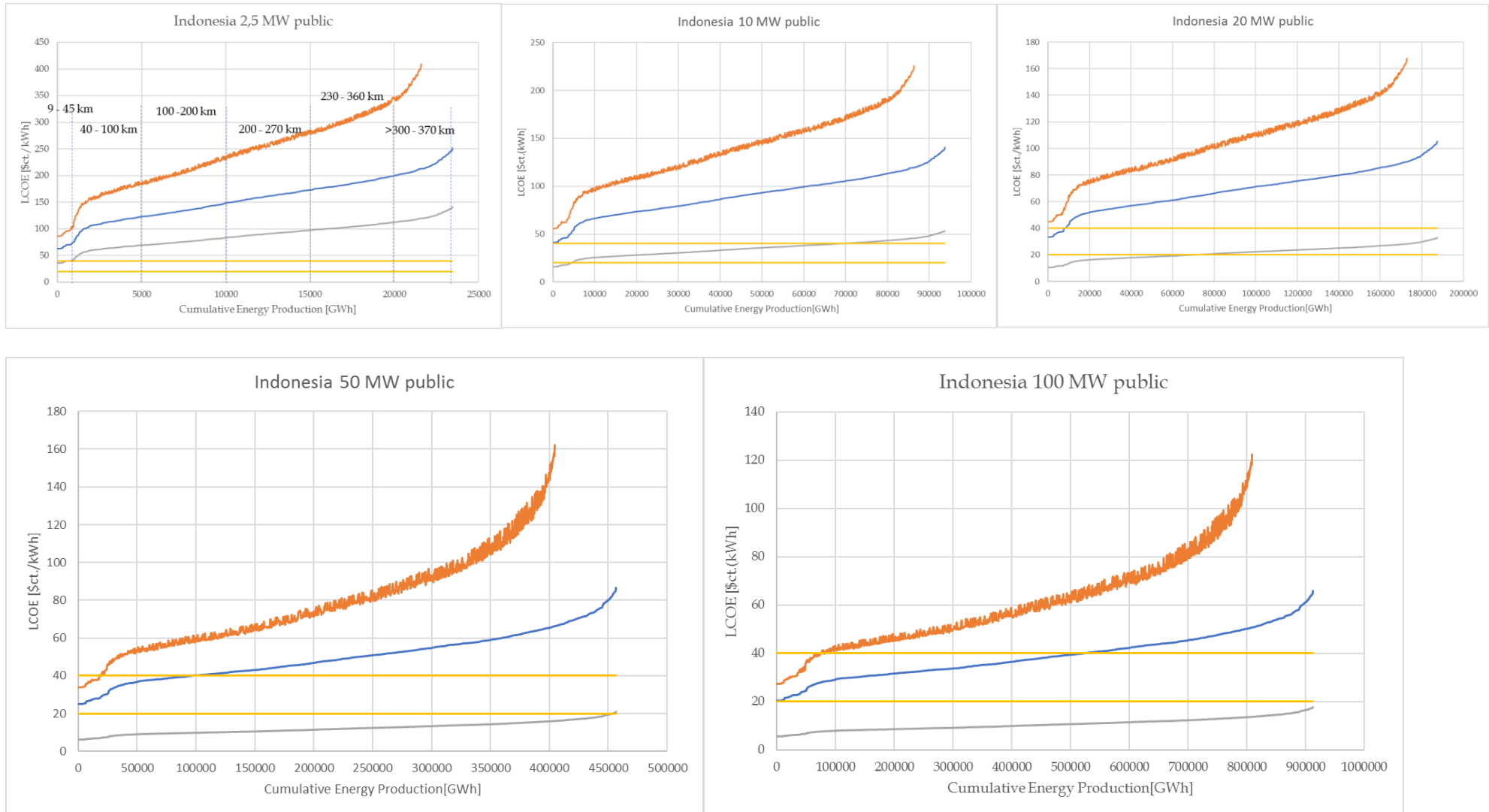
Figures G.4 Supply Curves for Publicly Funded OTEC in Fiji (Own Illustration).

G.5. Haiti



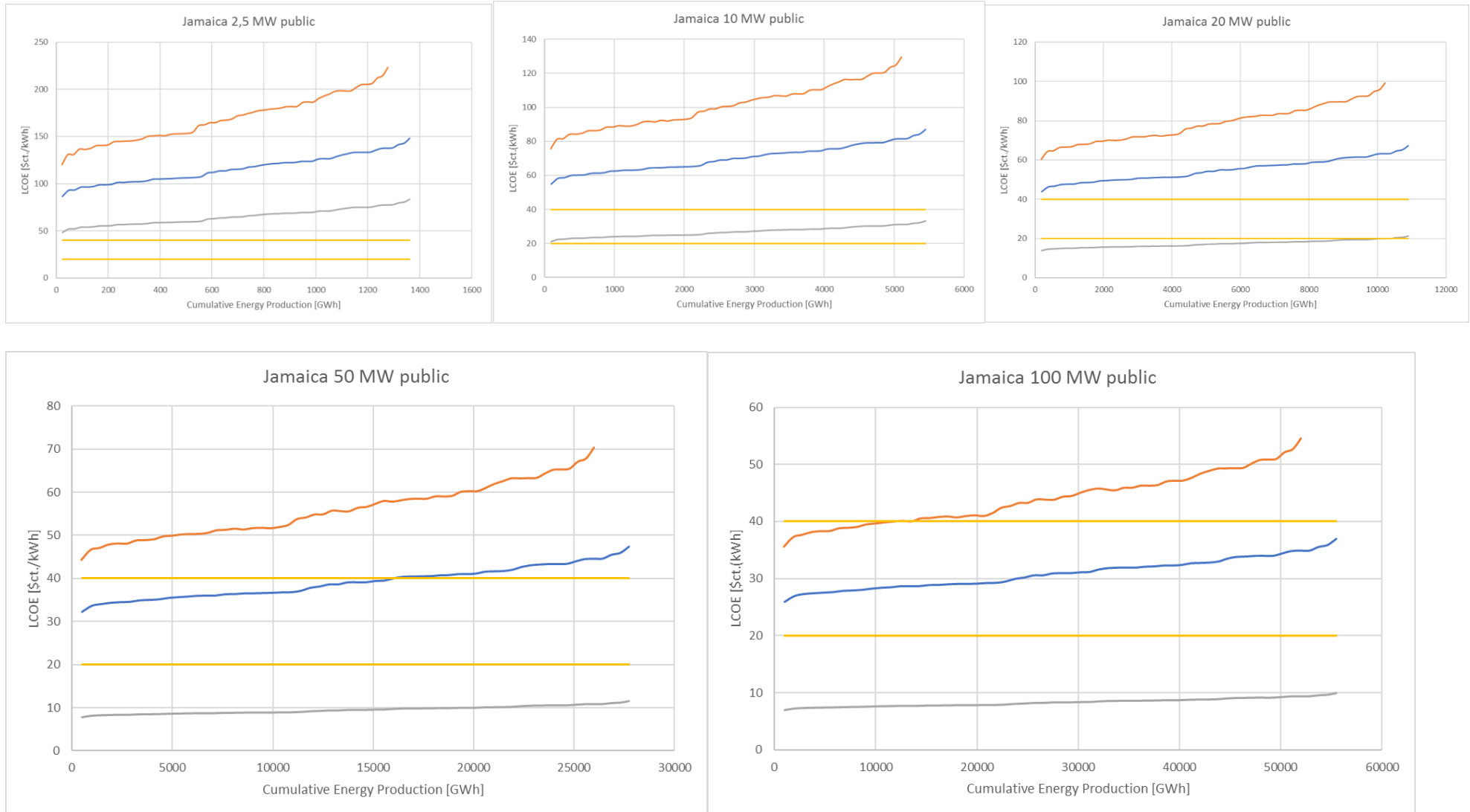
Figures G.5 Supply Curves for Publicly Funded OTEC in Haiti (Own Illustration).

G.6. Indonesia



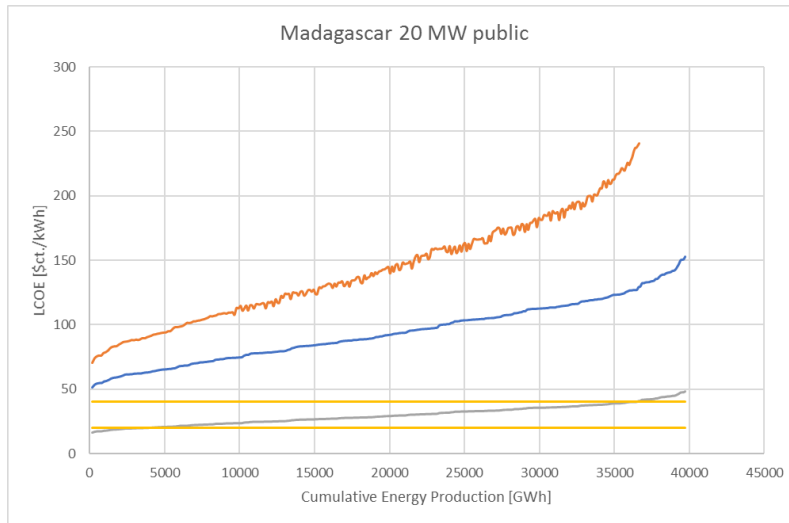
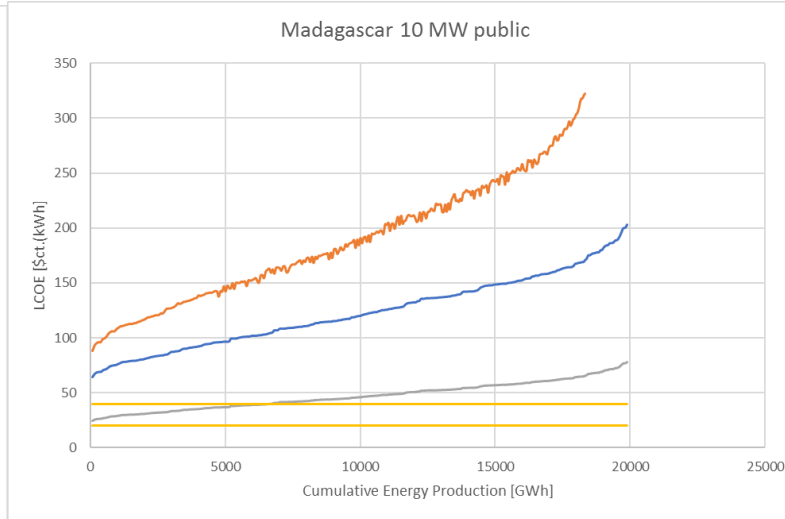
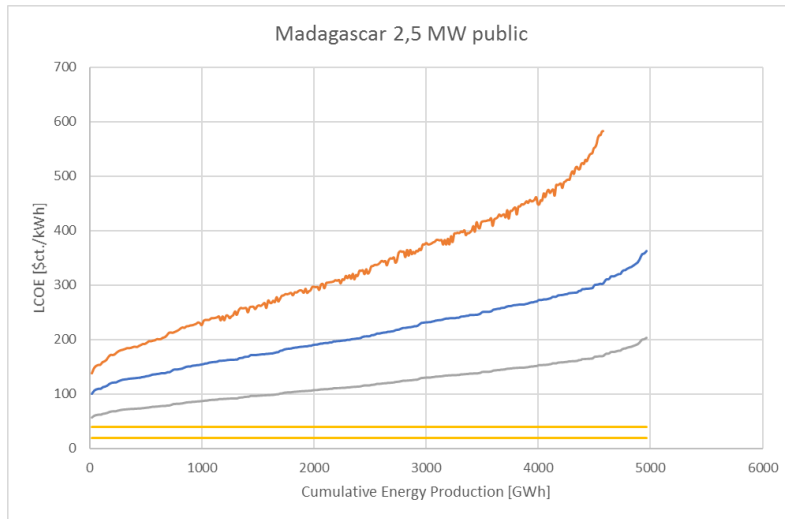
Figures G.6 Supply Curves for Publicly Funded OTEC in Indonesia (Own Illustration).

G.7. Jamaica



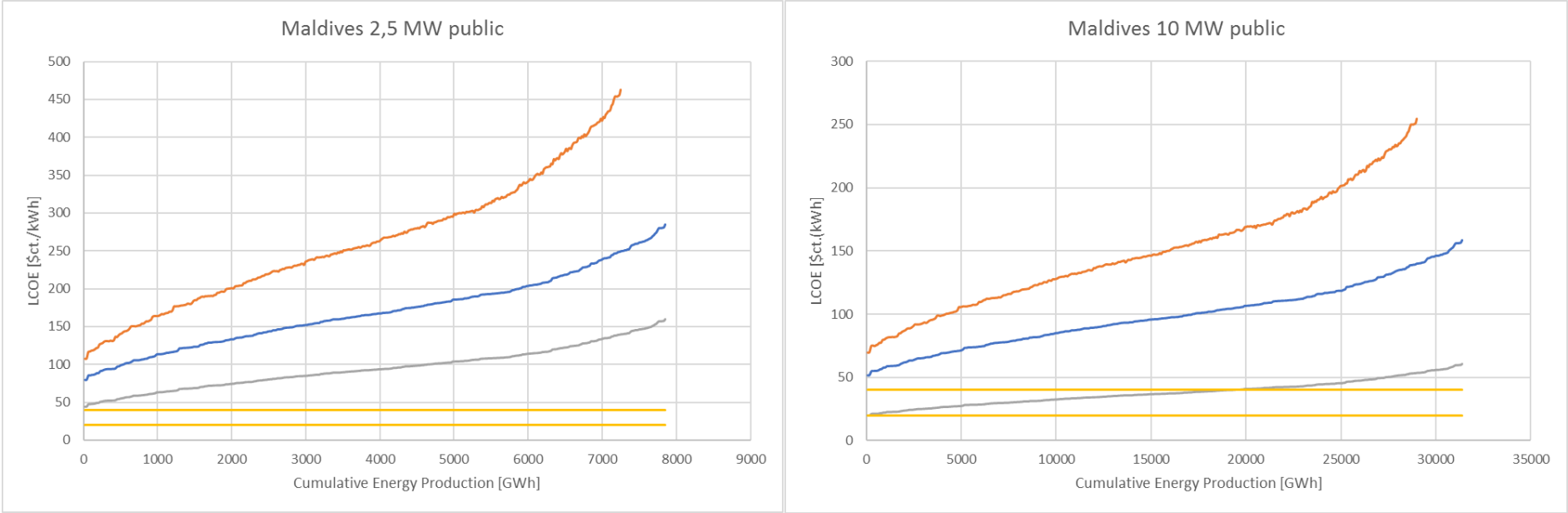
Figures G.7 Supply Curves for Publicly Funded OTEC in Jamaica (Own Illustration).

G.8. Madagascar



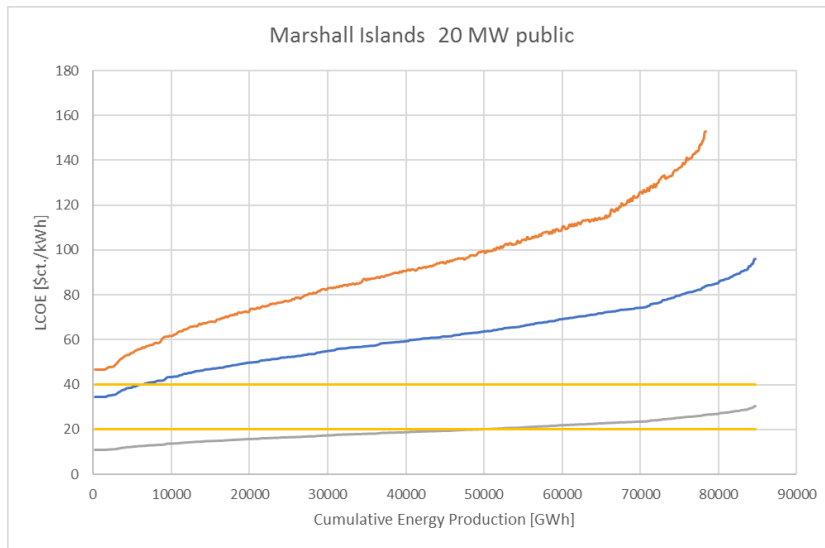
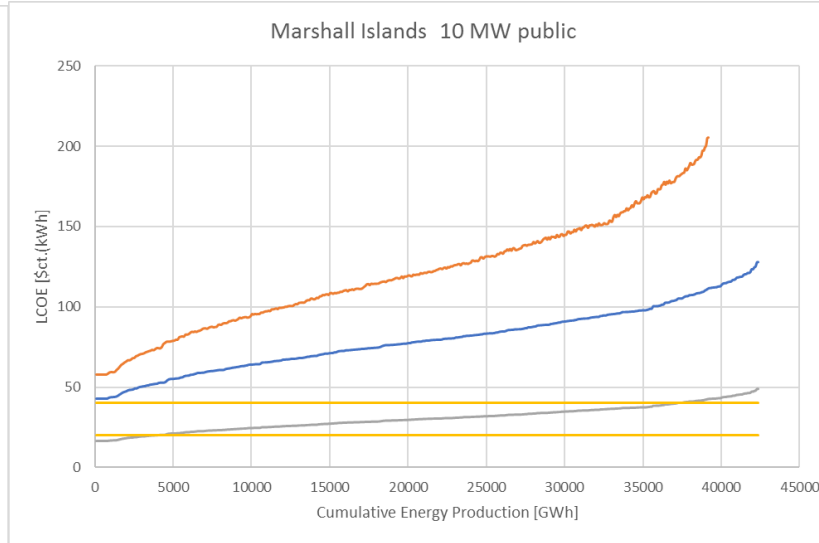
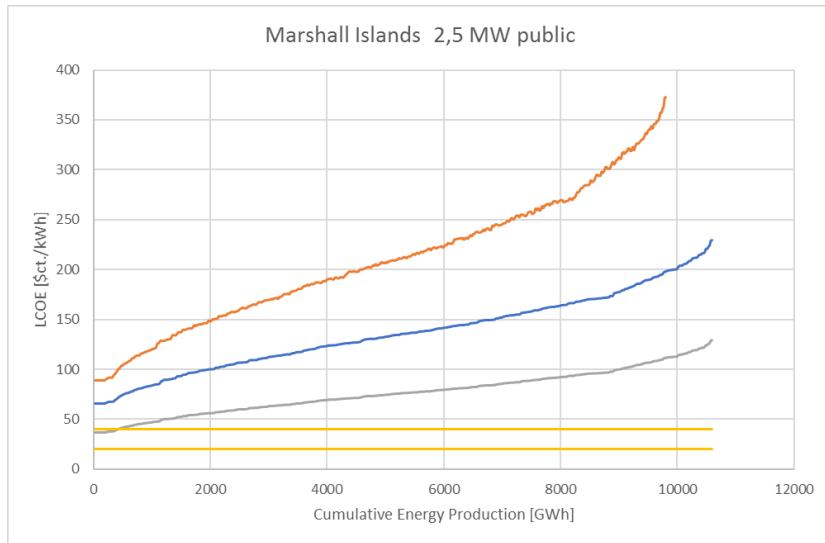
Figures G.8 Supply Curves for Publicly Funded OTEC in Madagascar (Own Illustration).

G.9. Maldives



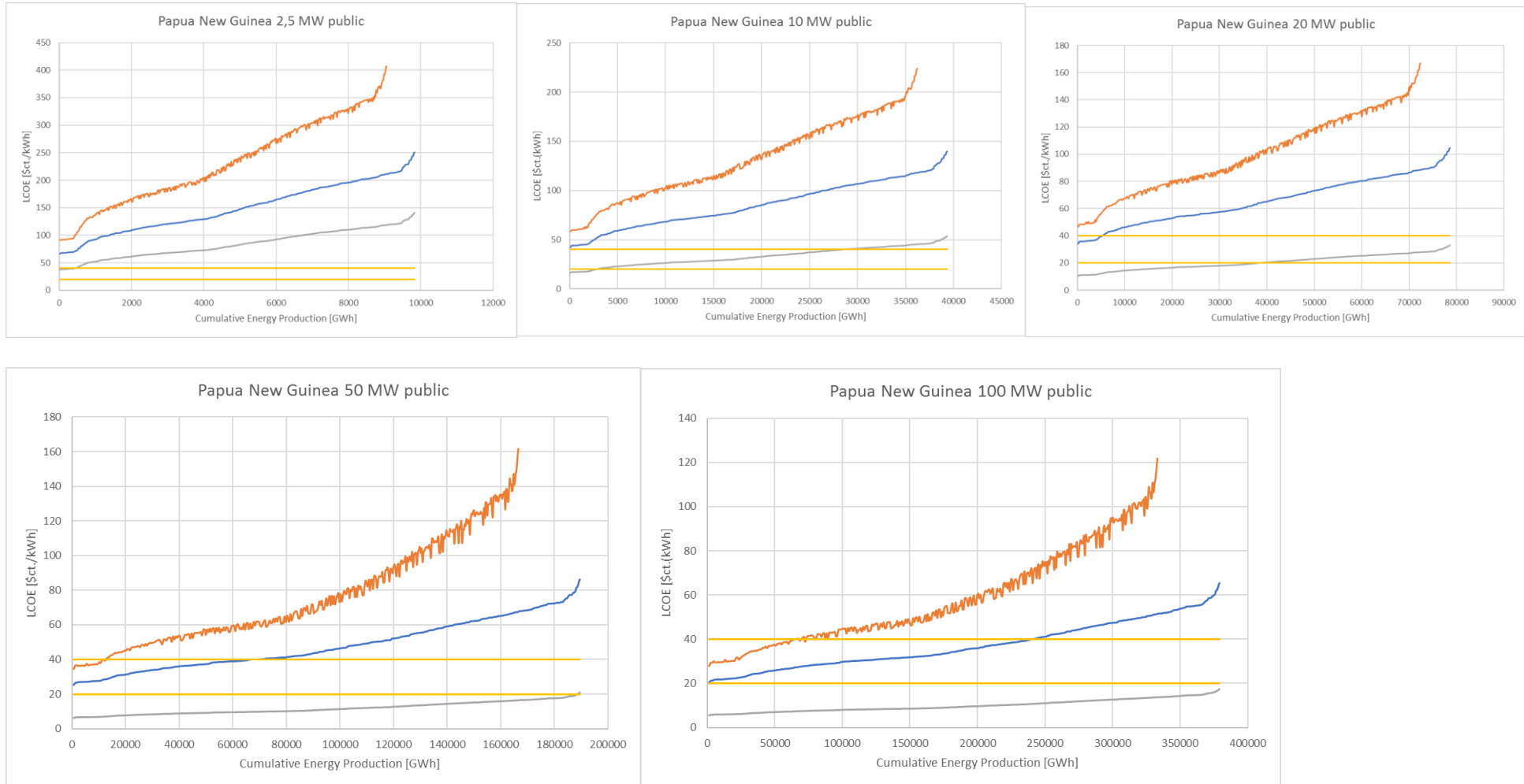
Figures G.9 Supply Curves for Publicly Funded OTEC in the Maldives (Own Illustration).

G.10. Marshall Islands



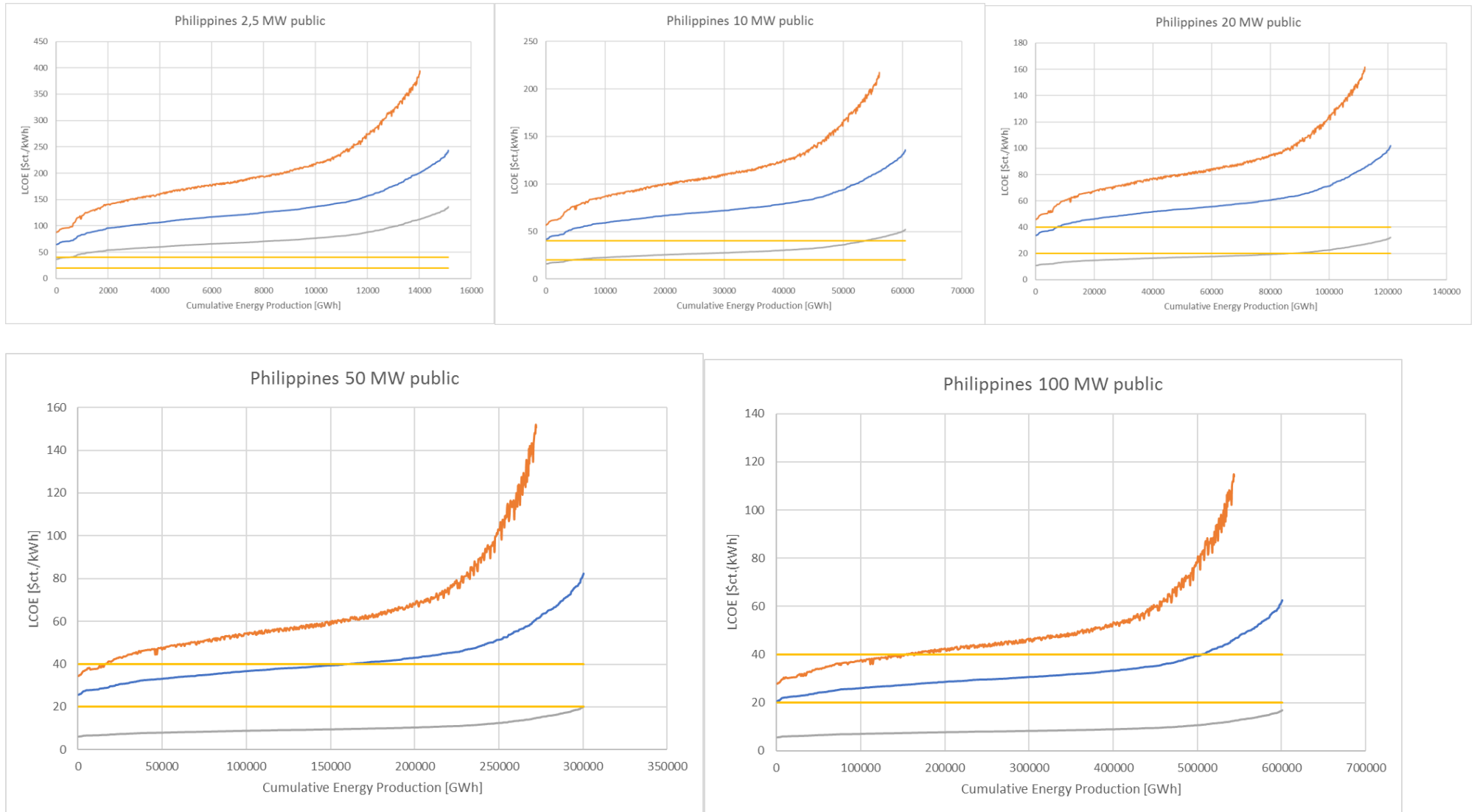
Figures G.10 Supply Curves for Publicly Funded OTEC at the Marshall Islands (Own Illustration).

G.11. Papua New Guinea



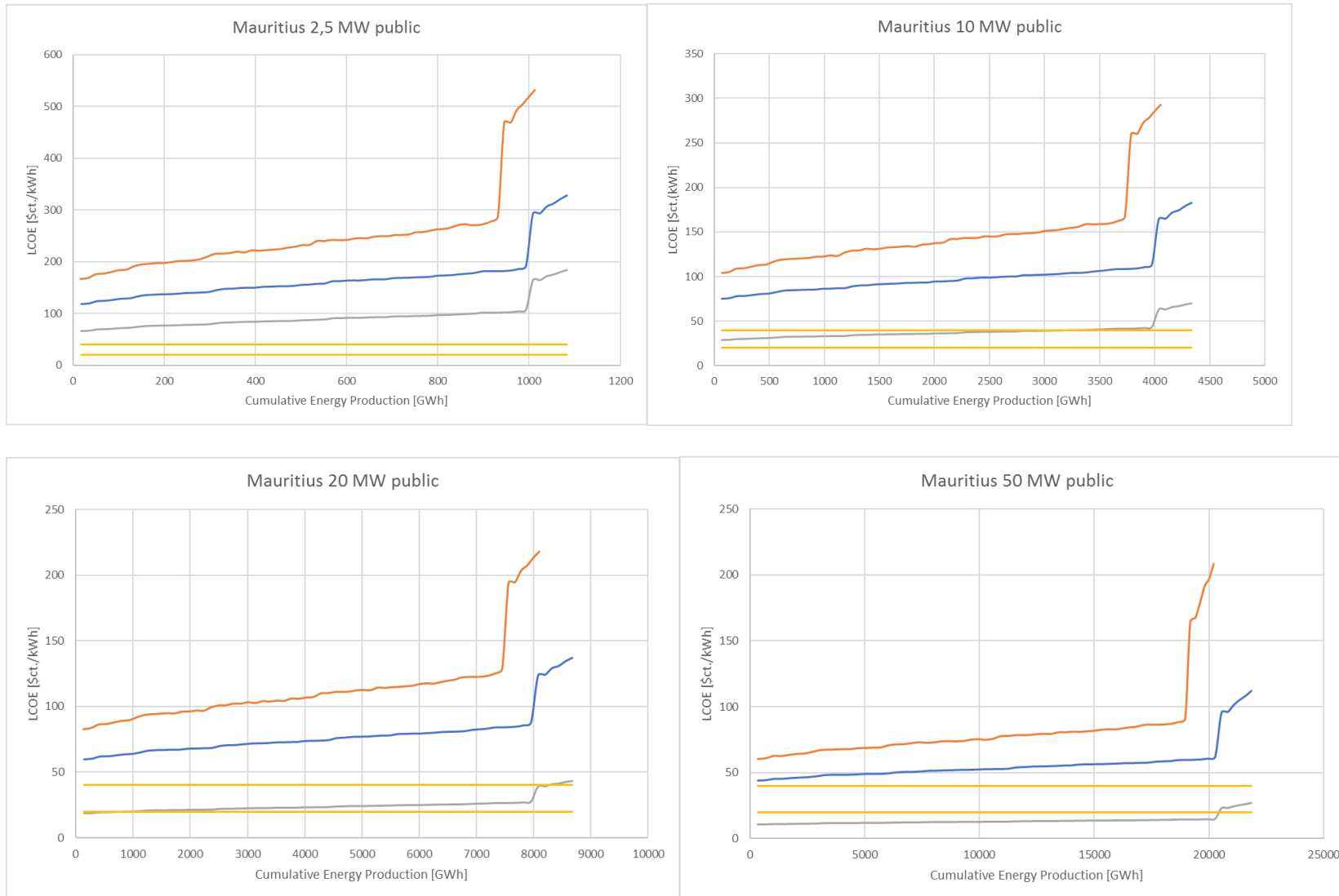
Figures G.11 Supply Curves for Publicly Funded OTEC in Papua New Guinea (Own Illustration).

G.12. Philippines



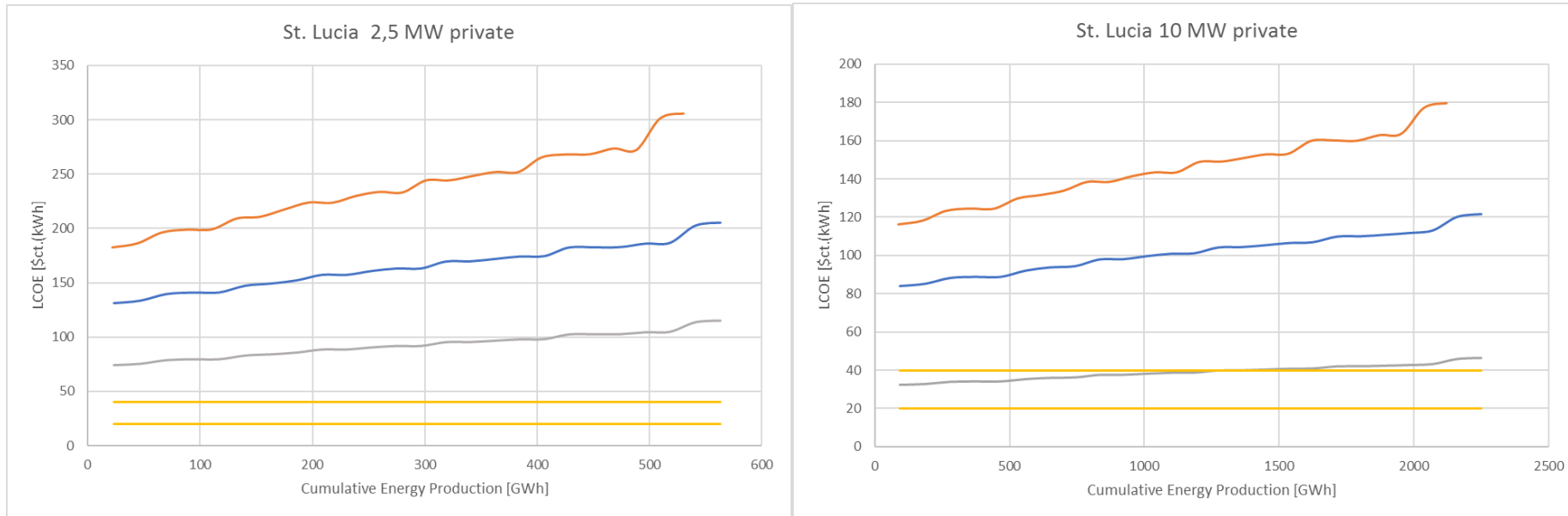
Figures G.12 Supply Curves for Publicly Funded OTEC in the Philippines (Own Illustration).

G.13. Republic of Mauritius



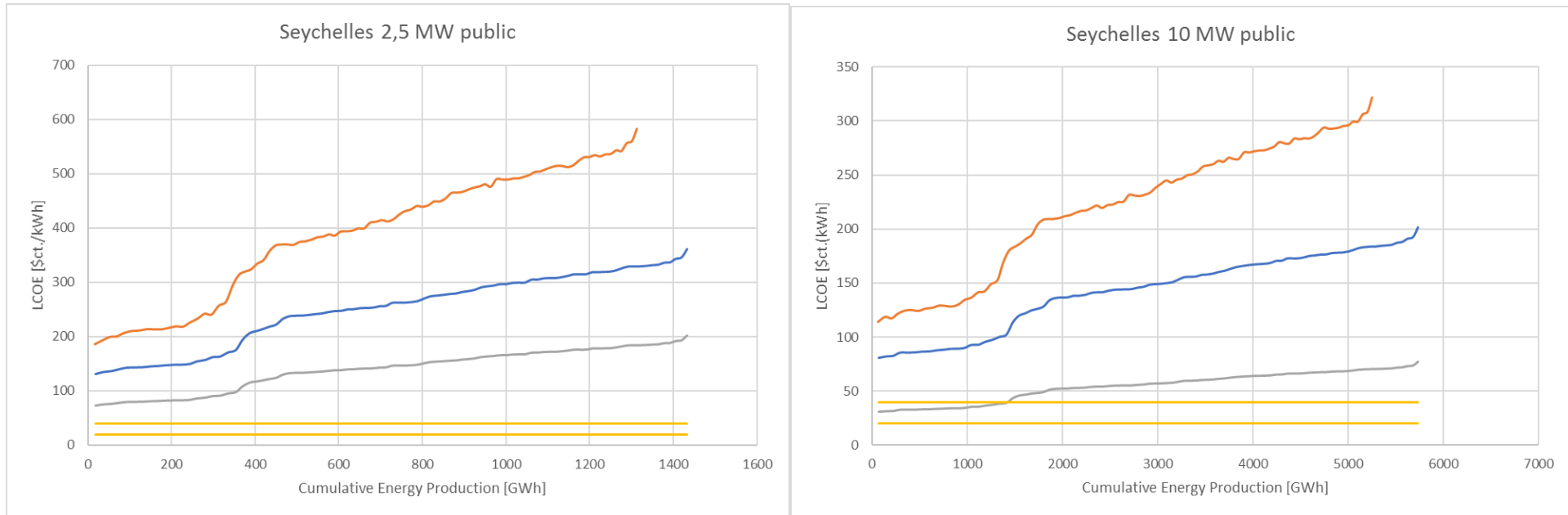
Figures G.13 Supply Curves for Publicly Funded OTEC in Mauritius (Own Illustration).

G.14. Saint Lucia



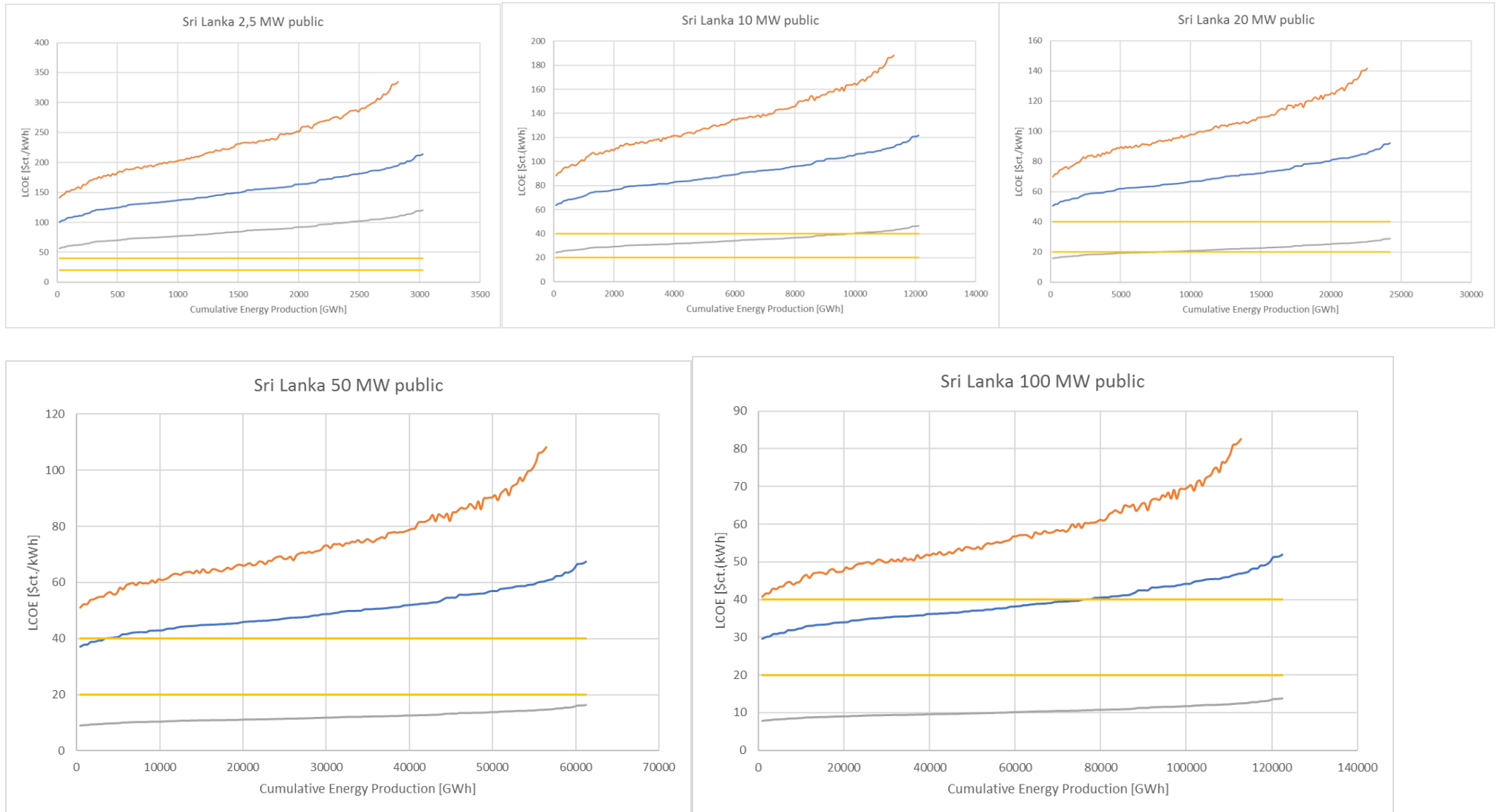
Figures G.14 Supply Curves for Publicly Funded OTEC in Saint Lucia (Own Illustration).

G.15. Seychelles



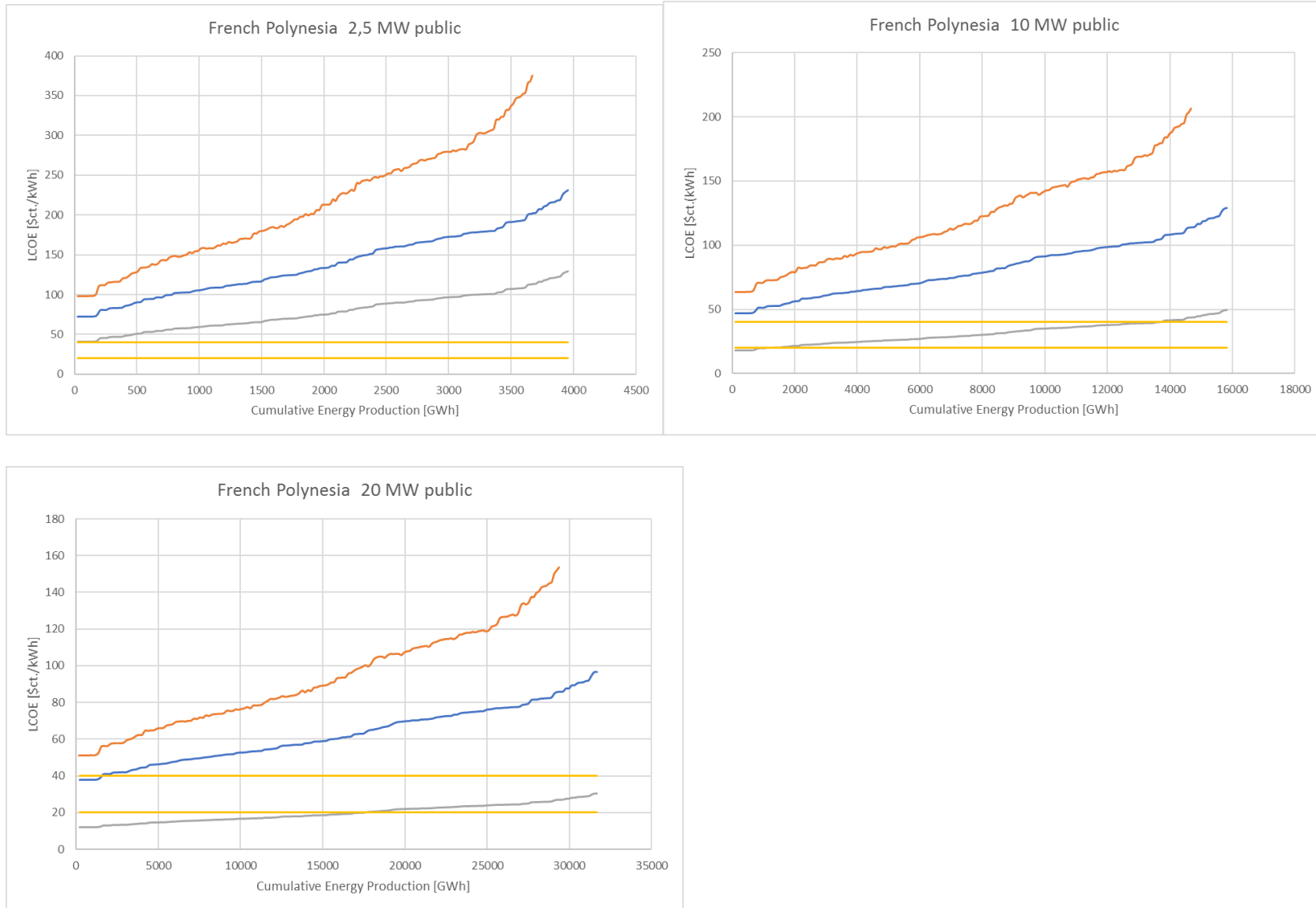
Figures G.15 Supply Curves for Publicly Funded OTEC in Seychelles (Own Illustration).

G.16. Sri Lanka



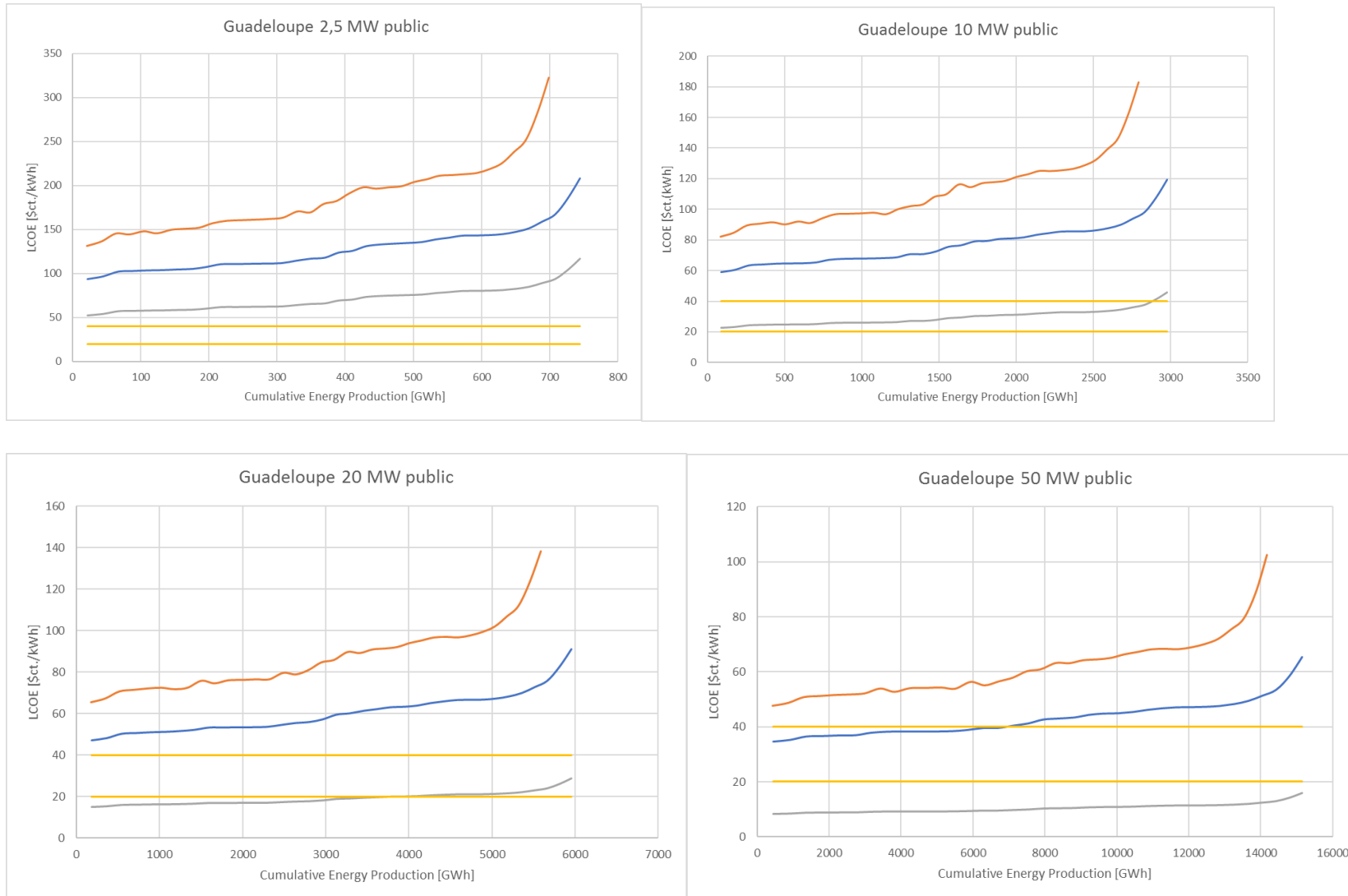
Figures G.16 Supply Curves for Publicly Funded OTEC in Sri Lanka (Own Illustration).

G.17. French Polynesia (France)



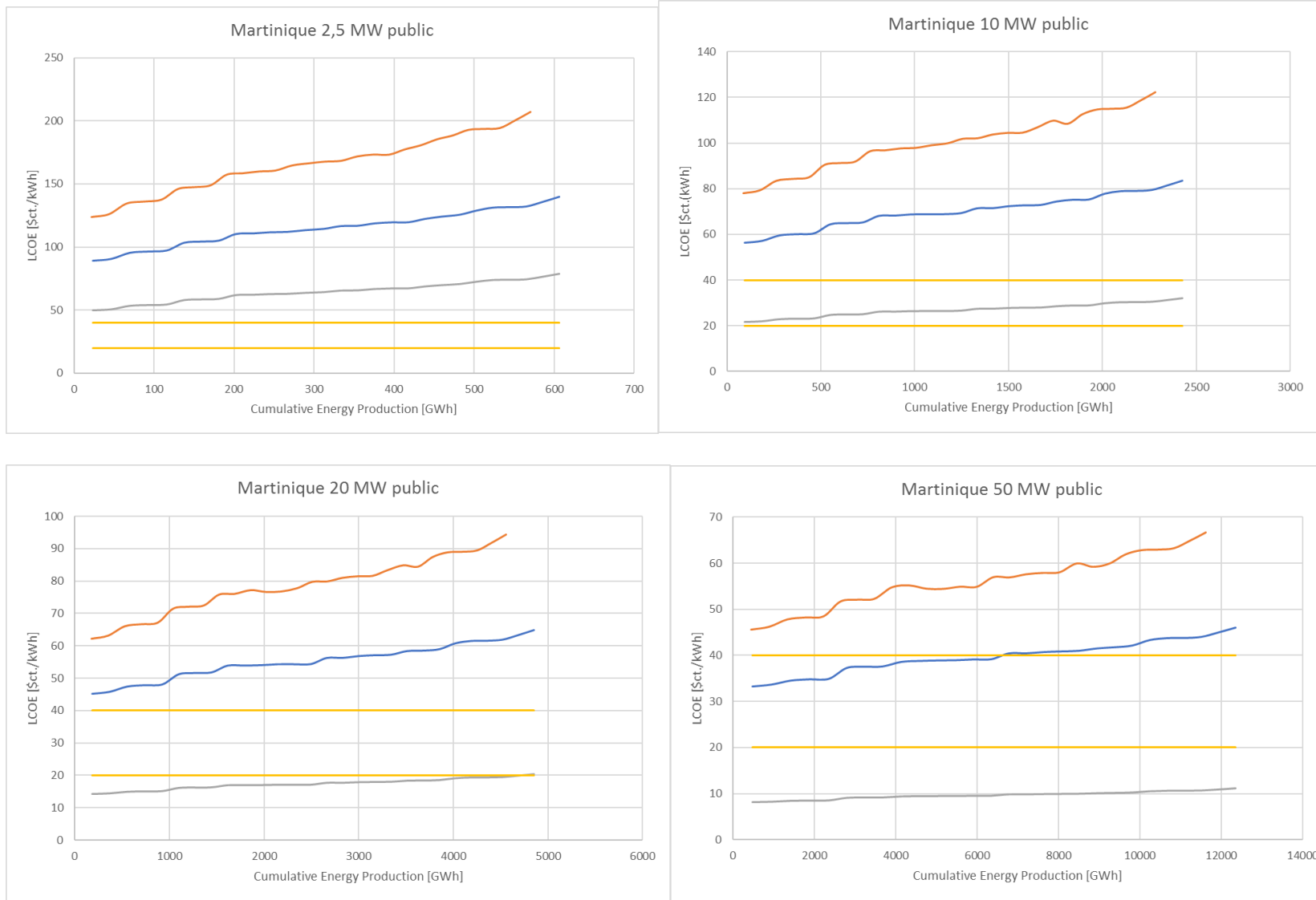
Figures G.17 Supply Curves for Publicly Funded OTEC in French Polynesia (Own Illustration).

G.18. Guadeloupe (France)



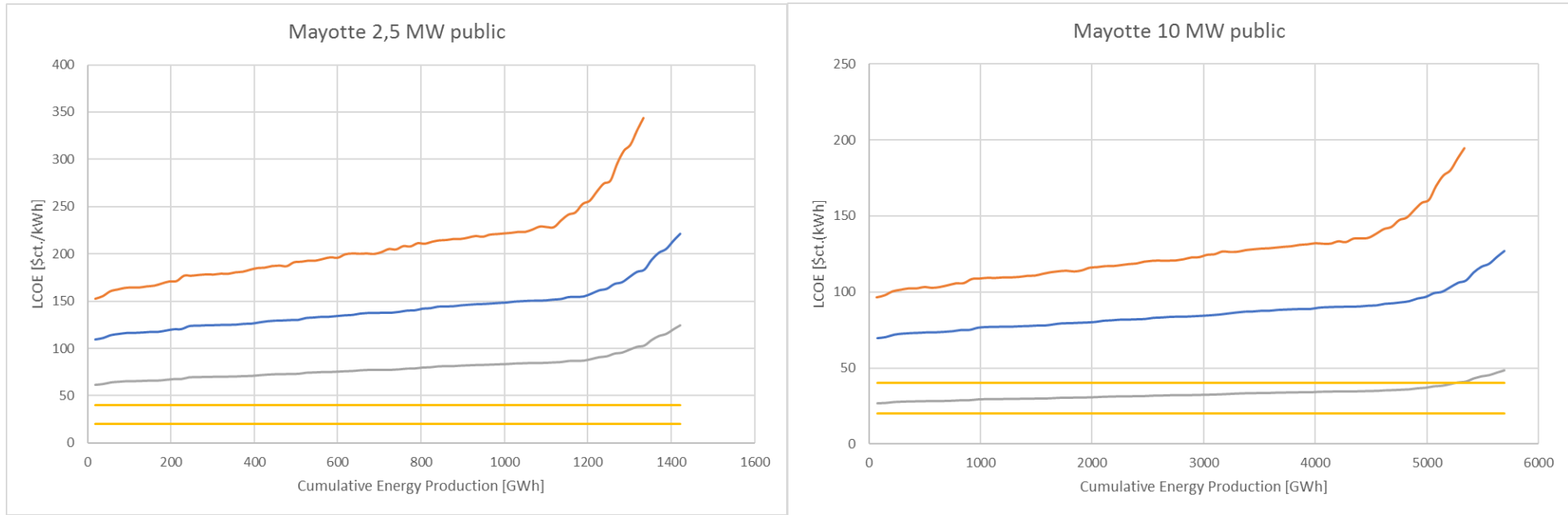
Figures G.18 Supply Curves for Publicly Funded OTEC in Guadeloupe (Own Illustration).

G.19. Martinique (France)



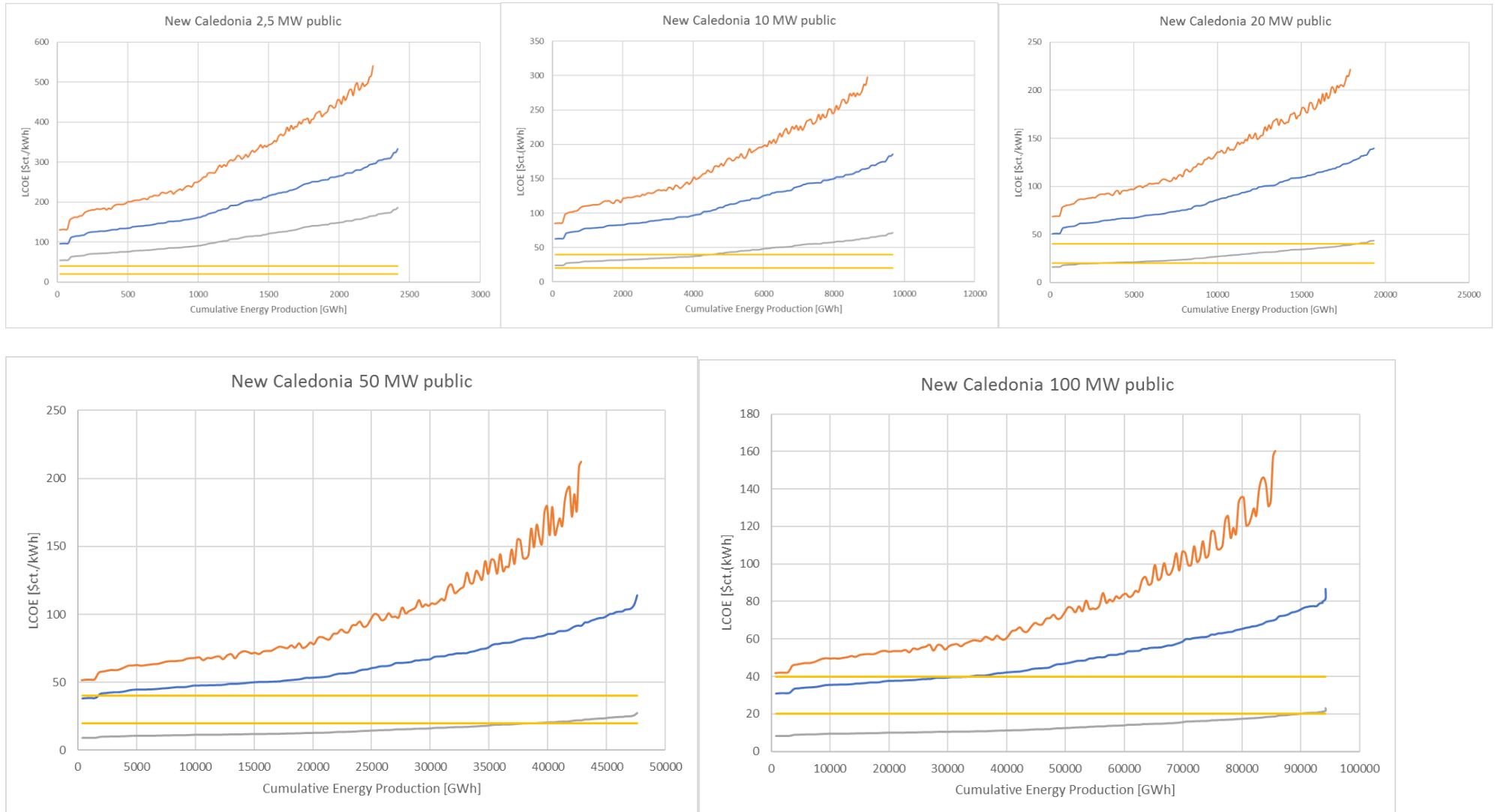
Figures G.19 Supply Curves for Publicly Funded OTEC in Martinique (Own Illustration).

G.20. Mayotte (France)



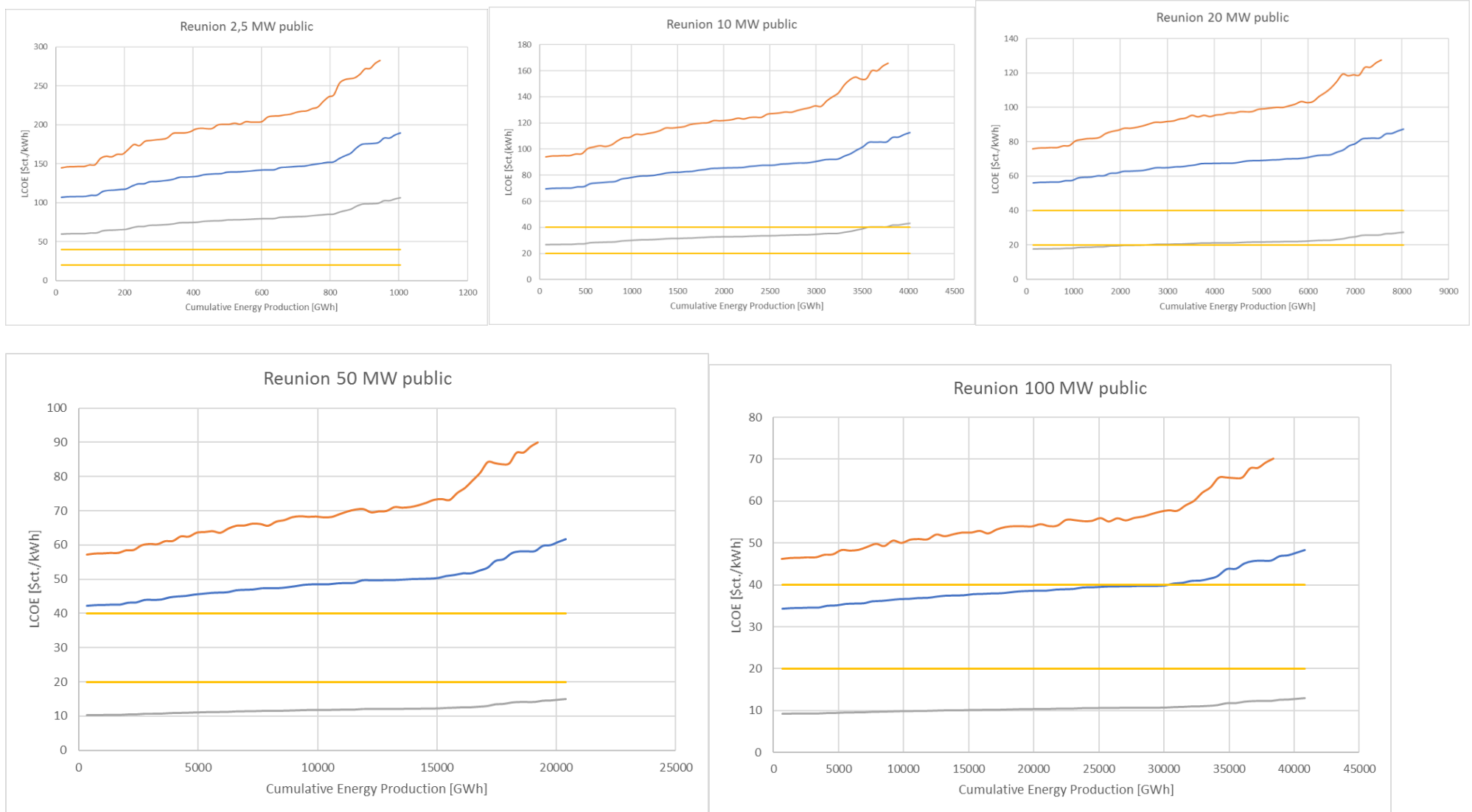
Figures G.20 Supply Curves for Publicly Funded OTEC in Mayotte (Own Illustration).

G.21. New Caledonia (France)



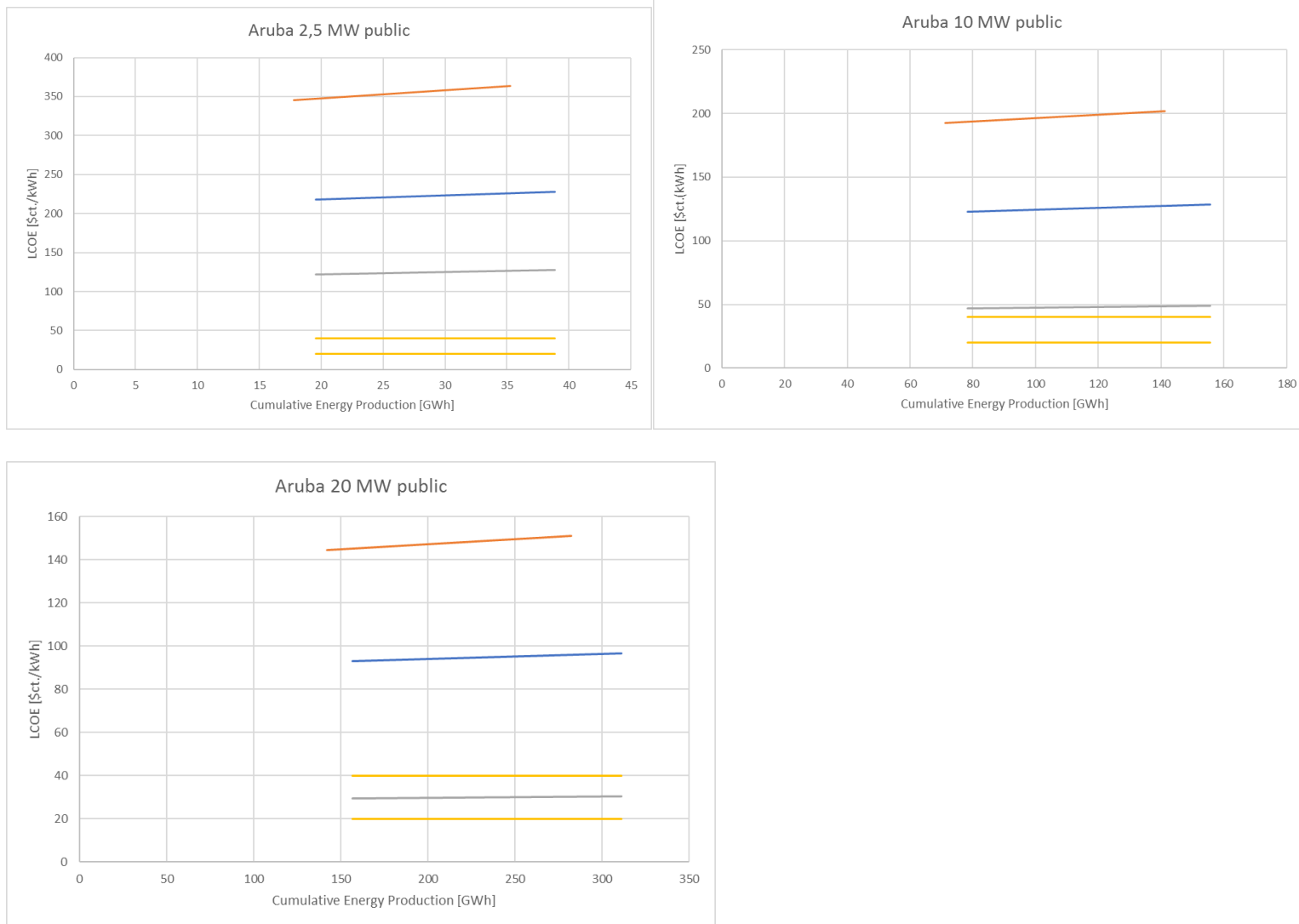
Figures G.21 Supply Curves for Publicly Funded OTEC in New Caledonia (Own Illustration).

G.22. Reunion (France)



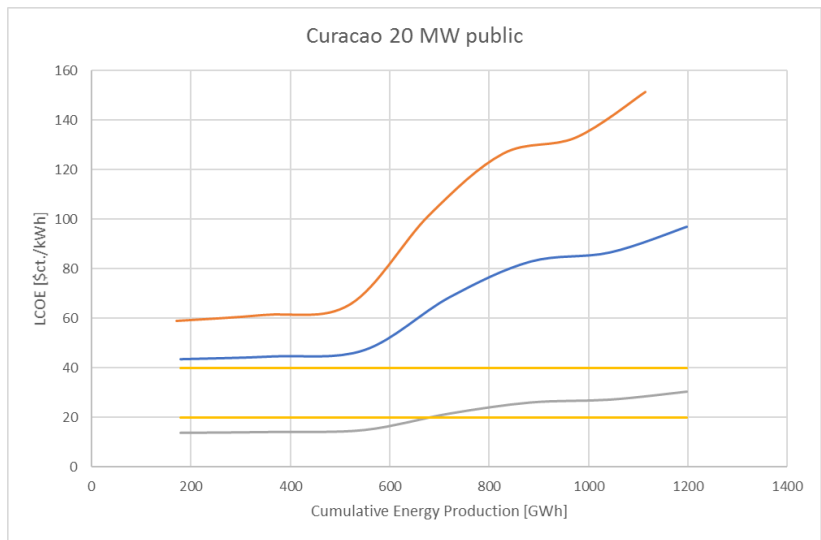
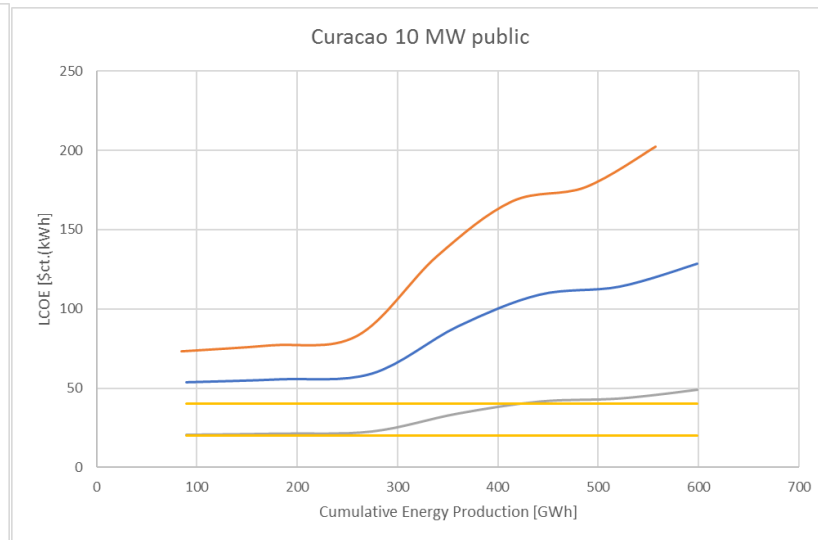
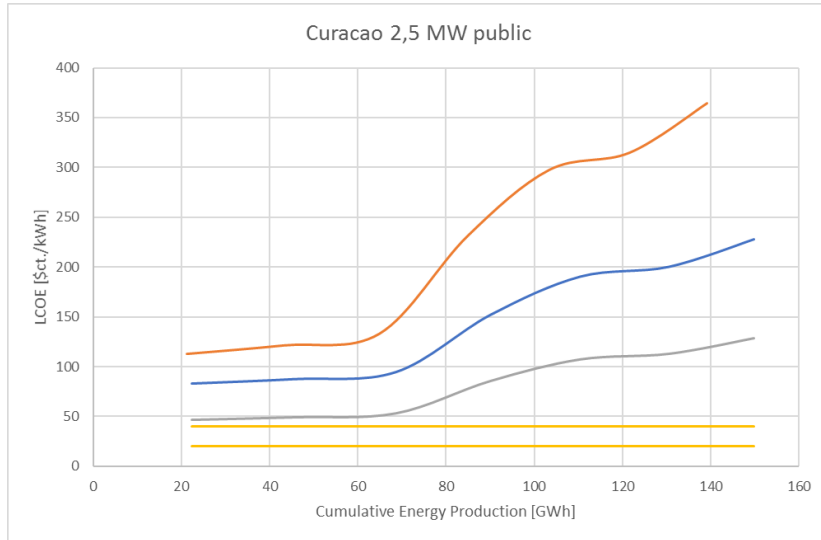
Figures G.22 Supply Curves for Publicly Funded OTEC in Reunion (Own Illustration).

G.23. Aruba (Netherlands)



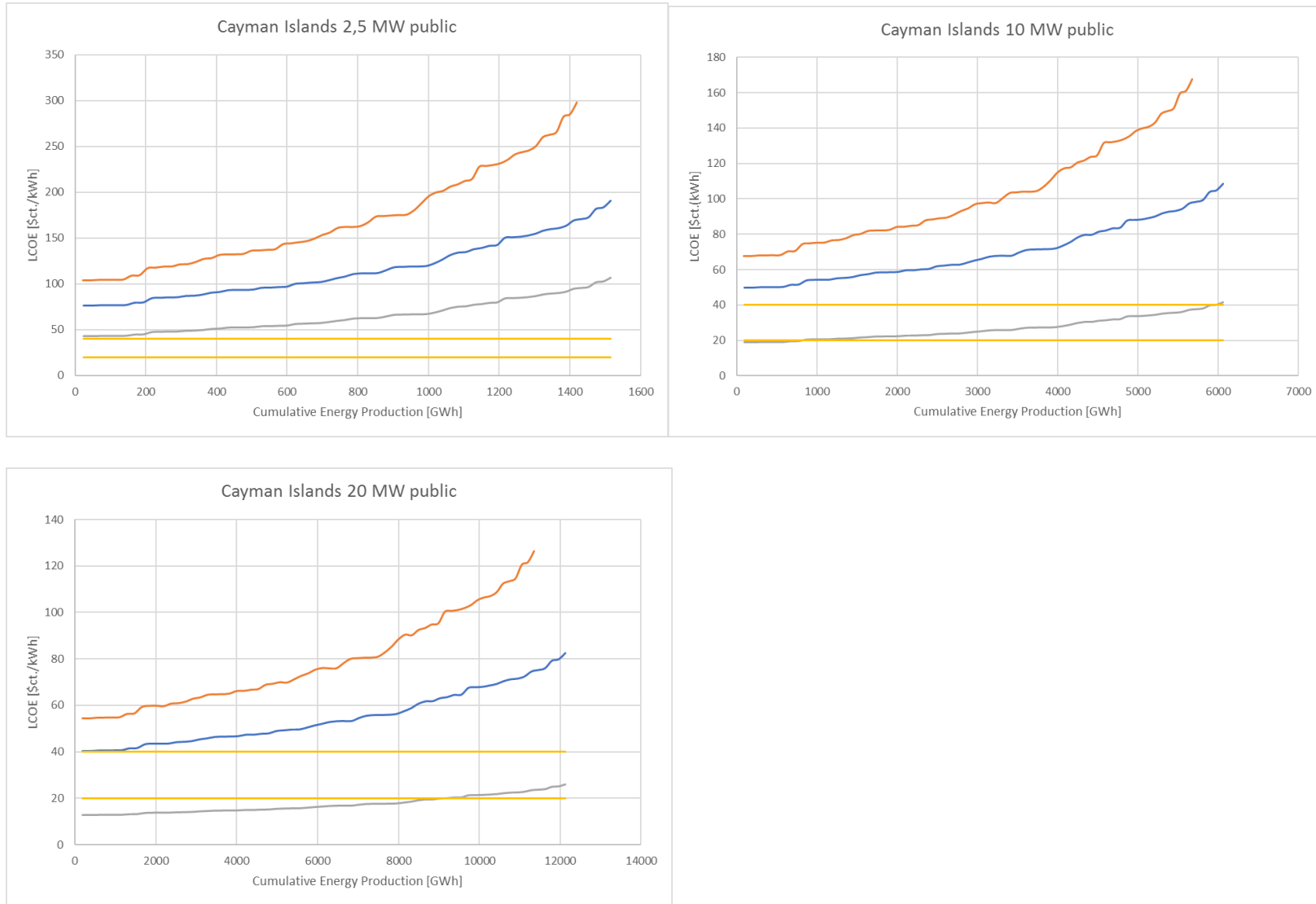
Figures G.23 Supply Curves for Publicly Funded OTEC in Aruba (Own Illustration).

G.24. Curaçao (Netherlands)



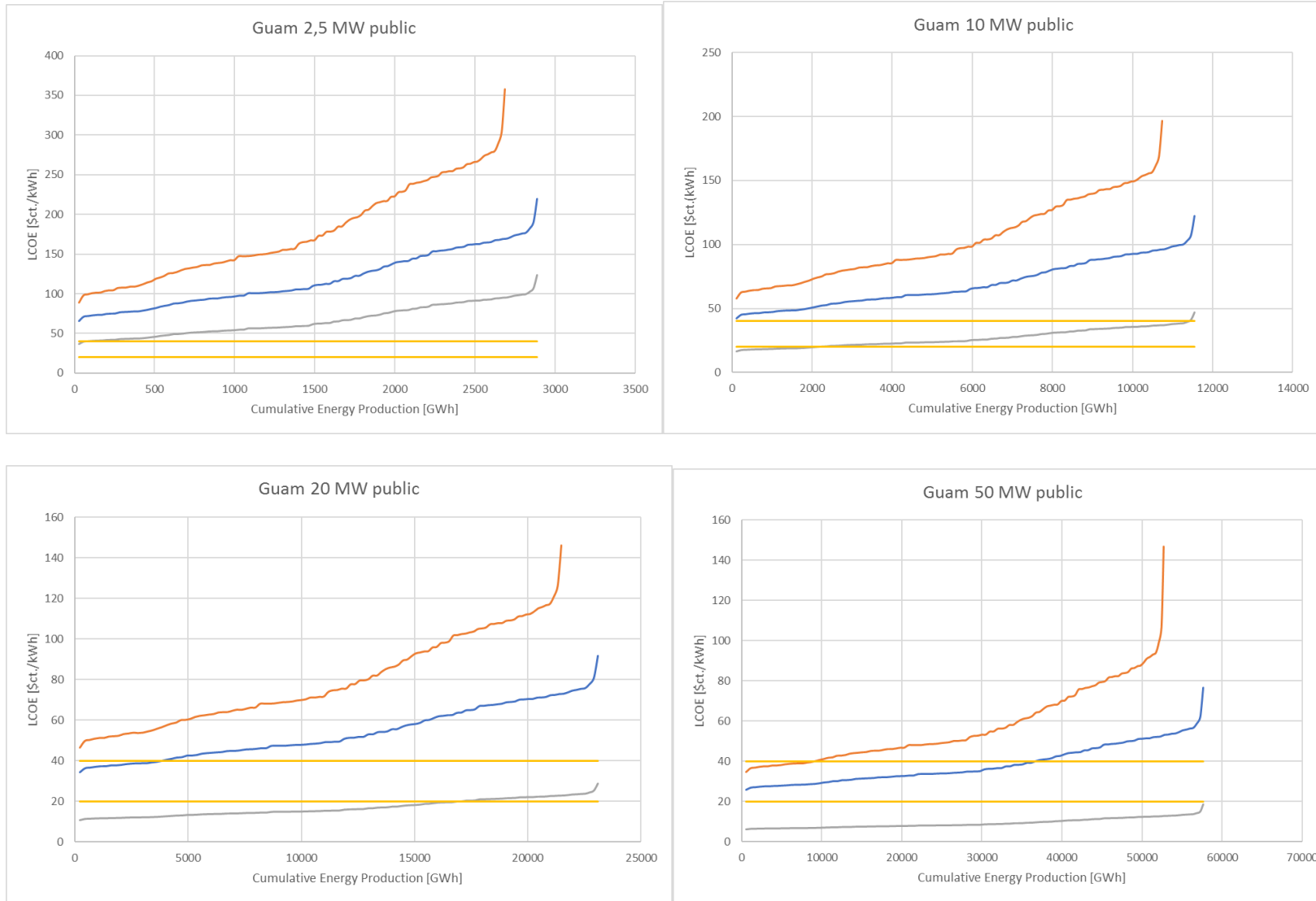
Figures G.24 Supply Curves for Publicly Funded OTEC in Curaçao (Own Illustration).

G.25. Cayman Islands (United Kingdom)



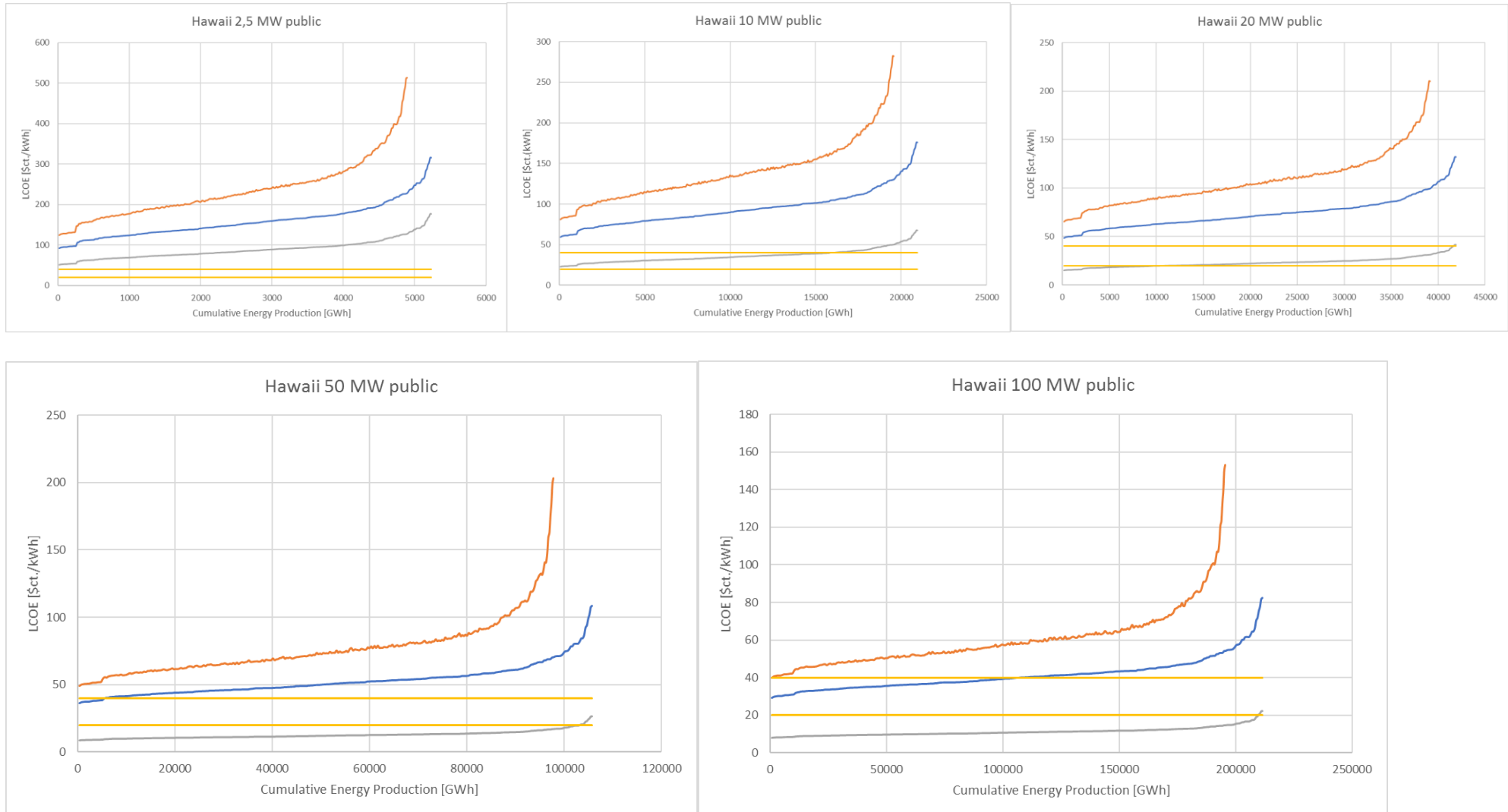
Figures G.25 Supply Curves for Publicly Funded OTEC at Cayman Islands (Own Illustration).

G.26. Guam (United States of America)



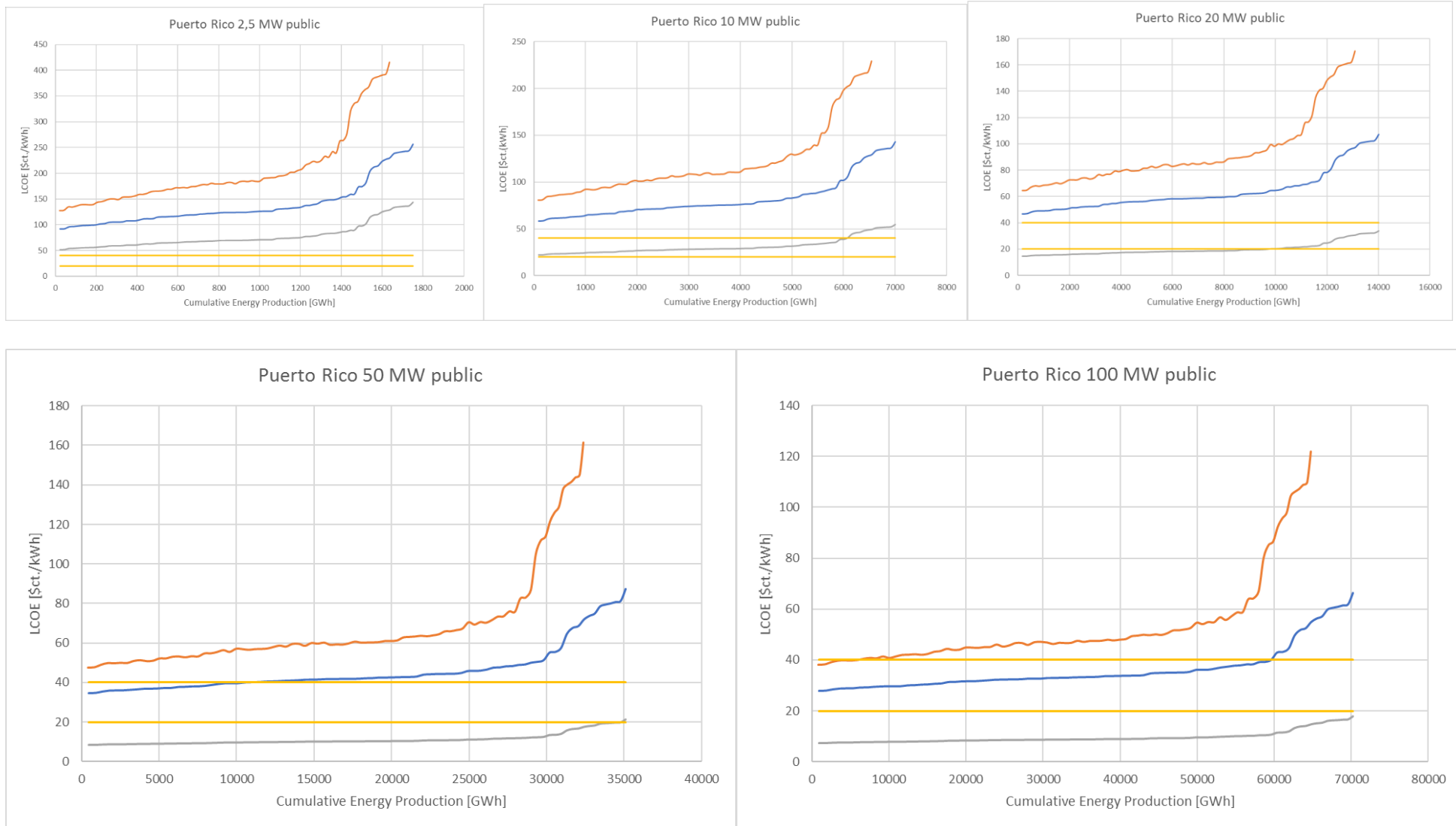
Figures G.26 Supply Curves for Publicly Funded OTEC in Guam (Own Illustration).

G.27. Hawaii (United States of America)



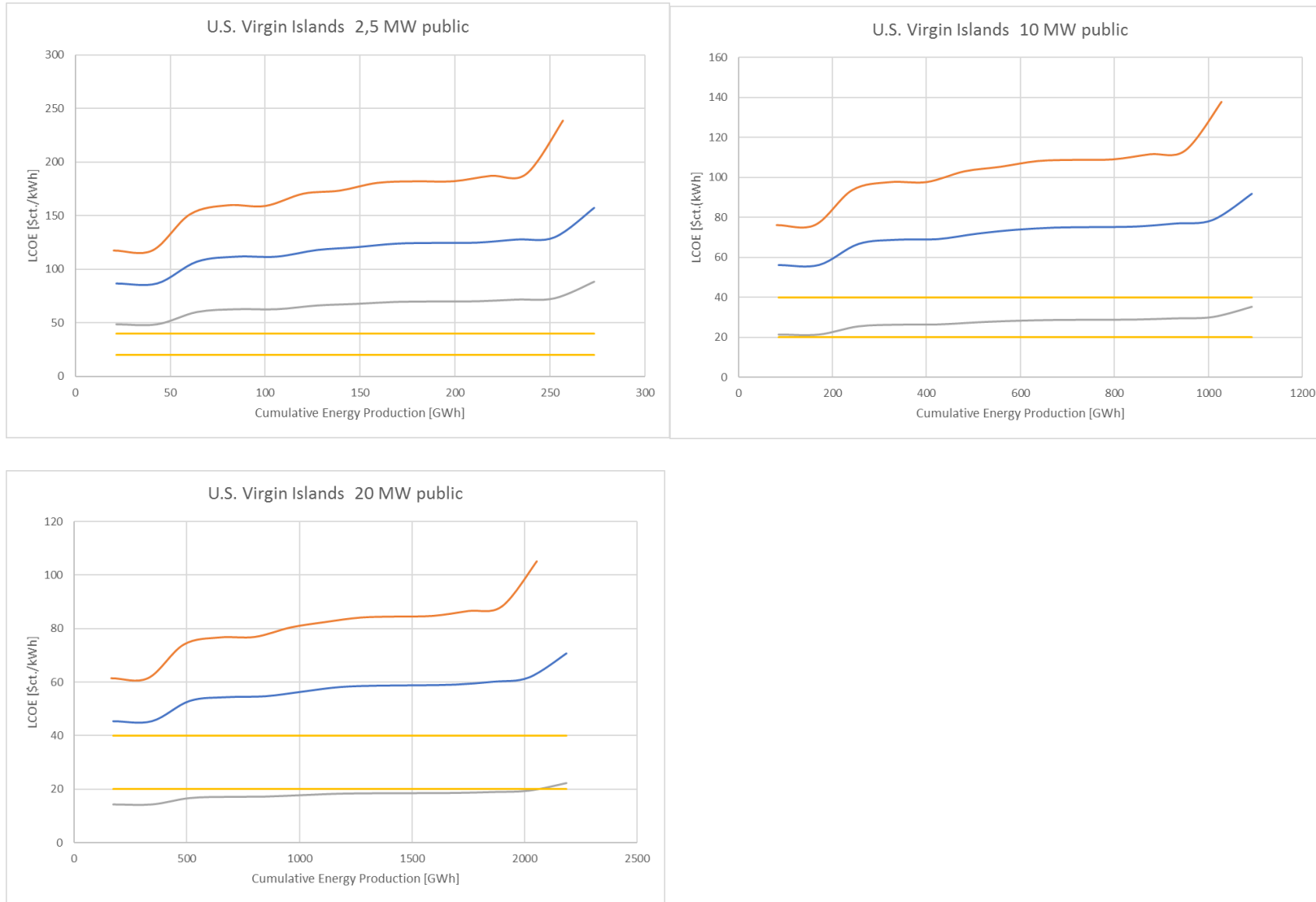
Figures G.27 Supply Curves for Publicly Funded OTEC in Hawaii (Own Illustration).

G.28. Puerto Rico (United States of America)



Figures G.28 Supply Curves for Publicly Funded OTEC in Puerto Rico (Own Illustration).

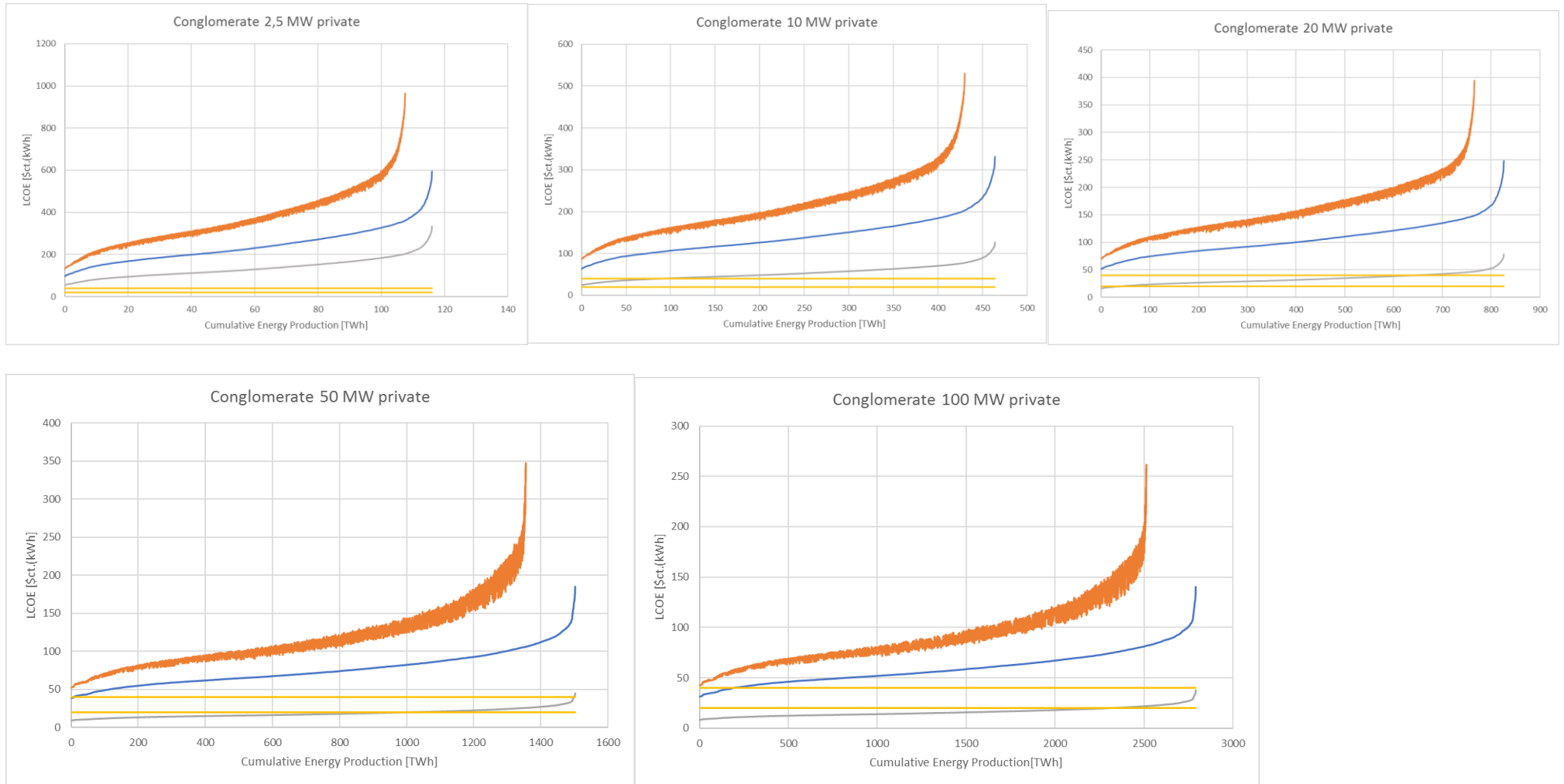
G.29. United States Virgin Islands (United States of America)



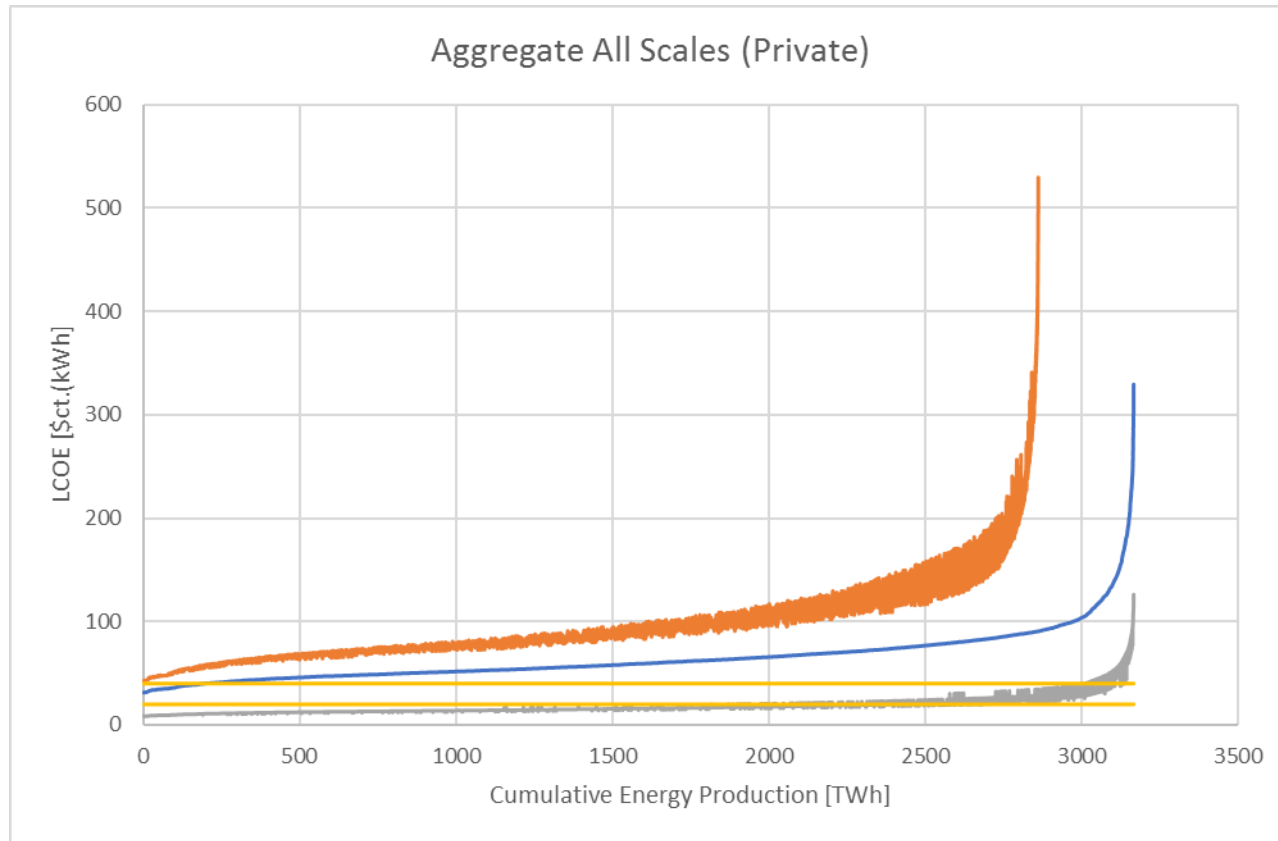
Figures G.29 Supply Curves for Publicly Funded OTEC at U.S. Virgin Islands (Own Illustration).

H. Aggregate Supply Curves of 29 Tropical Islands

H.1. Privately Funded (Discount Rate 18%)

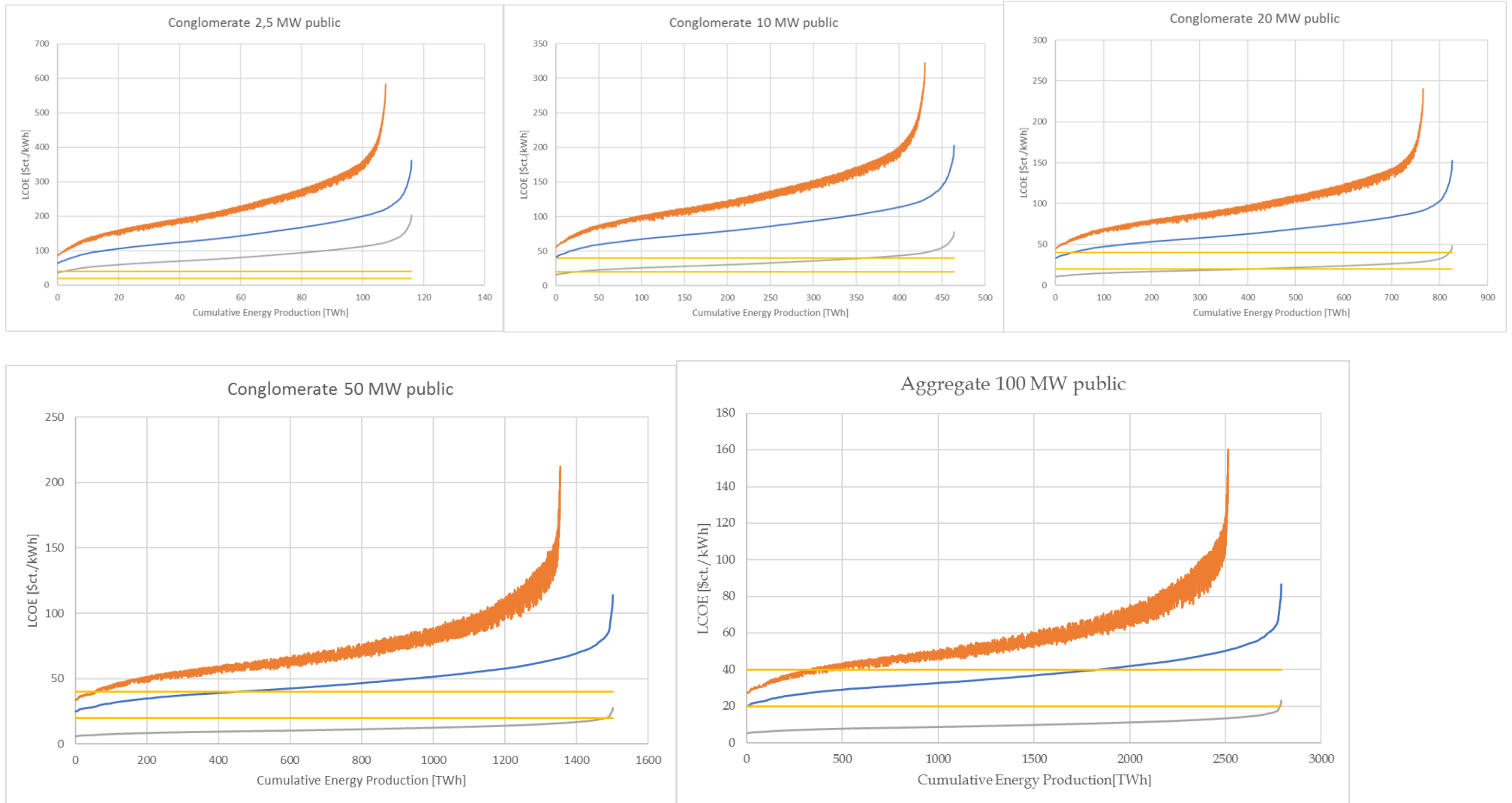


Figures H.1 Aggregate Supply Curves for Privately Funded OTEC (Own Illustration).



Figures H.2 Aggregate Supply Curve for all Five Scales, Privately Funded (Own Illustration).

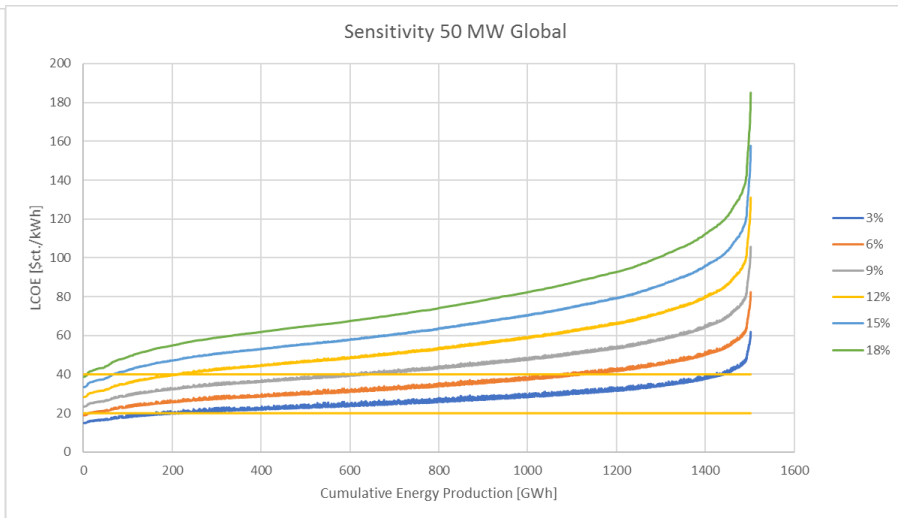
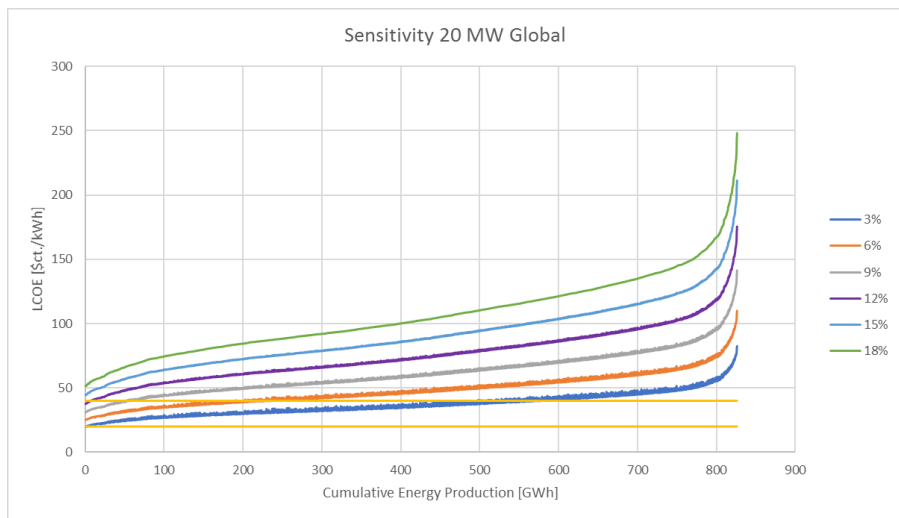
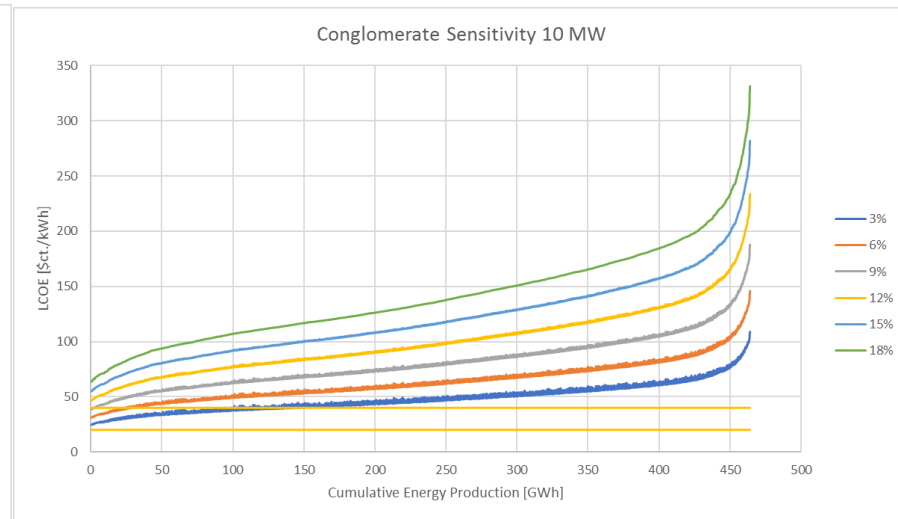
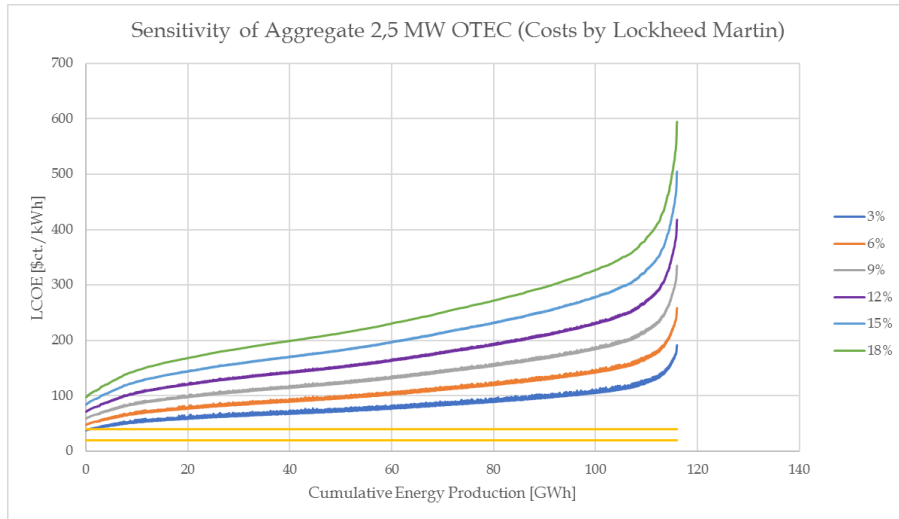
H.2. Publicly Funded (Discount Rate 10%)

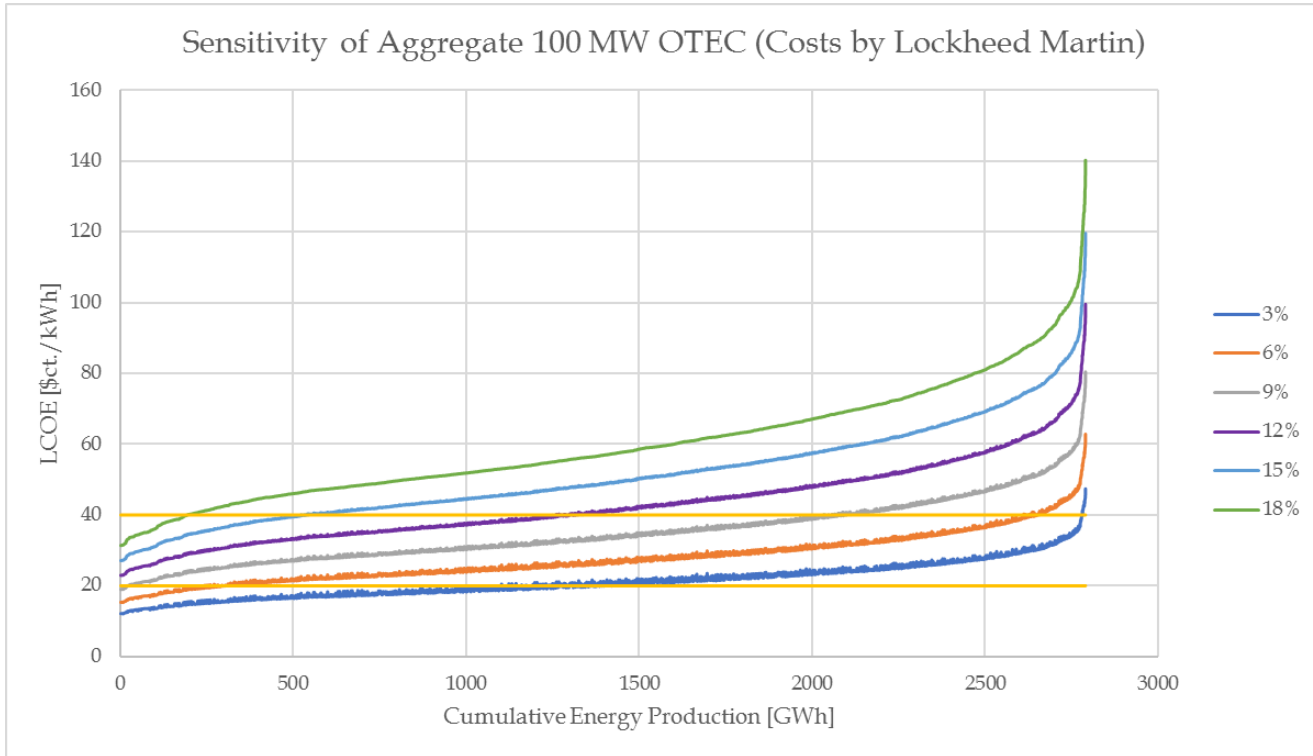


Figures H.3 Aggregate Supply Curves for Publicly Funded OTEC (Own Illustration).

I. Sensitivity Analysis

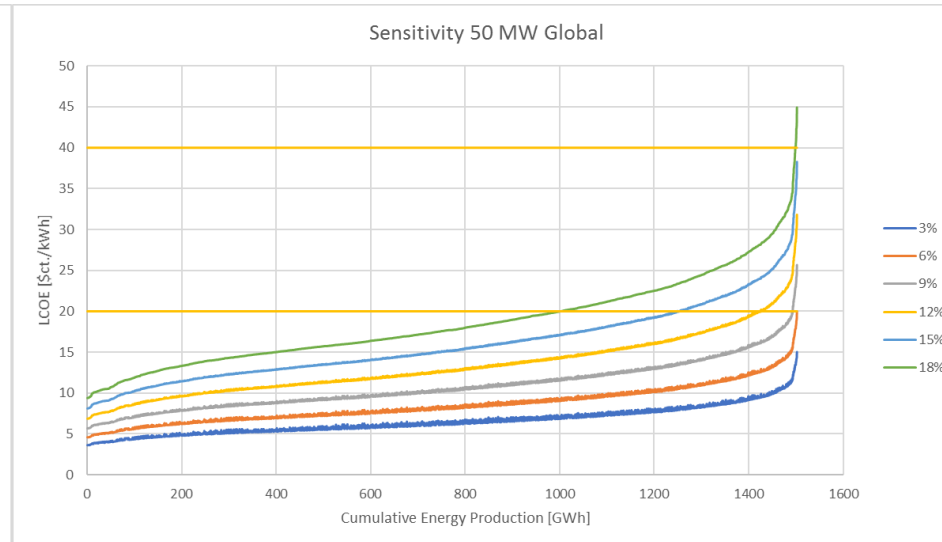
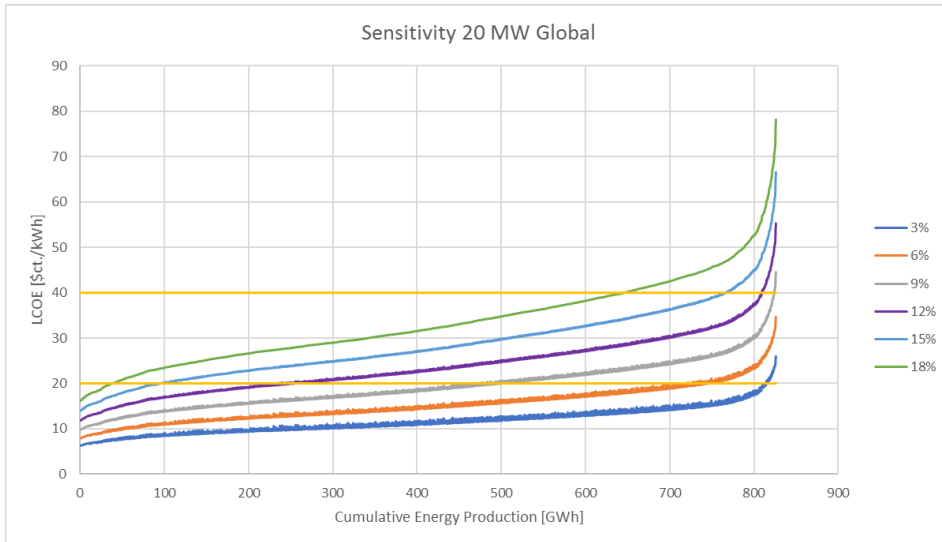
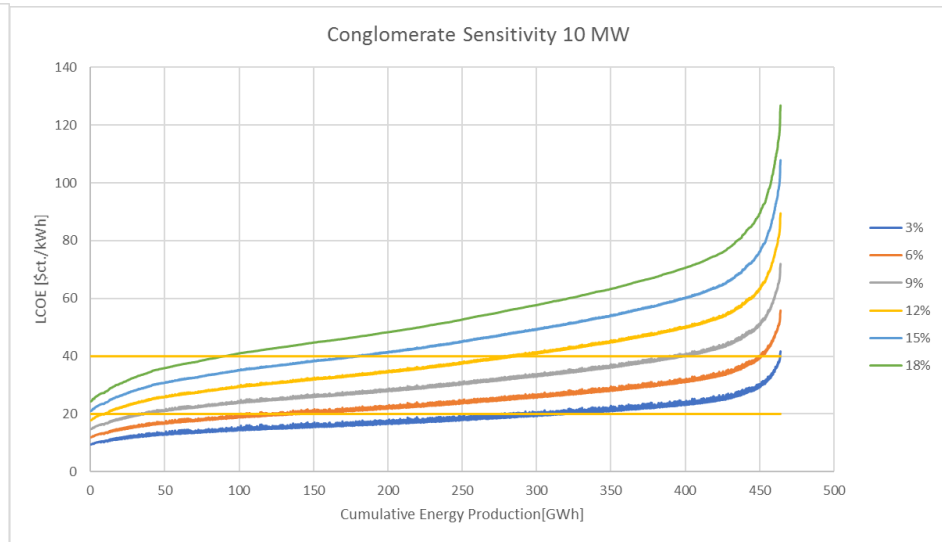
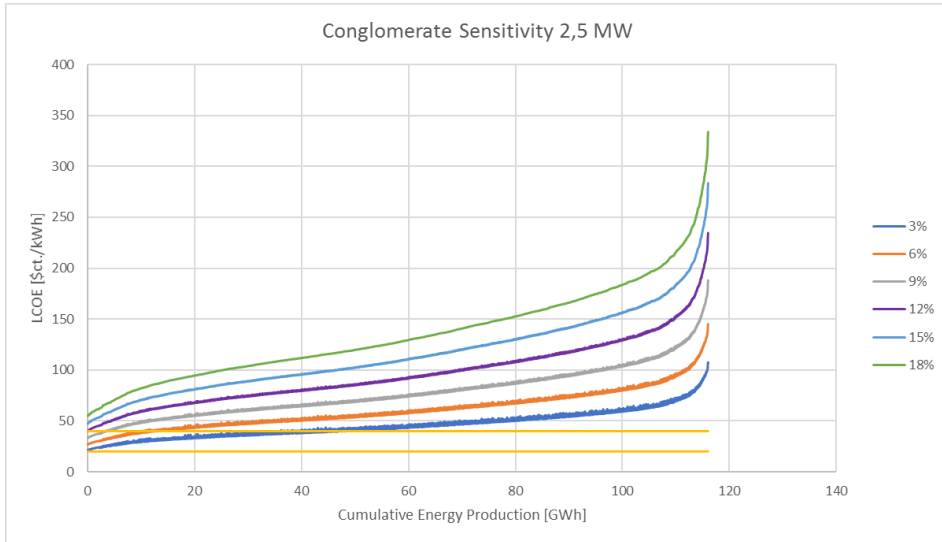
I.1. Costs by Lockheed Martin

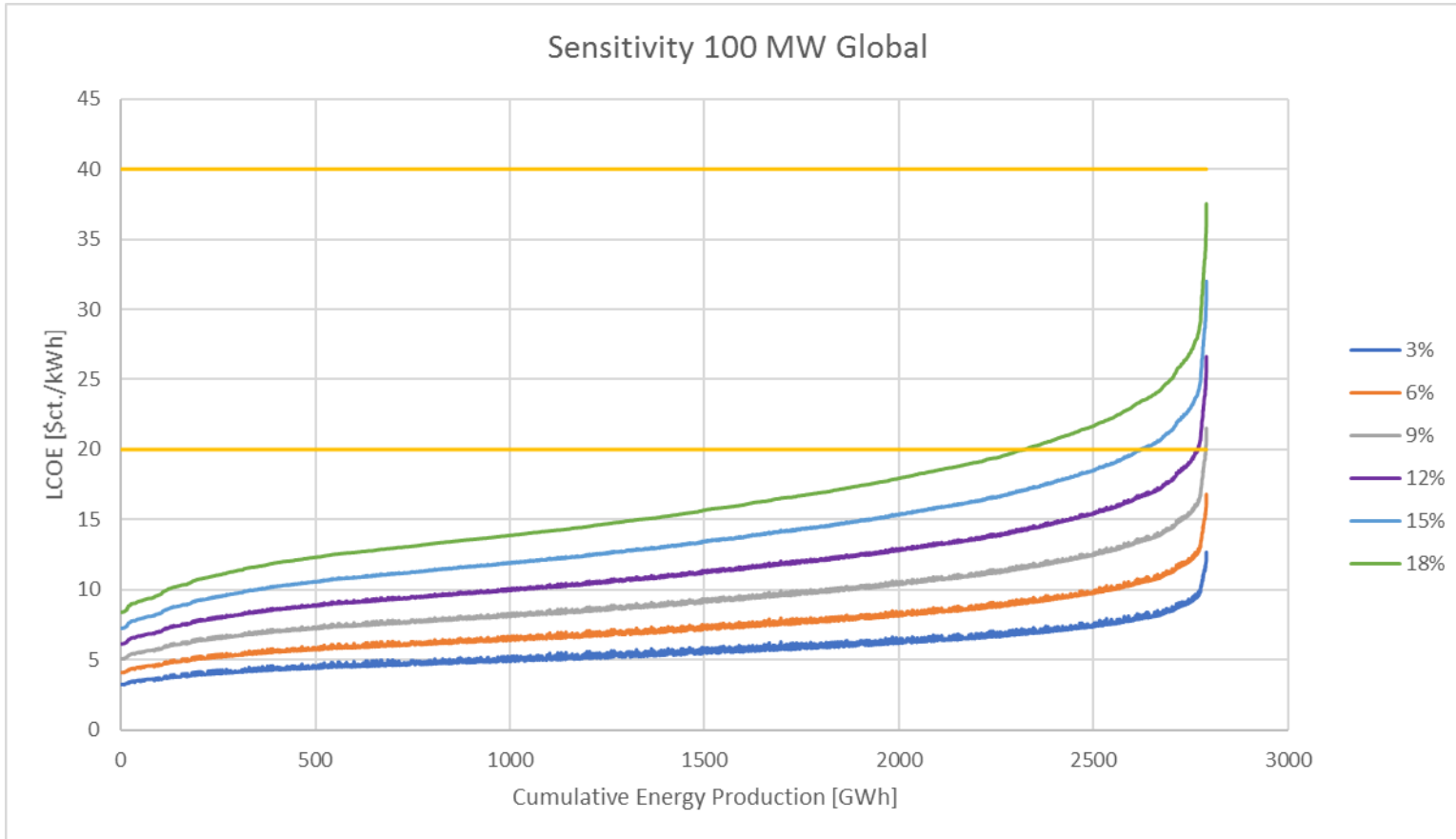




Figures I.1 Sensitivity of Supply Curves Based on Costs by Lockheed Martin (Own Illustration).

I.2. Costs by Academia and Other OTEC Companies





Figures I.2 Sensitivity of Supply Curves Based on Costs by Academia and Other OTEC Companies (Own Illustration).

J. List of Remaining Countries Suitable for OTEC

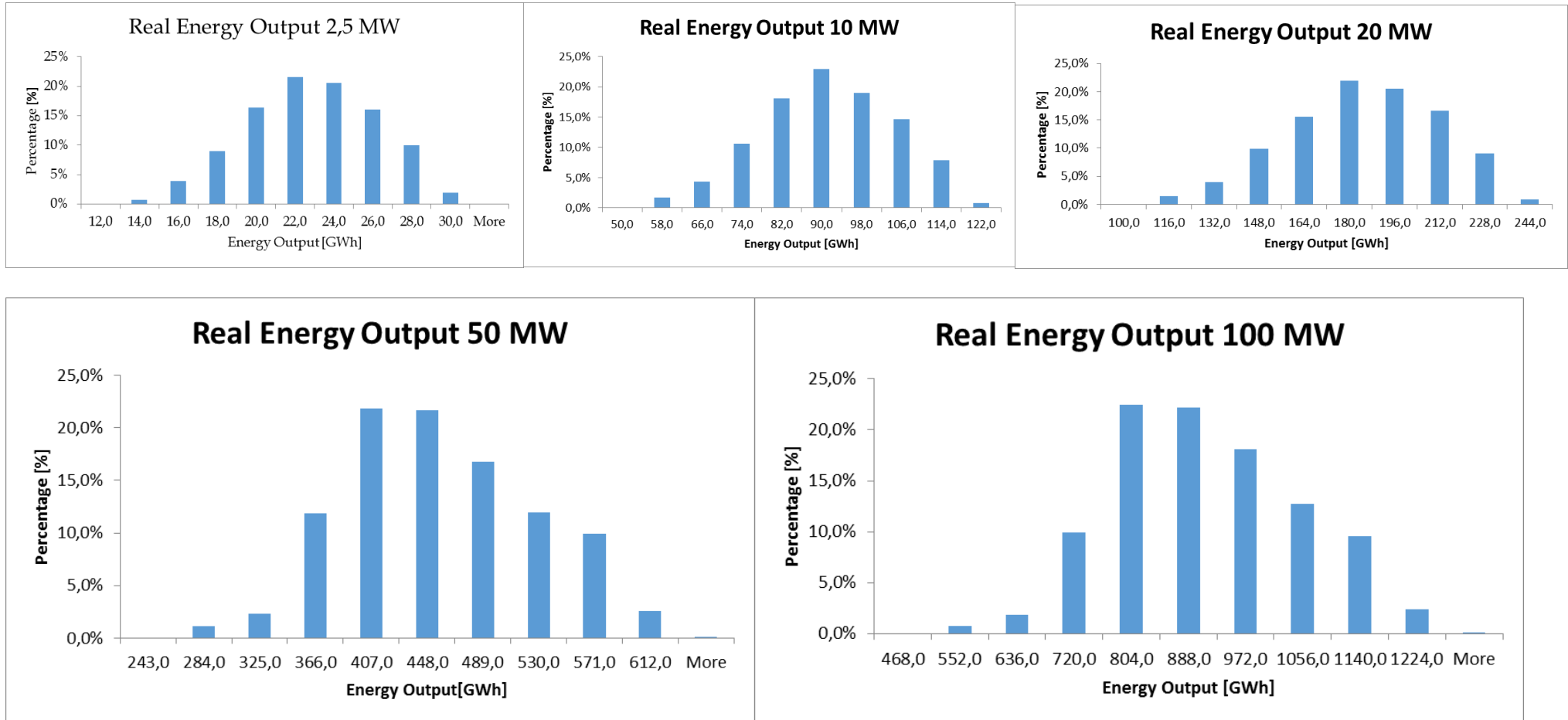
| Country | Electricity Consumption [TJ] | Practicable OTEC Potential [GWh] | OTEC Demand [GWh] | Largest Possible OTEC [MW] |
|---------------------|------------------------------|----------------------------------|-------------------|----------------------------|
| Antigua and Barbuda | 900 | 90908 | 30,82191781 | 2,5 |
| Australia | 760745 | 826310 | 26052,91096 | 100 |
| Bahamas | 7250 | 578829 | 248,2876712 | 20 |
| Belize | 2120 | 79947 | 72,60273973 | 2,5 |
| Benin | 3978 | 12169 | 136,2328767 | 10 |
| Brazil | 1773673 | 1366599 | 60742,22603 | 100 |
| Brunei | 12208 | 14023 | 418,0821918 | 50 |
| China | 1739052 | 12331 | 59556,57534 | 100 |
| Colombia | 184151 | 91150 | 6306,541096 | 100 |
| Comoros | 113 | 307056 | 3,869863014 | x |
| Costa Rica | 33942 | 65844 | 1162,39726 | 100 |
| Dominica | 342 | 41102 | 11,71232877 | x |
| East Timor | 915 | 153689 | 31,33561644 | 2,5 |
| El Salvador | 20642 | 18375 | 706,9178082 | 50 |
| Equatorial Guinea | 2531 | 81 | 86,67808219 | 10 |
| Ghana | 34862 | 4110 | 1193,90411 | 100 |
| Grenada | 663 | 57382 | 22,70547945 | 2,5 |
| Guatemala | 34079 | 81 | 1167,089041 | 100 |
| Guyana | 2844 | 65038 | 97,39726027 | 10 |
| Honduras | 28130 | 113715 | 963,3561644 | 100 |
| India | 3704688 | 1066716 | 126872,8767 | 100 |
| Ivory Coast | 21650 | 4110 | 741,4383562 | 50 |
| Japan | 3417242 | 736369 | 117028,8356 | 100 |
| Kenya | 27834 | 94615 | 953,2191781 | 100 |
| Kiribati | 71 | 414243 | 2,431506849 | x |
| Liberia | 954 | 57382 | 32,67123288 | 2,5 |
| Malaysia | 475916 | 25578 | 16298,49315 | 100 |
| Mexico | 926820 | 490322 | 31740,41096 | 100 |
| Micronesia | 186 | 2458943 | 6,369863014 | x |
| Mozambique | 43847 | 596220 | 1501,609589 | 100 |
| Myanmar | 48229 | 47710 | 1651,678082 | 100 |
| Nauru | 83 | 361455 | 2,842465753 | x |
| New Zealand | 140882 | 384182 | 4824,726027 | 100 |
| Nicaragua | 12226 | 80028 | 418,6986301 | 50 |

| Country | Electricity Consumption [TJ] | Practicable OTEC Potential [GWh] | OTEC Demand [GWh] | Largest Possible OTEC [MW] |
|---------------------------|------------------------------|----------------------------------|-------------------|----------------------------|
| Nigeria | 90320 | 1854 | 3093,150685 | 100 |
| Palau | 266 | 941234 | 9,109589041 | x |
| Panama | 30775 | 20309 | 1053,938356 | 100 |
| S. Kitts and Nevis | 662 | 2418 | 22,67123288 | 2,5 |
| S. Vincent and Grenadines | 540 | 67697 | 18,49315068 | x |
| Samoa | 419 | 64715 | 14,34931507 | x |
| Sao Tome and Principe | 191 | 61572 | 6,54109589 | x |
| Sierra Leone | 396 | 18617 | 13,56164384 | x |
| Solomon Islands | 298 | 1768188 | 10,20547945 | x |
| South Africa | 714460 | 12331 | 24467,80822 | 100 |
| Taiwan | - | 156751 | - | - |
| Tanzania | 43 | 237021 | 1,47260274 | x |
| Tonga | 177 | 247579 | 6,061643836 | x |
| Trinidad & Tobago | 34931 | 82204 | 1196,267123 | 100 |
| Tuvalu | 26 | 18456 | 0,890410959 | x |
| Vanuatu | 210 | 387486 | 7,191780822 | x |
| Venezuela | 258343 | 178270 | 8847,363014 | 100 |
| Vietnam | 517259 | 5077 | 17714,34932 | 100 |
| Σ | 15113084 | 14988391 | 517571,37 | |

Table J.1 Remaining Countries Suitable for OTEC. Electricity Consumption Taken from 2015 UN Energy Balances (United Nations, 2015). Practicable OTEC Potential Taken from (Chalkiadakis, 2017). One OTEC Plant Must Not Occupy More Than 30% of the National Electricity Demand. Therefore, the OTEC Demand Equals 30% of National Electricity Demand.

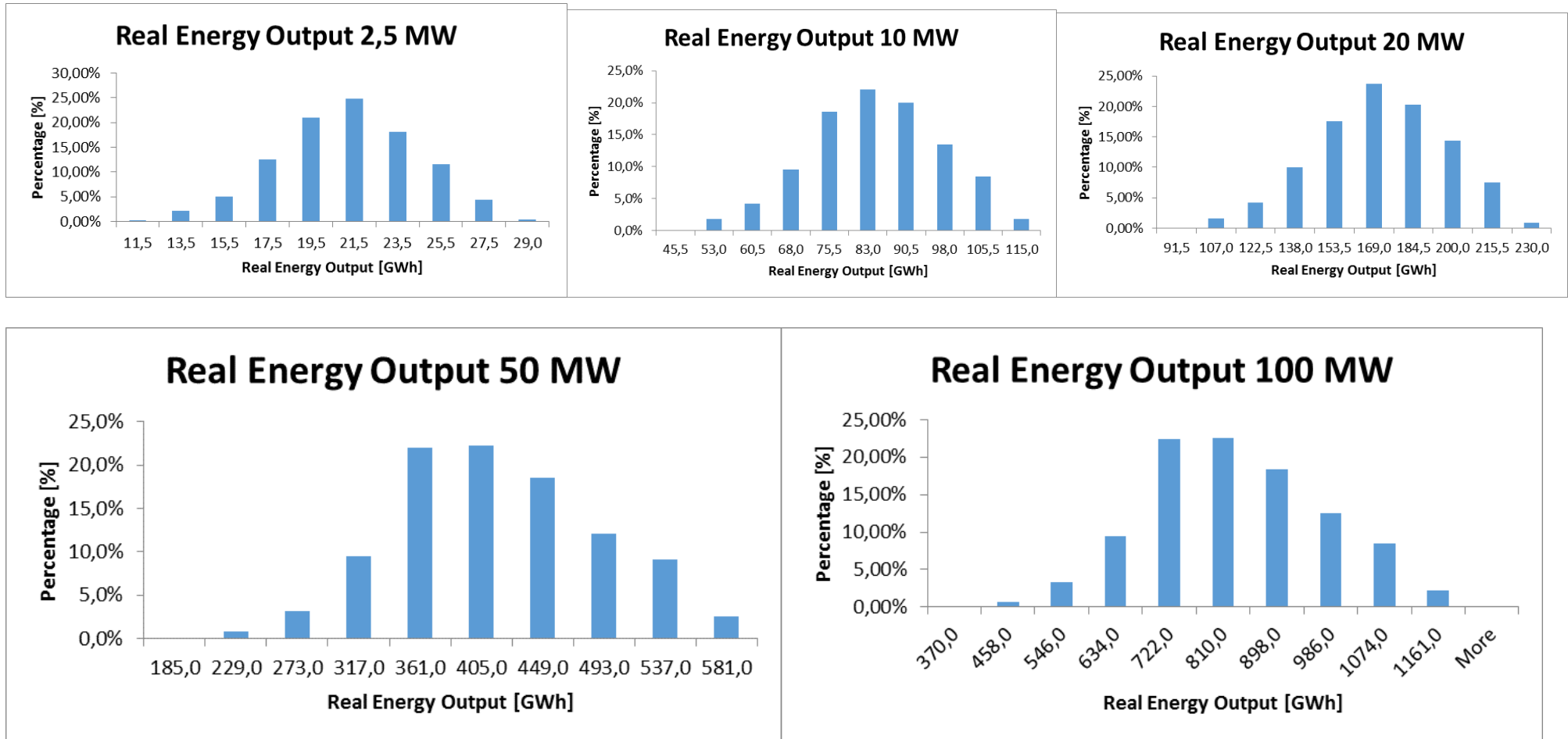
K. Histograms Regarding Power Output

K.1. Base Case and Lower Uncertainty



Figures K.1 Histograms of Real Power Output for Base Case and Lower Uncertainty (Own Illustration).

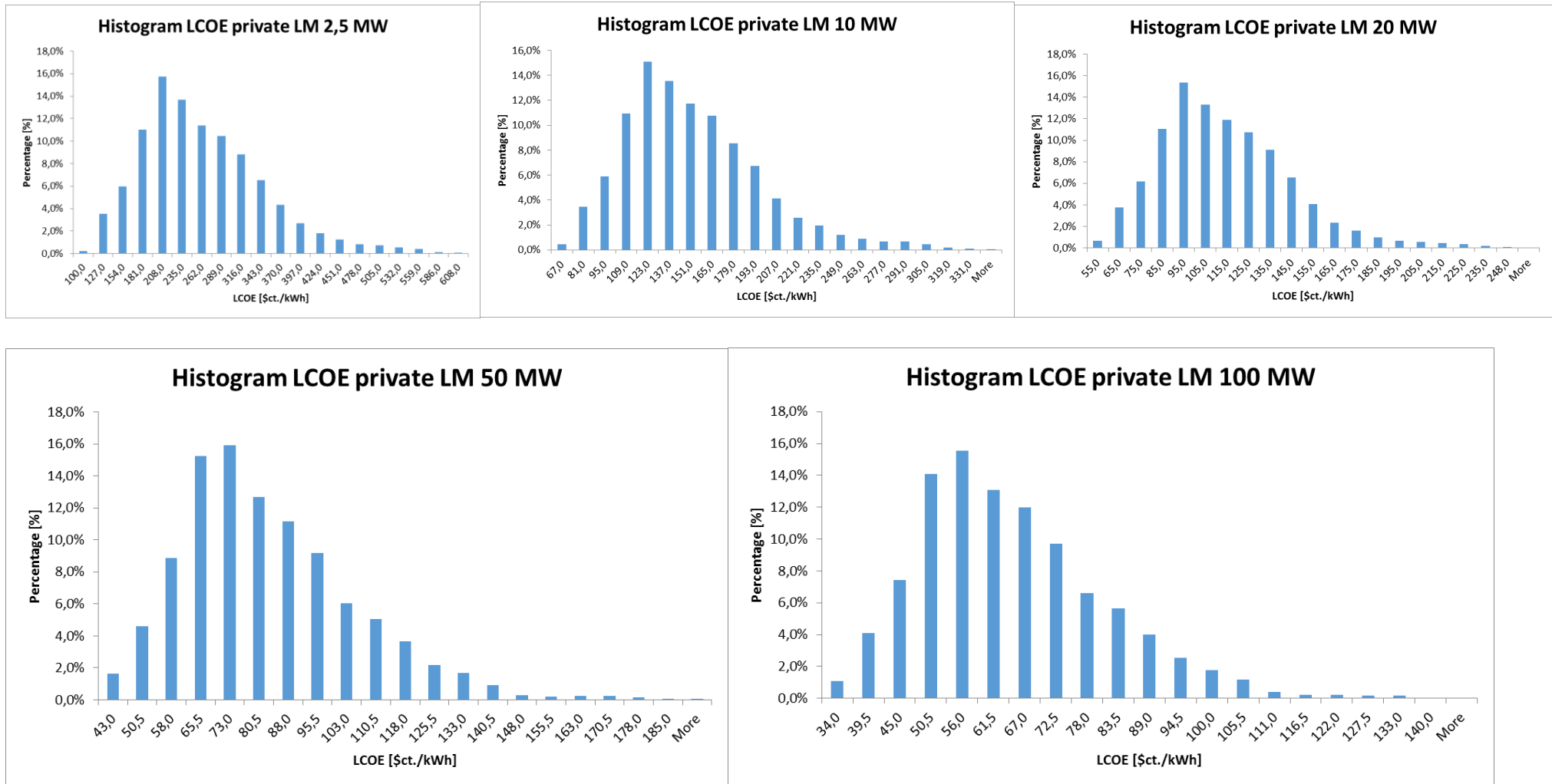
K.2. Upper Uncertainty



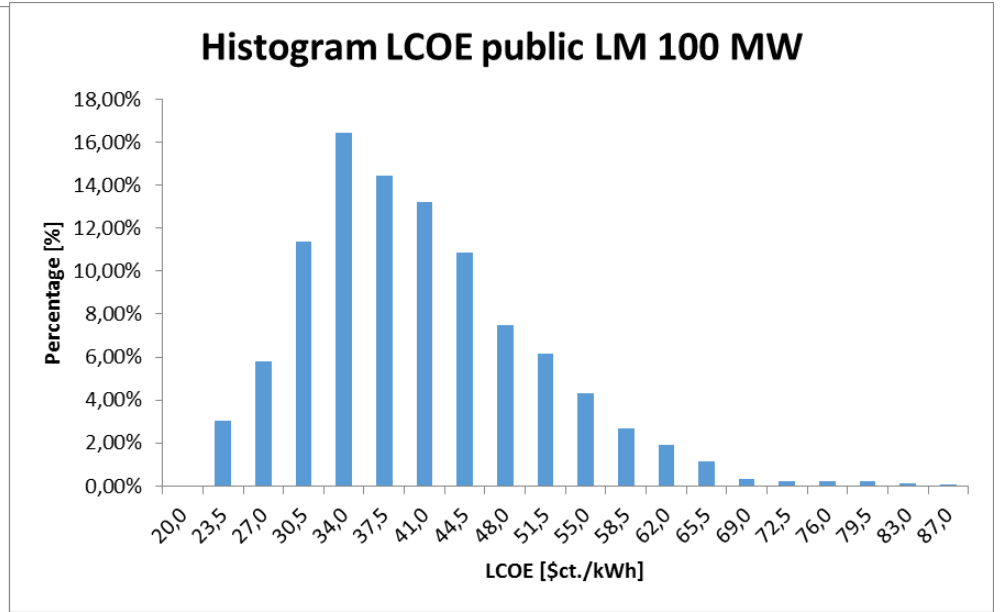
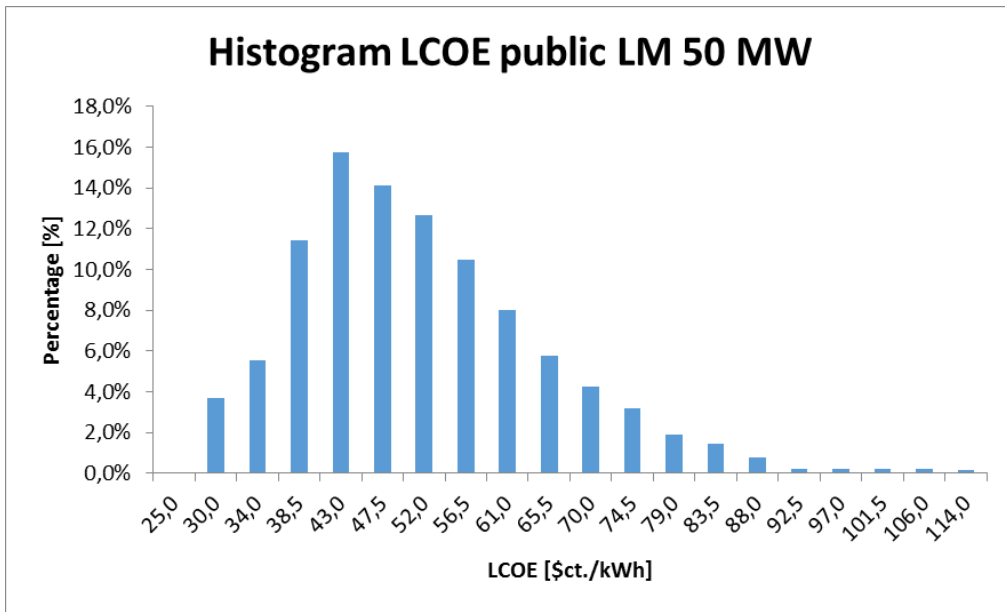
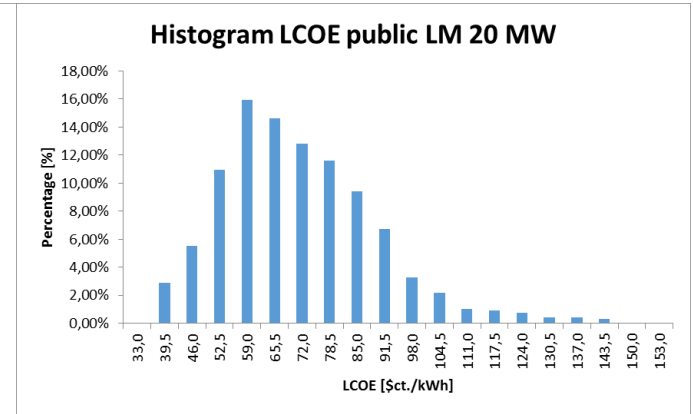
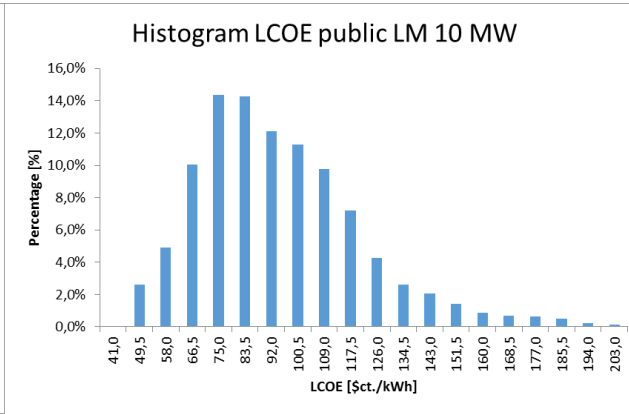
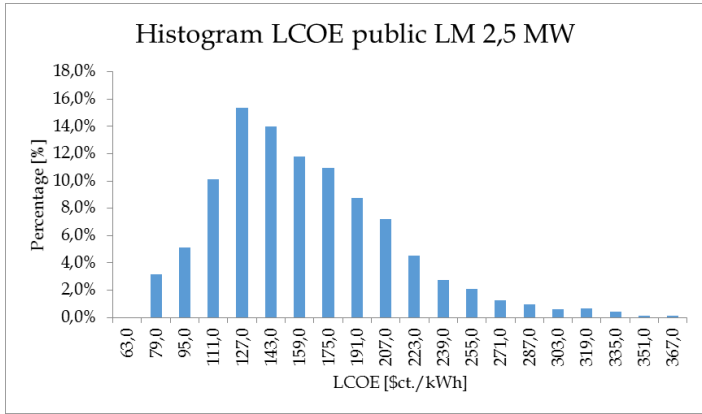
Figures K.2 Histograms of Real Power Output for Upper Uncertainty (Own Illustration).

L. Histograms for LCOE

L.1 Base Case (Lockheed Martin, No Uncertainties)

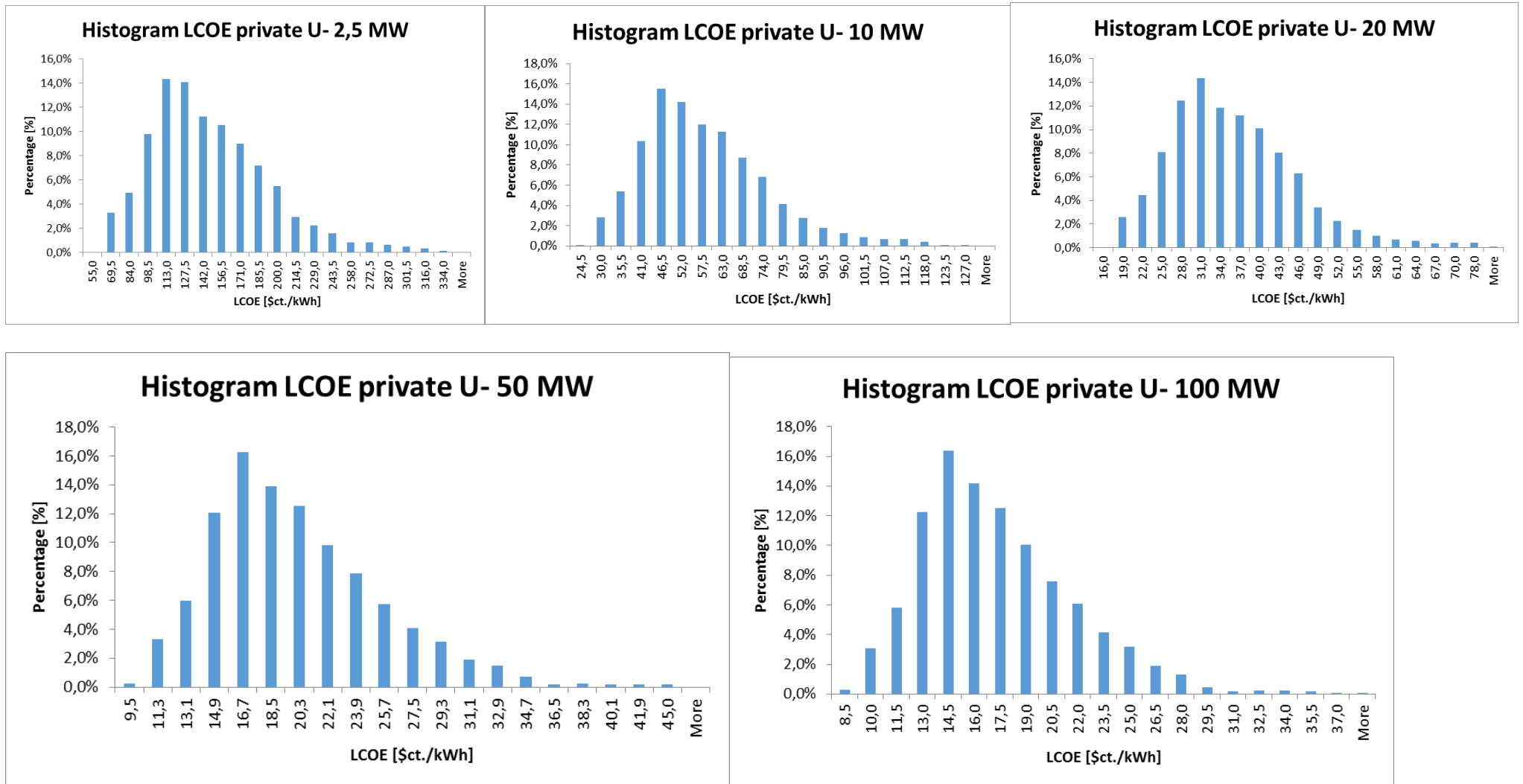


Figures L.1 Histograms of LCOEs for Base Case Costs by Lockheed Martin, Private Projects, No Uncertainty (Own Illustration).

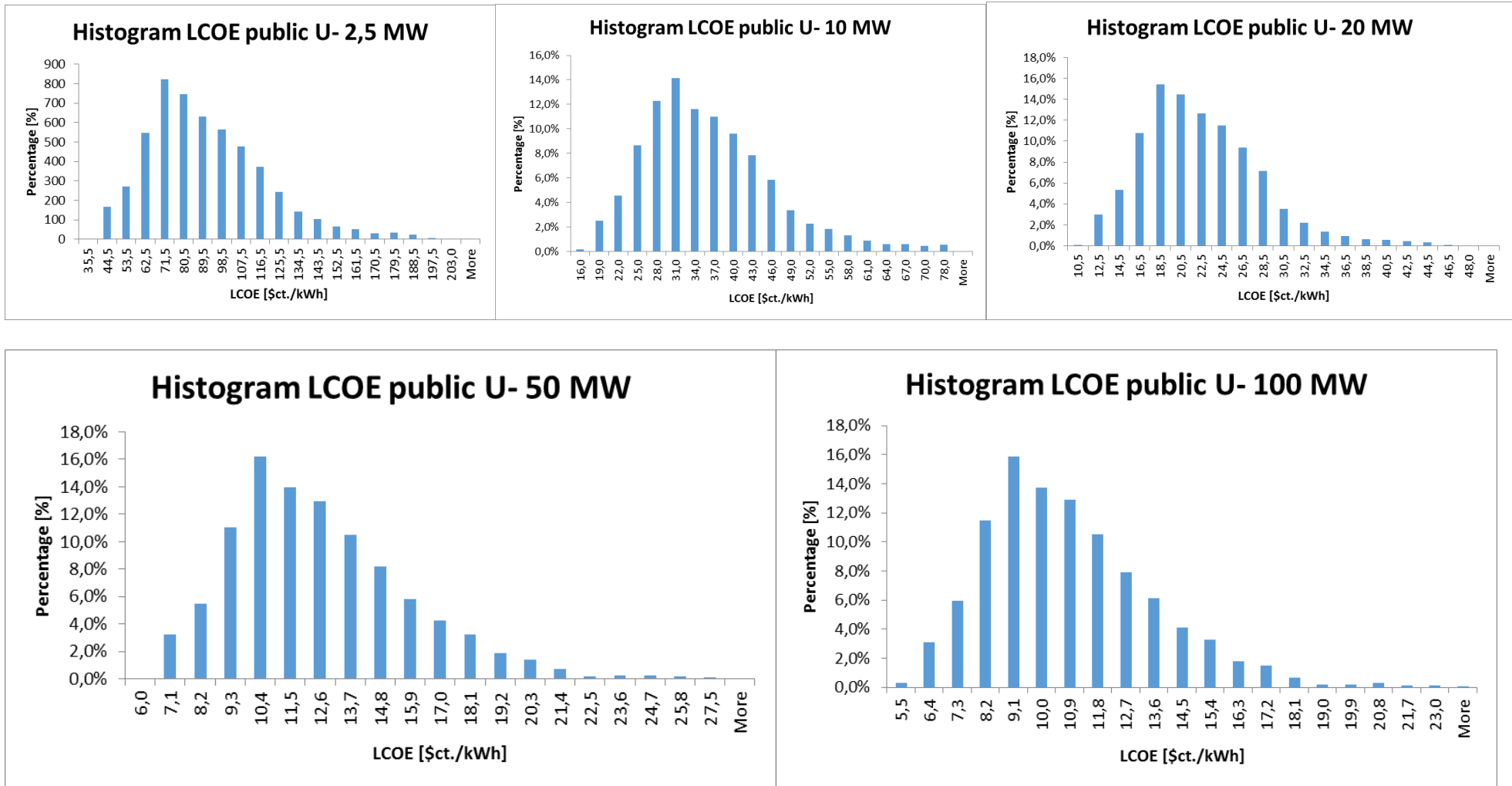


Figures L.2 Histograms of LCOEs for Base Case Costs by Lockheed Martin, Public Projects, No Uncertainty (Own Illustration).

L.2. Lower Boundary of Uncertainty (Costs by Academia and Other OTEC Companies)

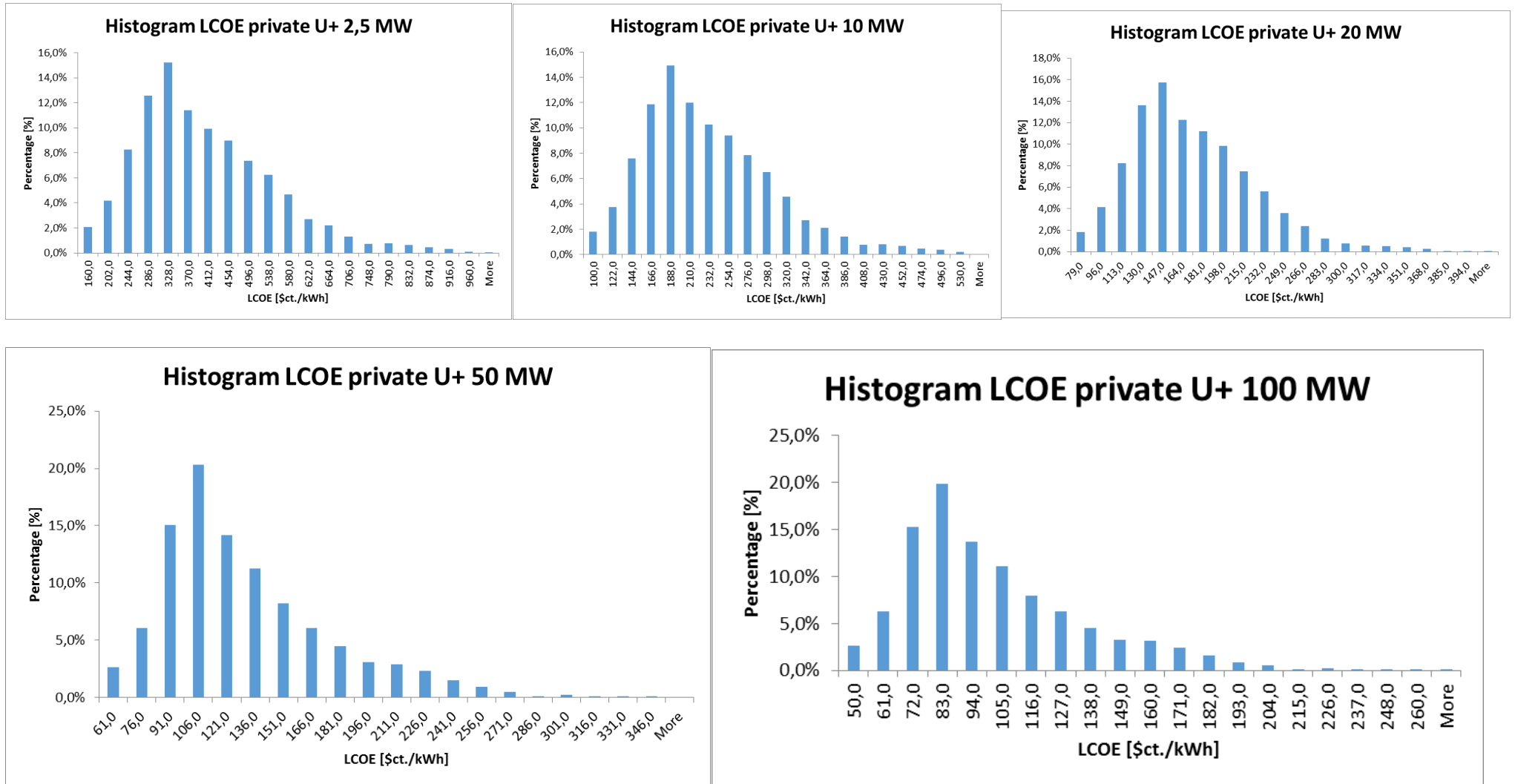


Figures L.3 Histograms of LCOEs for Lower Boundary of Uncertainty Costs by Academia and Other OTEC Companies. Private Projects (Own Illustration).

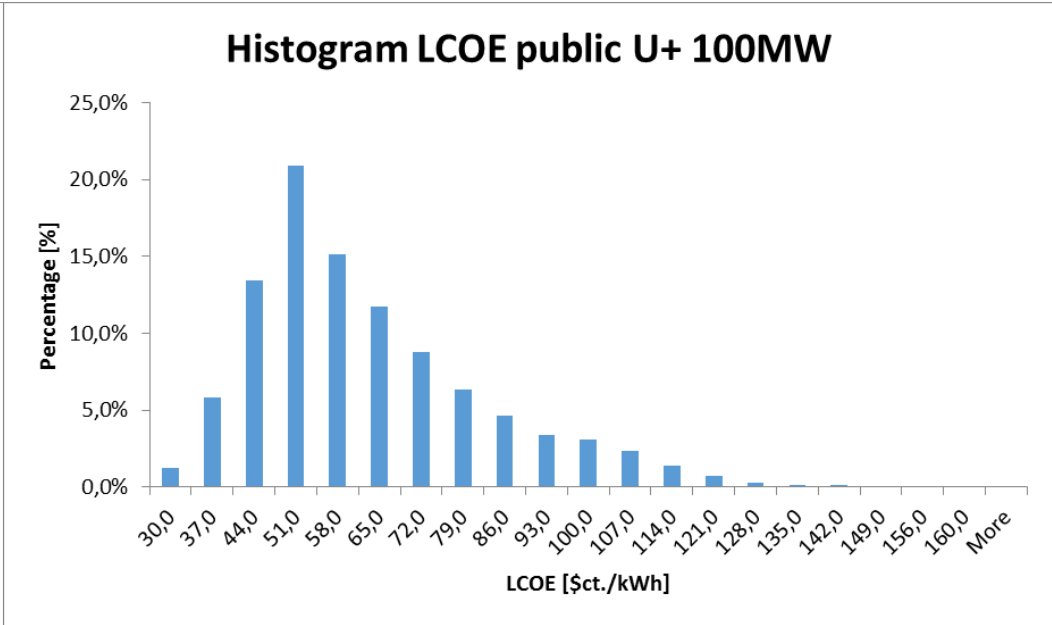
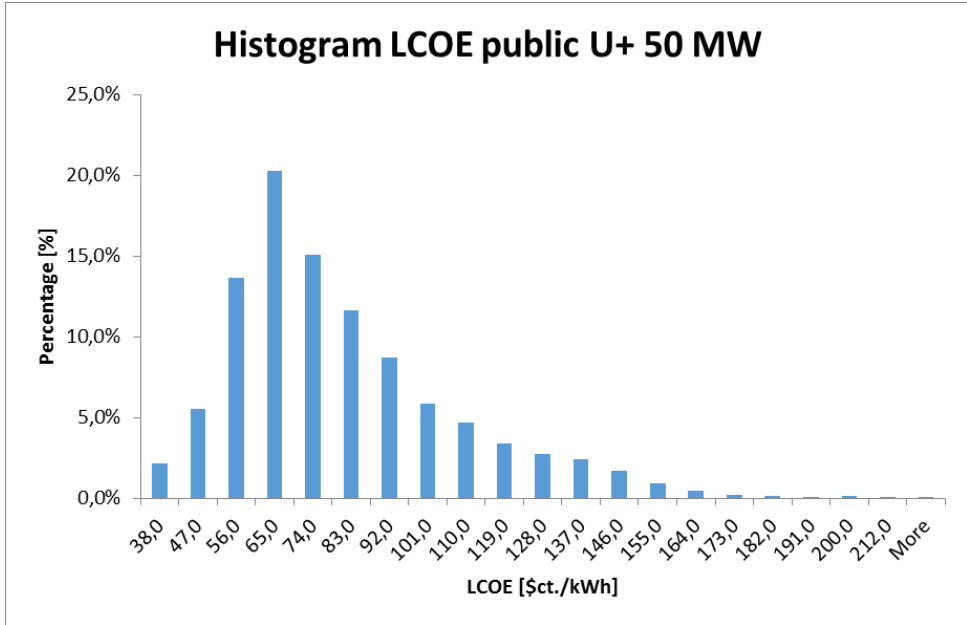
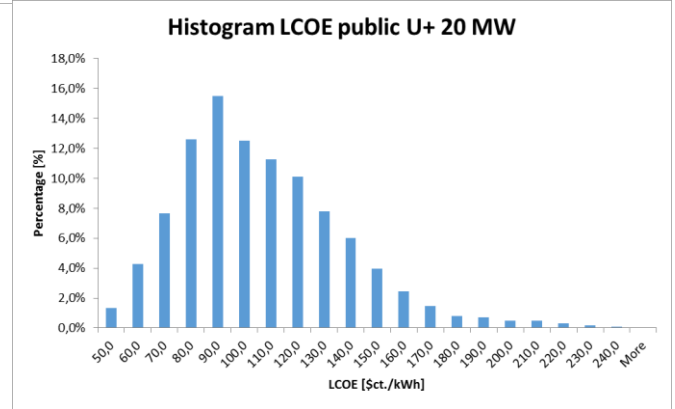
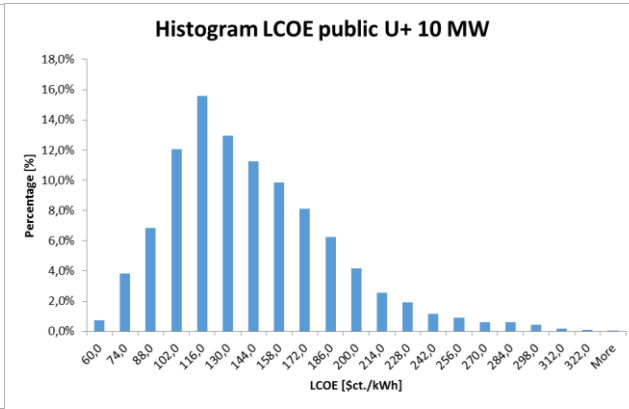
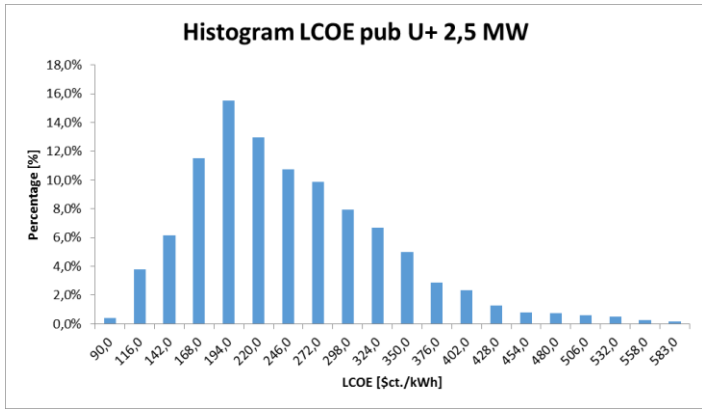


Figures L.4 Histograms of LCOEs for Lower Boundary of Uncertainty. Costs by Academia and Other OTEC Companies, Public Projects(Own Illustration).

L.3. Upper Layer of Uncertainty (Base Case +30% CAPEX and OPEX, +20% Cable Length, -5% Capacity Factor)



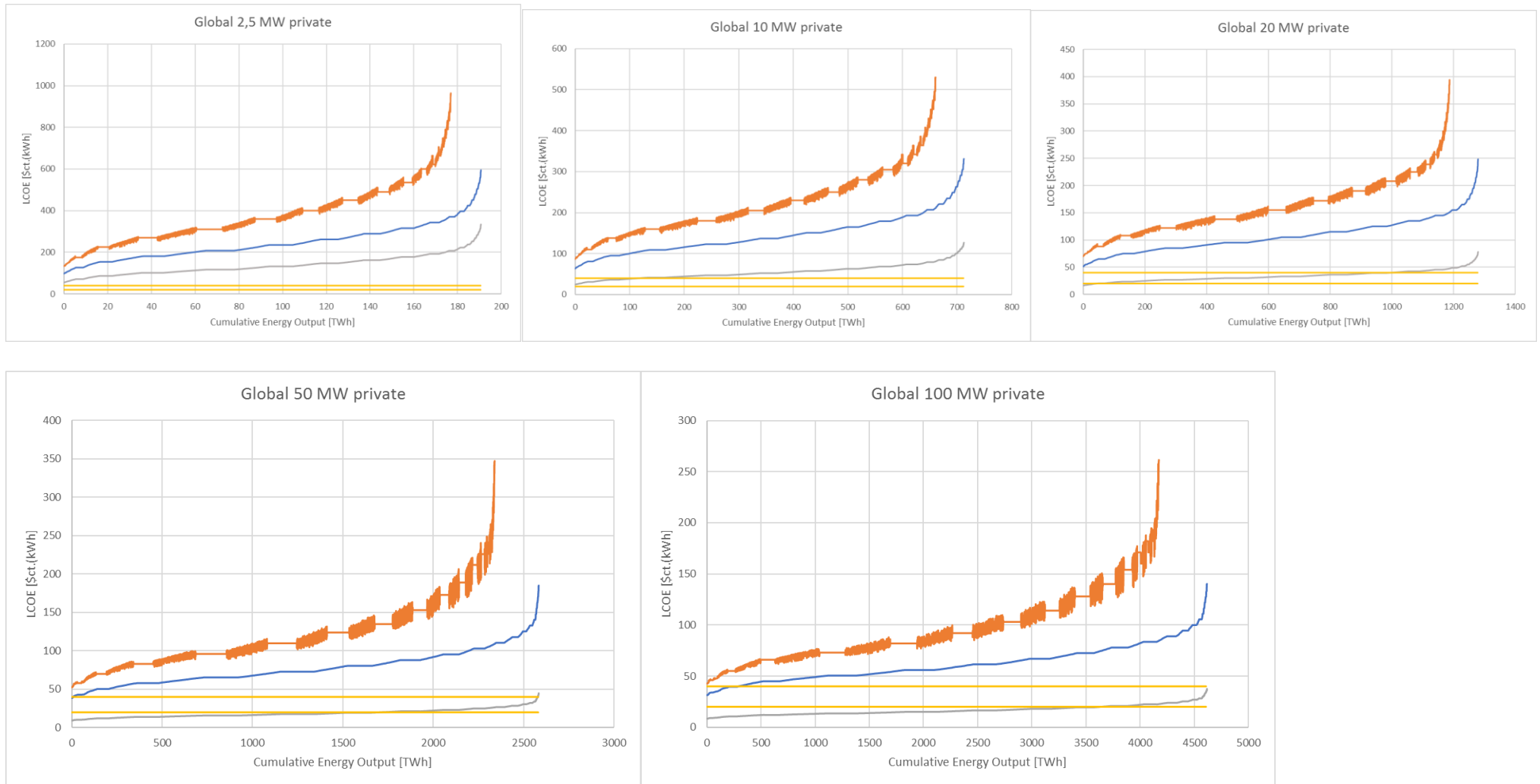
Figures L.5 Histograms of Private LCOEs for Upper Layer of Uncertainty (Own Illustration).



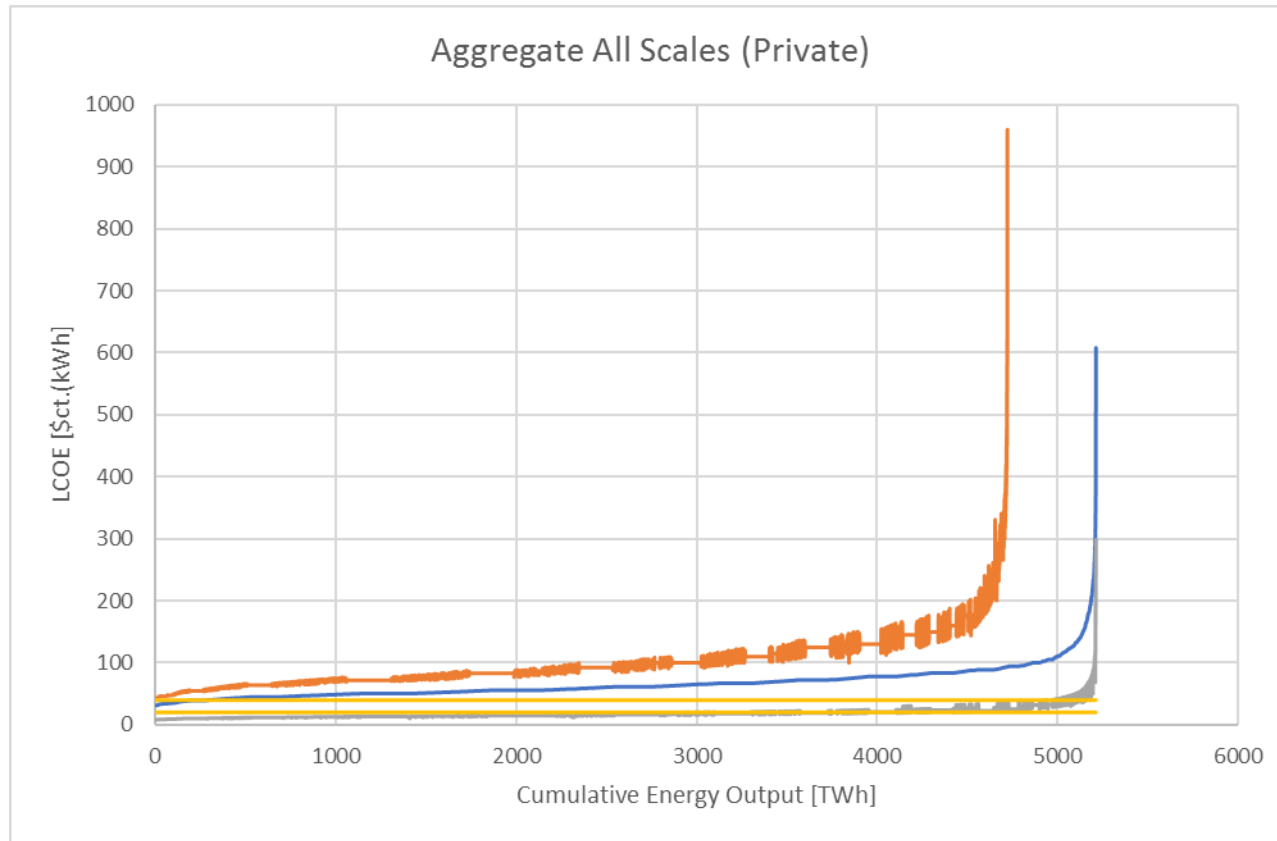
Figures L.6 Histograms of Public LCOEs for Upper Layer of Uncertainty (Own Illustration).

M. Global Supply Curves for OTEC

M.1. Privately Funded OTEC (Discount Rate 18%)

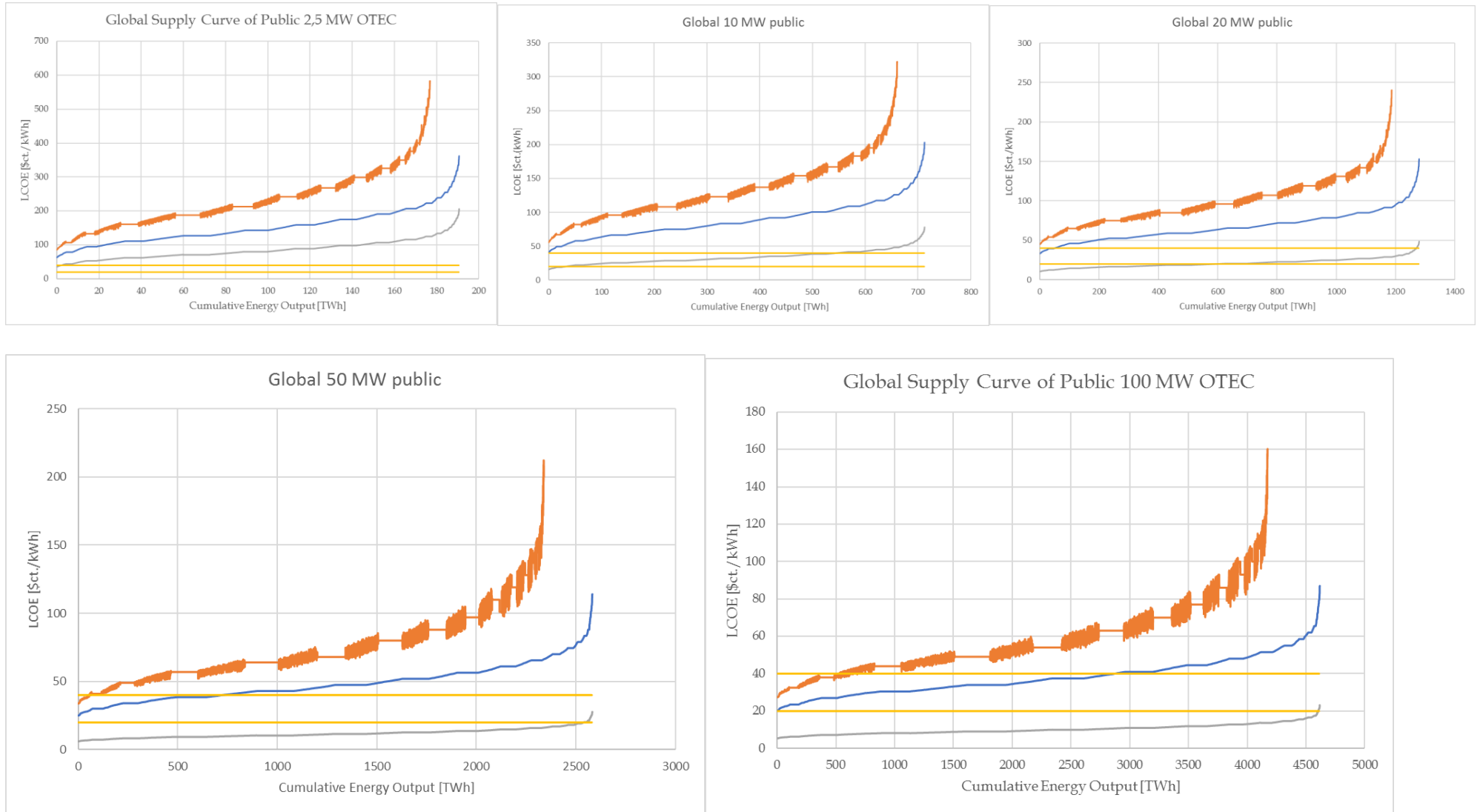


Figures M.1 Global Supply Curves for Privately Funded OTEC (Own Illustration).



Figures M.2 Global Supply Curve for Privately Funded OTEC for All Scales (Own Illustration).

M.2. Publicly Funded (Discount Rate 10%)



Figures M.3 Global Supply Curves for Publicly Funded OTEC (Own Illustration).

N. Implementation Scenarios and Experience Curves of OTEC

N.1. Scenario Design

N.1.1. Modest Growth

| Electricity Cons. Growth per Year [%] | | 1,15 | OTEC Growth per Year [%] | 20 | # of Installed Systems per Year | | | | |
|---------------------------------------|--------------------------------|----------------|--------------------------------------|----------|---------------------------------|-----------|----------|----------|-----|
| Year | Global Elec. Consumption [GWh] | Cum. OTEC [MW] | Installed OTEC | Coverage | 2,5 | 10 | 20 | 50 | 100 |
| 0 | 15493460 | 2,5 | 2,5 | 0,00013% | 1 | | | | |
| 1 | 15671634,79 | 5 | 2,5 | 0,00026% | 1 | | | | |
| 2 | 15851858,59 | 7,5 | 2,5 | 0,00038% | 1 | | | | |
| 3 | 16034154,96 | 10 | 2,5 | 0,00050% | 1 | | | | |
| 4 | 16218547,75 | 20 | 10 | 0,00099% | | 1 | | | |
| 5 | 16405061,05 | 30 | 10 | 0,00147% | | 1 | | | |
| 6 | 16593719,25 | 40 | 10 | 0,00194% | | 1 | | | |
| 7 | 16784547,02 | 50 | 10 | 0,00240% | | 1 | | | |
| 8 | 16977569,31 | 60 | 10 | 0,00285% | | 1 | | | |
| 9 | 17172811,36 | 70 | 10 | 0,00329% | | 1 | | | |
| 10 | 17370298,69 | 80 | 10 | 0,00371% | | 1 | | | |
| 11 | 17570057,12 | 100 | 20 | 0,00459% | | | 1 | | |
| 12 | 17772112,78 | 120 | 20 | 0,00544% | | | 1 | | |
| 13 | 17976492,08 | 140 | 20 | 0,00628% | | | 1 | | |
| 14 | 18183221,73 | 170 | 30 | 0,00753% | | 1 | 1 | | |
| 15 | 18392328,78 | 200 | 30 | 0,00876% | | 1 | 1 | | |
| 16 | 18603840,57 | 240 | 40 | 0,01040% | | | 2 | | |
| 17 | 18817784,73 | 290 | 50 | 0,01242% | | 1 | 2 | | |
| 18 | 19034189,26 | 350 | 60 | 0,01482% | | | 3 | | |
| 19 | 19253082,43 | 420 | 70 | 0,01758% | | | 1 | 1 | |
| 20 | 19474492,88 | 500 | 80 | 0,02069% | | 1 | 1 | 1 | |
| 21 | 19698449,55 | 600 | 100 | 0,02455% | | | | | 1 |
| 22 | 19924981,72 | 720 | 120 | 0,02912% | | | 1 | | 1 |
| 23 | 20154119,01 | 860 | 140 | 0,03439% | | | 2 | | 1 |
| 24 | 20385891,38 | 1030 | 170 | 0,04072% | | | 1 | 1 | 1 |
| Total Σ of Installed OTEC | | 40 | Σ of Installed OTEC per Scale | 4 | 11 | 18 | 3 | 4 | |

Table N.1 Scenario Design for Modest Growth (Own Illustration).

N.1.2. Fast Growth

| Electricity Cons. Growth per Year [%] | | 1,15 | OTEC Growth per Year [%] | 30 | # of Installed Systems per Year | | | | |
|---------------------------------------|--------------------------------|----------------|------------------------------------|----------|---------------------------------|----------|-----------|-----------|-----------|
| Year | Global Elec. Consumption [GWh] | Cum. OTEC [MW] | Installed OTEC | Coverage | 2,5 | 10 | 20 | 50 | 100 |
| 0 | 15493460 | 2,5 | 2,5 | 0,00013% | 1 | | | | |
| 1 | 15671634,79 | 5 | 2,5 | 0,00026% | 1 | | | | |
| 2 | 15851858,59 | 7,5 | 2,5 | 0,00038% | 1 | | | | |
| 3 | 16034154,96 | 10 | 2,5 | 0,00050% | 1 | | | | |
| 4 | 16218547,75 | 20 | 10 | 0,00099% | | 1 | | | |
| 5 | 16405061,05 | 30 | 10 | 0,00147% | | 1 | | | |
| 6 | 16593719,25 | 40 | 10 | 0,00194% | | 1 | | | |
| 7 | 16784547,02 | 50 | 10 | 0,00240% | | 1 | | | |
| 8 | 16977569,31 | 70 | 20 | 0,00332% | | | 1 | | |
| 9 | 17172811,36 | 90 | 20 | 0,00422% | | | 1 | | |
| 10 | 17370298,69 | 120 | 30 | 0,00557% | | 1 | 1 | | |
| 11 | 17570057,12 | 160 | 40 | 0,00734% | | | 2 | | |
| 12 | 17772112,78 | 210 | 50 | 0,00952% | | 1 | 2 | | |
| 13 | 17976492,08 | 270 | 60 | 0,01210% | | | 3 | | |
| 14 | 18183221,73 | 350 | 80 | 0,01551% | | | 4 | | |
| 15 | 18392328,78 | 460 | 110 | 0,02016% | | | 3 | 1 | |
| 16 | 18603840,57 | 600 | 140 | 0,02599% | | | 2 | 2 | |
| 17 | 18817784,73 | 780 | 180 | 0,03341% | | | 4 | 2 | |
| 18 | 19034189,26 | 1010 | 230 | 0,04276% | | | 4 | 1 | 1 |
| 19 | 19253082,43 | 1310 | 300 | 0,05484% | | | | 2 | 2 |
| 20 | 19474492,88 | 1700 | 390 | 0,07035% | | | 2 | 3 | 2 |
| 21 | 19698449,55 | 2210 | 510 | 0,09042% | | | 3 | 1 | 4 |
| 22 | 19924981,72 | 2870 | 660 | 0,11608% | | | 3 | 2 | 5 |
| 23 | 20154119,01 | 3730 | 860 | 0,14915% | | | 3 | 2 | 7 |
| 24 | 20385891,38 | 4850 | 1120 | 0,19174% | | | 1 | 4 | 9 |
| Total \sum of Installed OTEC | | 99 | \sum of Installed OTEC per Scale | | 4 | 6 | 39 | 20 | 30 |

Table N.2 Scenario Design for Fast Growth (Own Illustration).

N.1.3. Rapid Growth

| Electricity Cons. Growth per Year [%] | | 1,15 | OTEC Growth per Year [%] | 40 | # of Installed Systems per Year | | | | |
|---------------------------------------|--------------------------------|----------------|--------------------------------------|----------|---------------------------------|-----------|-----------|-----------|------------|
| Year | Global Elec. Consumption [GWh] | Cum. OTEC [MW] | Installed OTEC | Coverage | 2,5 | 10 | 20 | 50 | 100 |
| 0 | 15493460 | 2,5 | 2,5 | 0,00013% | 1 | | | | |
| 1 | 15671634,79 | 5 | 2,5 | 0,00026% | 1 | | | | |
| 2 | 15851858,59 | 7,5 | 2,5 | 0,00038% | 1 | | | | |
| 3 | 16034154,96 | 10 | 2,5 | 0,00050% | 1 | | | | |
| 4 | 16218547,75 | 20 | 10 | 0,00099% | | 1 | | | |
| 5 | 16405061,05 | 30 | 10 | 0,00147% | | 1 | | | |
| 6 | 16593719,25 | 40 | 10 | 0,00194% | | 1 | | | |
| 7 | 16784547,02 | 60 | 20 | 0,00288% | | 2 | | | |
| 8 | 16977569,31 | 80 | 20 | 0,00380% | | | 1 | | |
| 9 | 17172811,36 | 110 | 30 | 0,00516% | | 1 | 1 | | |
| 10 | 17370298,69 | 150 | 40 | 0,00696% | | | 2 | | |
| 11 | 17570057,12 | 210 | 60 | 0,00963% | | 2 | 2 | | |
| 12 | 17772112,78 | 290 | 80 | 0,01315% | | 2 | 3 | | |
| 13 | 17976492,08 | 410 | 120 | 0,01838% | | 1 | 3 | 1 | |
| 14 | 18183221,73 | 570 | 160 | 0,02526% | | | 3 | 2 | |
| 15 | 18392328,78 | 800 | 230 | 0,03505% | | | 4 | 3 | |
| 16 | 18603840,57 | 1120 | 320 | 0,04852% | | | 6 | 4 | |
| 17 | 18817784,73 | 1570 | 450 | 0,06724% | | | | 7 | 1 |
| 18 | 19034189,26 | 2200 | 630 | 0,09315% | | | 4 | 7 | 2 |
| 19 | 19253082,43 | 3080 | 880 | 0,12893% | | | 4 | 8 | 4 |
| 20 | 19474492,88 | 4310 | 1230 | 0,17836% | | | 4 | 7 | 8 |
| 21 | 19698449,55 | 6030 | 1720 | 0,24670% | | | 1 | 6 | 14 |
| 22 | 19924981,72 | 8440 | 2410 | 0,34138% | | | 4 | 7 | 20 |
| 23 | 20154119,01 | 11820 | 3380 | 0,47266% | | | 4 | 6 | 30 |
| 24 | 20385891,38 | 16550 | 4730 | 0,65427% | | | 4 | 13 | 40 |
| Total Σ of Installed OTEC | | 255 | Σ of Installed OTEC per Scale | | 4 | 11 | 50 | 71 | 119 |

Table N.3 Scenario Design for Rapid Growth (Own Illustration).

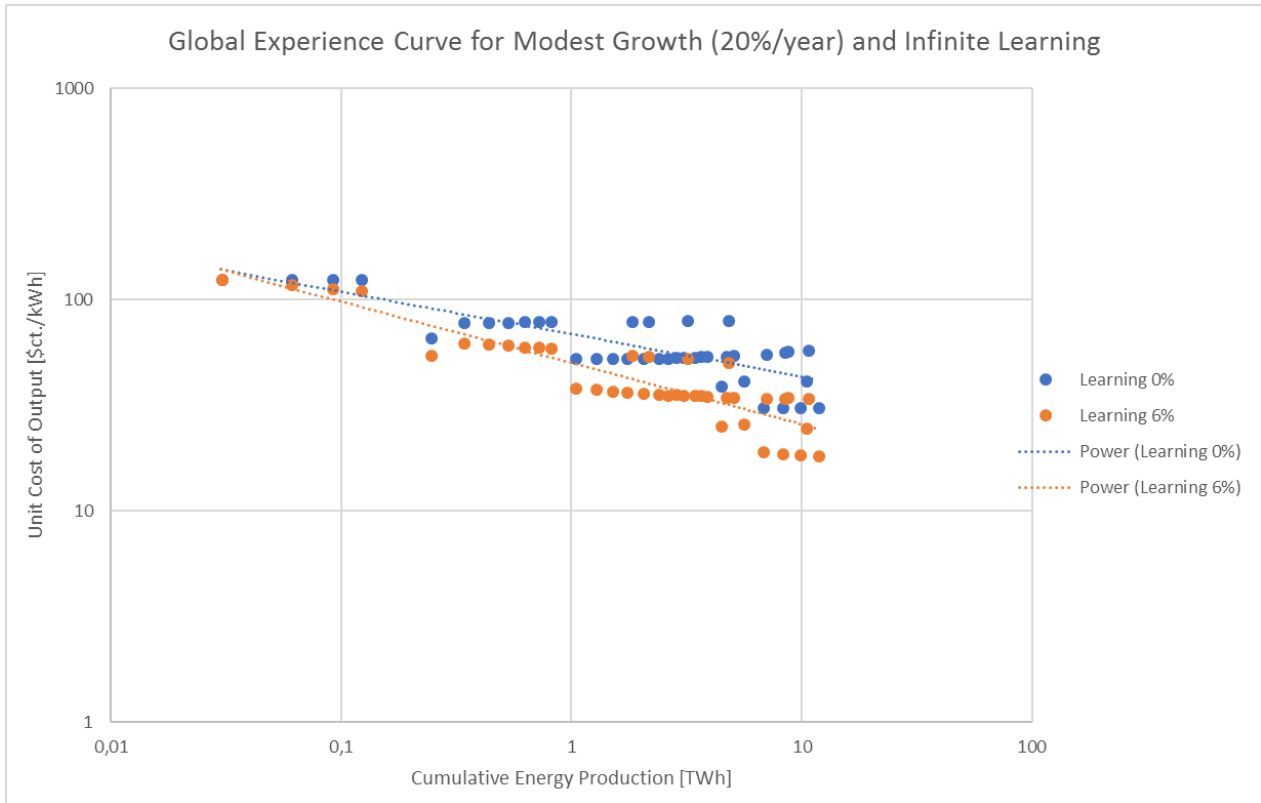
N.1.4. Superaggressive Expansion

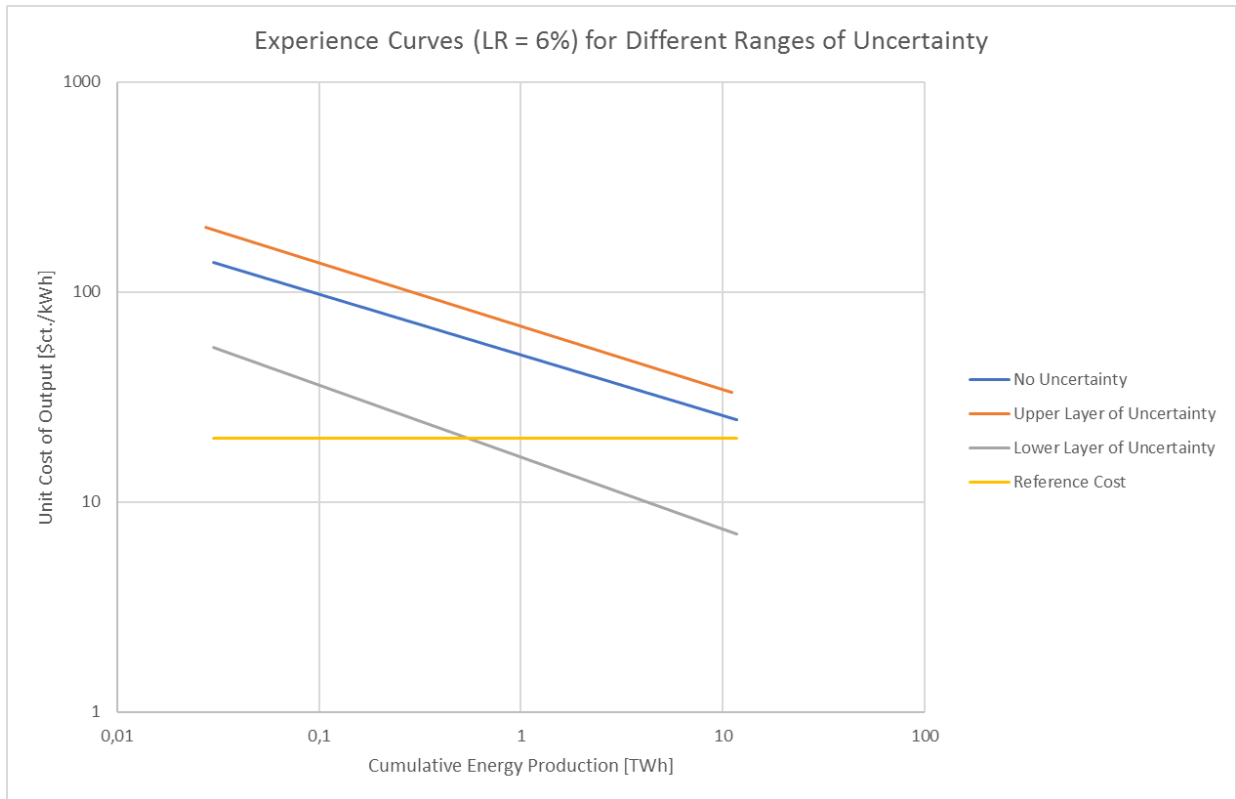
| Electricity Cons. Growth per Year [%] | | 1,15 | OTEC Growth per Year [%] | 40 | # of Installed Systems per Year | | | | |
|---------------------------------------|--------------------------|----------------|--------------------------------------|-----------|---------------------------------|------------|-------------|------------|-------------|
| Year | Global Elec. Cons. [GWh] | Cum. OTEC [MW] | Installed OTEC | Coverage | 2,5 | 10 | 20 | 50 | 100 |
| 0 | 15493460 | 2,5 | 2,5 | 0,00013% | 1 | | | | |
| 1 | 15671634,79 | 5 | 2,5 | 0,00026% | 1 | | | | |
| 2 | 15851858,59 | 7,5 | 2,5 | 0,00038% | 1 | | | | |
| 3 | 16034154,96 | 10 | 2,5 | 0,00050% | 1 | | | | |
| 4 | 16218547,75 | 20 | 10 | 0,00099% | | 1 | | | |
| 5 | 16405061,05 | 30 | 10 | 0,00147% | | 1 | | | |
| 6 | 16593719,25 | 40 | 10 | 0,00194% | | 1 | | | |
| 7 | 16784547,02 | 60 | 20 | 0,00288% | | 2 | | | |
| 8 | 16977569,31 | 80 | 20 | 0,00380% | | 2 | | | |
| 9 | 17172811,36 | 110 | 30 | 0,00516% | | 3 | | | |
| 10 | 17370298,69 | 150 | 40 | 0,00696% | | 4 | | | |
| 11 | 17570057,12 | 210 | 60 | 0,00963% | | 4 | 1 | | |
| 12 | 17772112,78 | 290 | 80 | 0,01315% | | 6 | 1 | | |
| 13 | 17976492,08 | 410 | 120 | 0,01838% | | 8 | 2 | | |
| 14 | 18183221,73 | 570 | 160 | 0,02526% | | 12 | 2 | | |
| 15 | 18392328,78 | 800 | 230 | 0,03505% | | 15 | 4 | | |
| 16 | 18603840,57 | 1120 | 320 | 0,04852% | | 24 | 4 | | |
| 17 | 18817784,73 | 1570 | 450 | 0,06724% | | 24 | 8 | 1 | |
| 18 | 19034189,26 | 2200 | 630 | 0,09315% | | 42 | 8 | 1 | |
| 19 | 19253082,43 | 3080 | 880 | 0,12893% | | 46 | 16 | 2 | |
| 20 | 19474492,88 | 4310 | 1230 | 0,17836% | | 81 | 16 | 2 | |
| 21 | 19698449,55 | 6030 | 1720 | 0,24670% | | 78 | 32 | 4 | 1 |
| 22 | 19924981,72 | 8440 | 2410 | 0,34138% | | 57 | 52 | 8 | 4 |
| 23 | 20154119,01 | 11820 | 3380 | 0,47266% | | 46 | 76 | 16 | 6 |
| 24 | 20385891,38 | 16550 | 4730 | 0,65427% | | 41 | 106 | 32 | 6 |
| 25 | 20620329,13 | 23170 | 6620 | 0,90557% | | 40 | 96 | 30 | 28 |
| 26 | 20857462,91 | 32440 | 9270 | 1,25346% | | 40 | 96 | 49 | 45 |
| 27 | 21097323,74 | 45420 | 12980 | 1,73505% | | 40 | 104 | 50 | 80 |
| 28 | 21339942,96 | 63590 | 18170 | 2,40153% | | 41 | 103 | 50 | 132 |
| 29 | 21585352,3 | 89030 | 25440 | 3,32406% | | 40 | 102 | 50 | 205 |
| 30 | 21833583,85 | 124640 | 35610 | 4,60070% | | 41 | 100 | 50 | 307 |
| 31 | 22084670,07 | 174500 | 49860 | 6,36790% | | 46 | 100 | 60 | 444 |
| 32 | 22338643,77 | 244300 | 69800 | 8,81371% | | 50 | 100 | 60 | 643 |
| 33 | 22595538,18 | 342020 | 97720 | 12,19890% | | 30 | 61 | 46 | 939 |
| 34 | 22855386,87 | 478830 | 136810 | 16,88436% | | 31 | 60 | 40 | 1333 |
| 35 | 23118223,82 | 585350 | 106520 | 20,40577% | | 26 | 68 | 50 | 1024 |
| Total Σ of Installed OTEC | | 8043 | Σ of Installed OTEC per Scale | | 4 | 923 | 1318 | 601 | 5197 |

Table N.4 Scenario Design for Superaggressive Expansion (Own Illustration).

N.2. Experience Curves

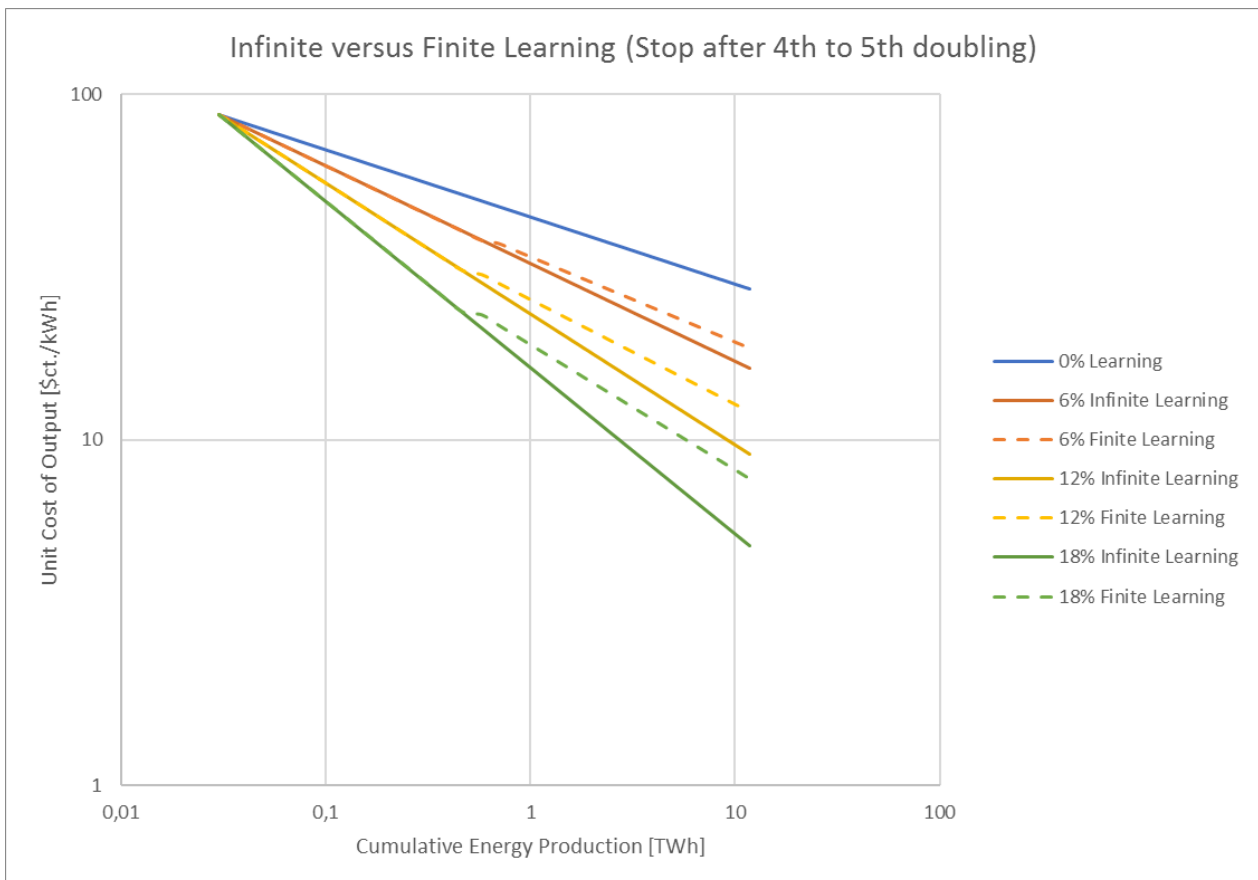
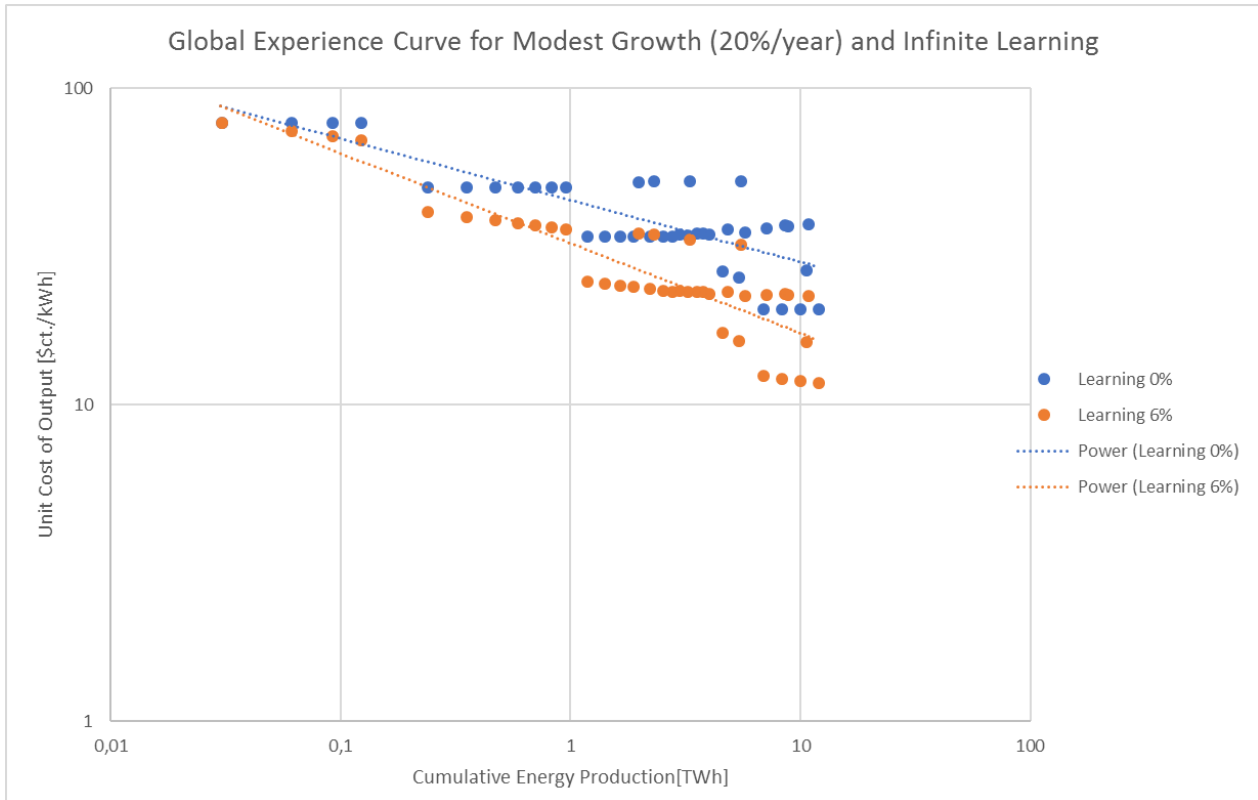
N.2.1. Modest Growth (Discount Rate 18%)

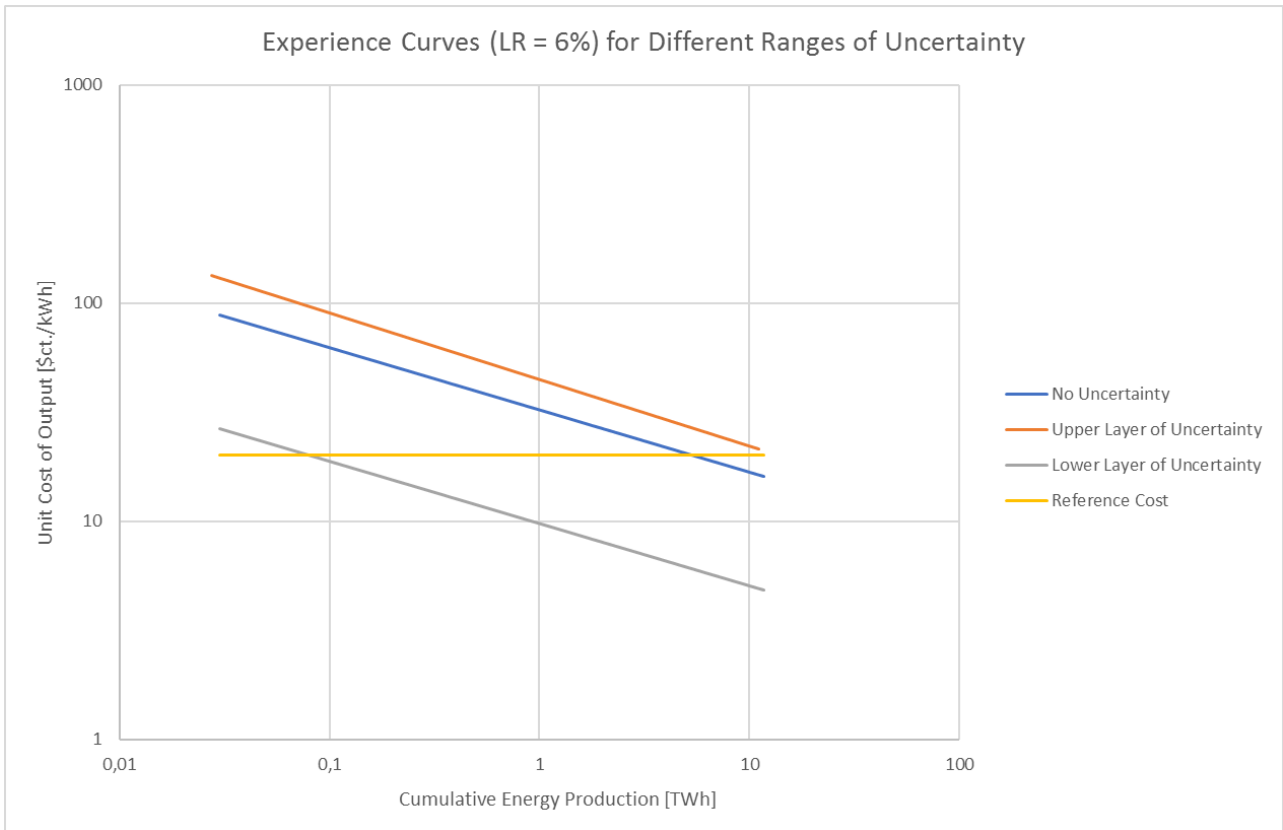




Figures N.1 Experience Curves for Modest Growth (Discount Rate 18%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

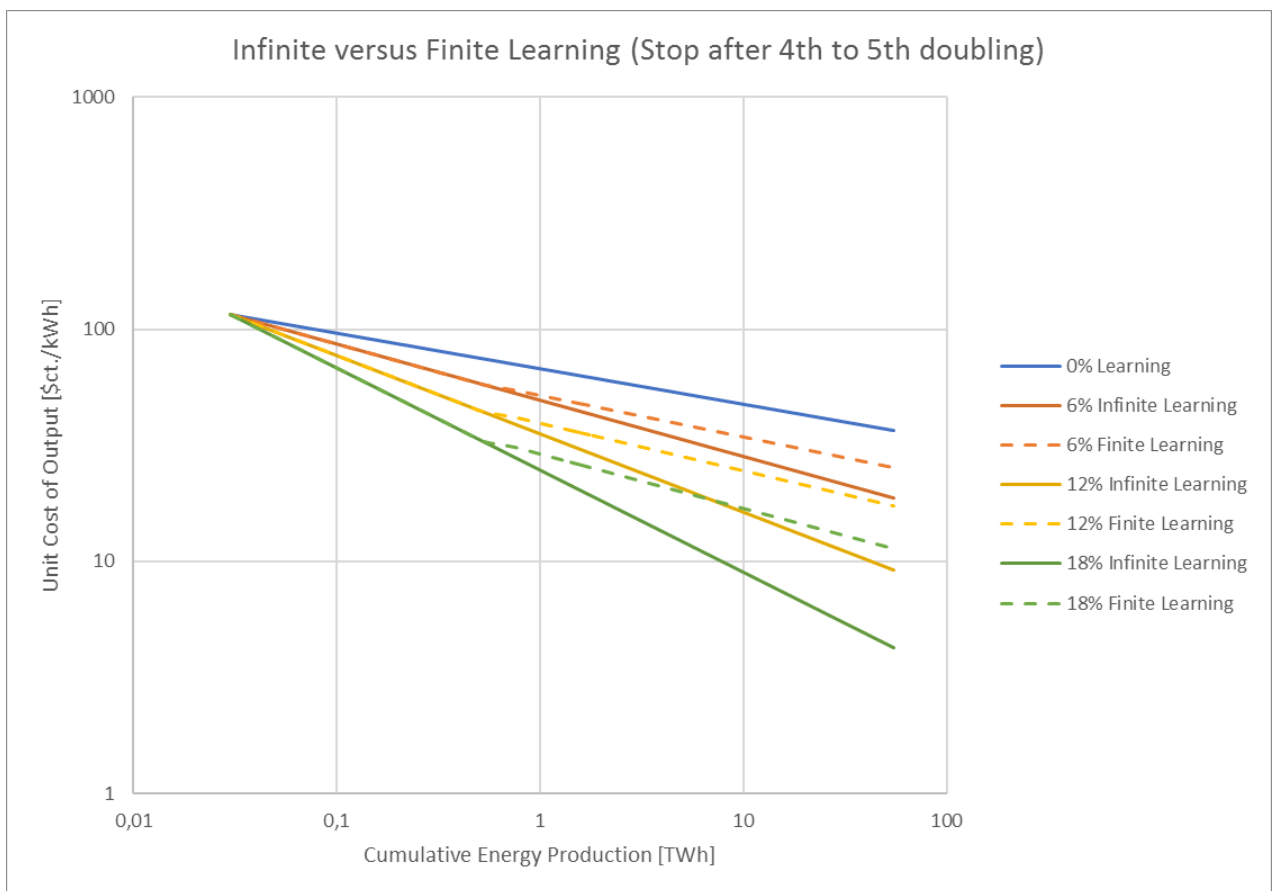
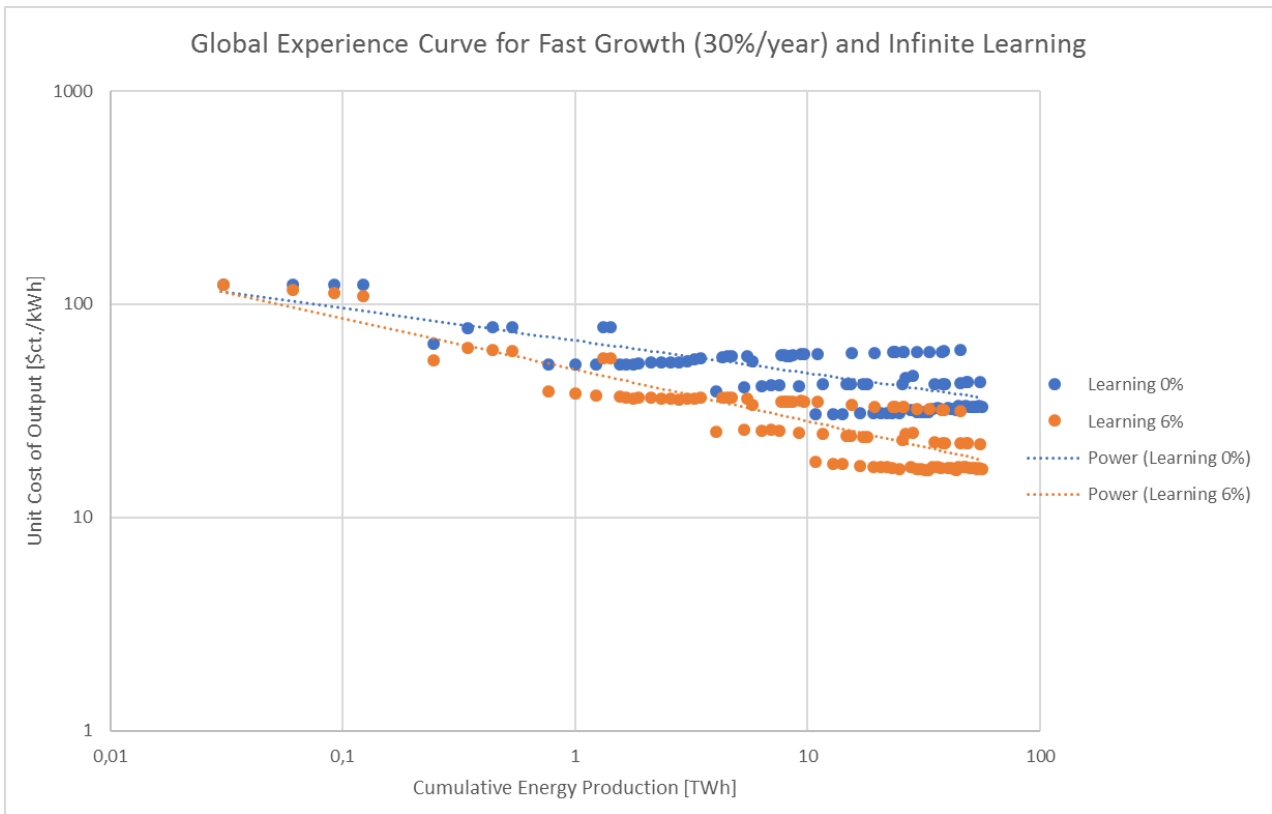
N.2.2. Modest Growth (Discount Rate 10%)

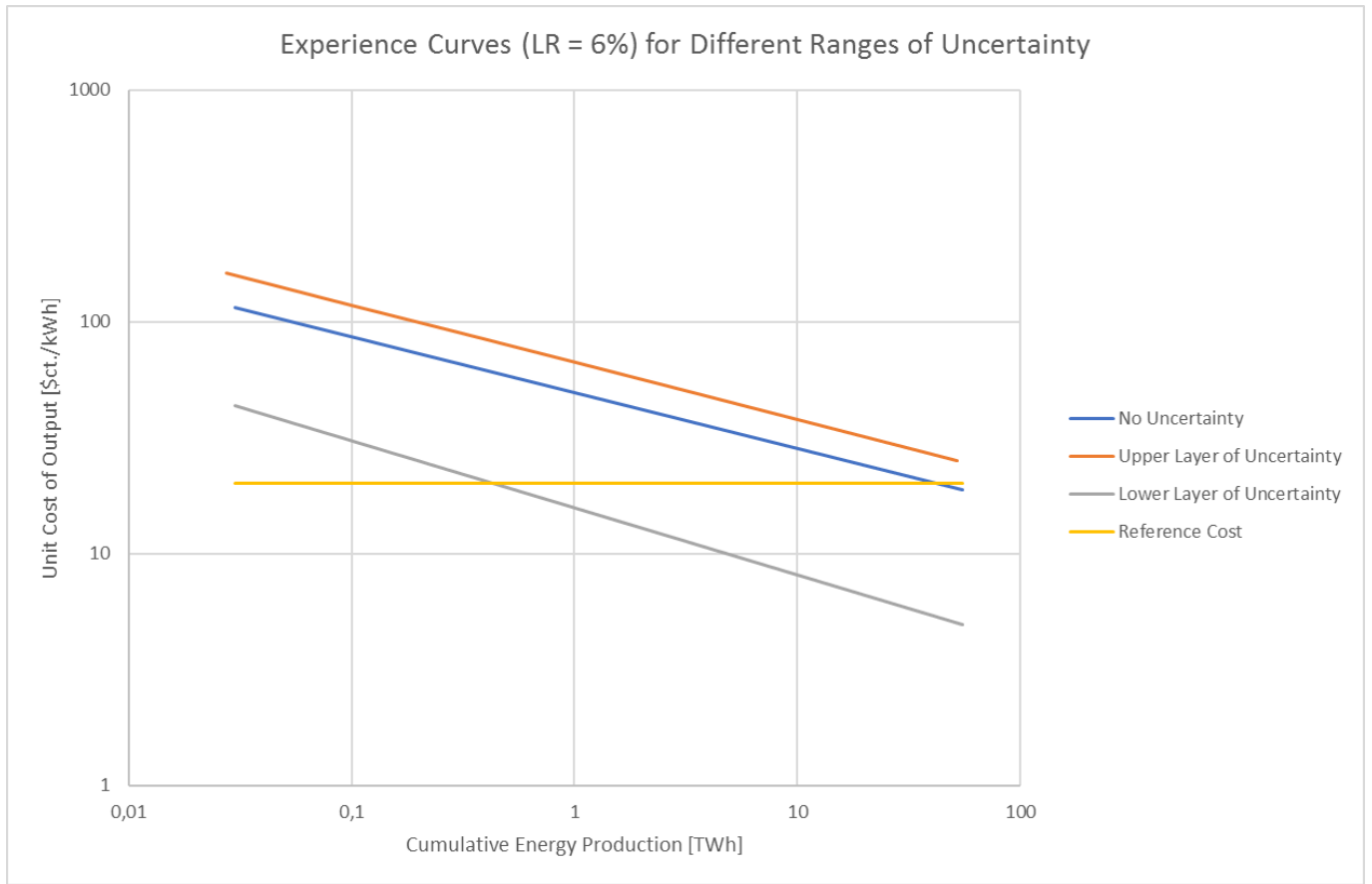




Figures N.2 Experience Curves for Modest Growth (Discount Rate 10%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

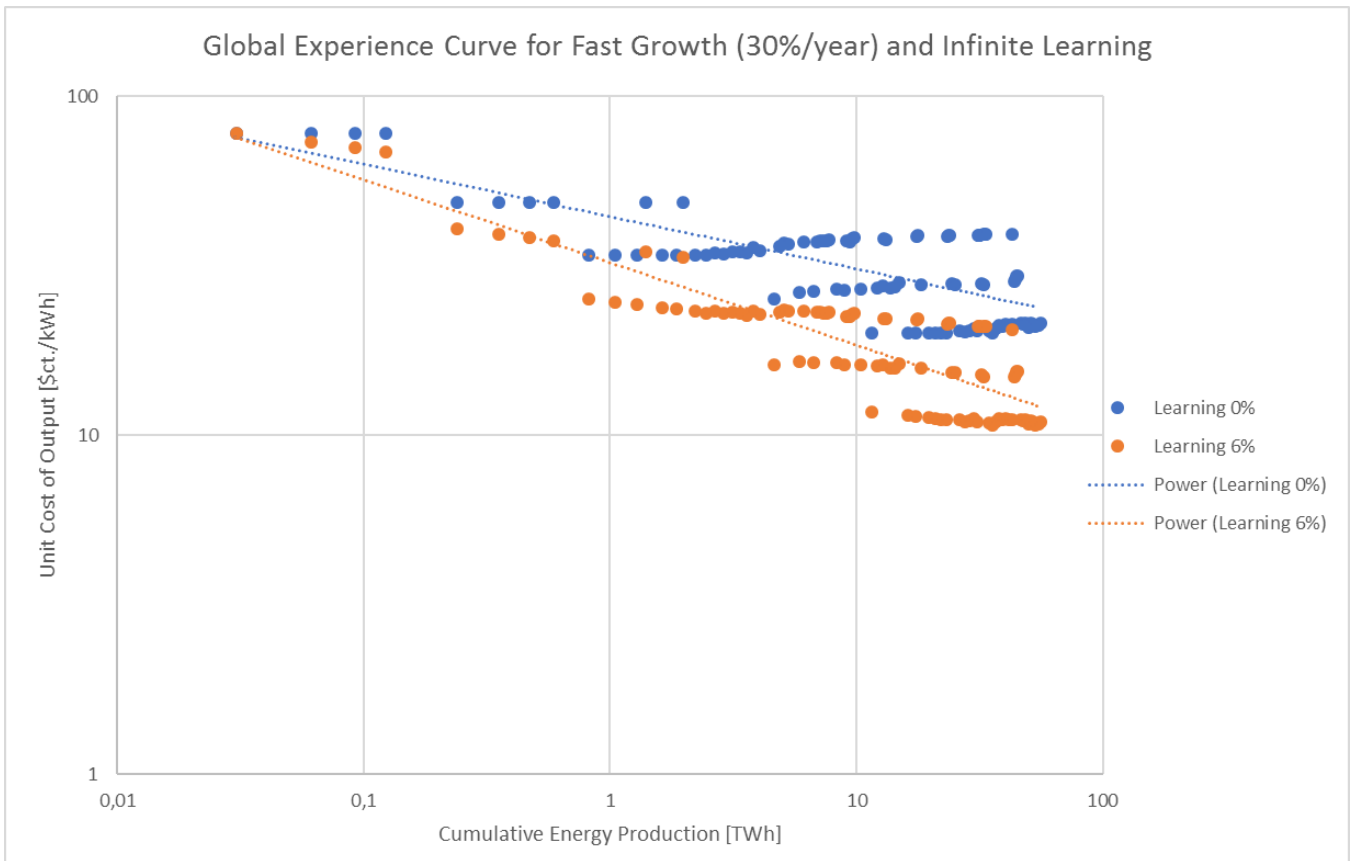
N.2.4. Fast Growth (Discount Rate 18%)

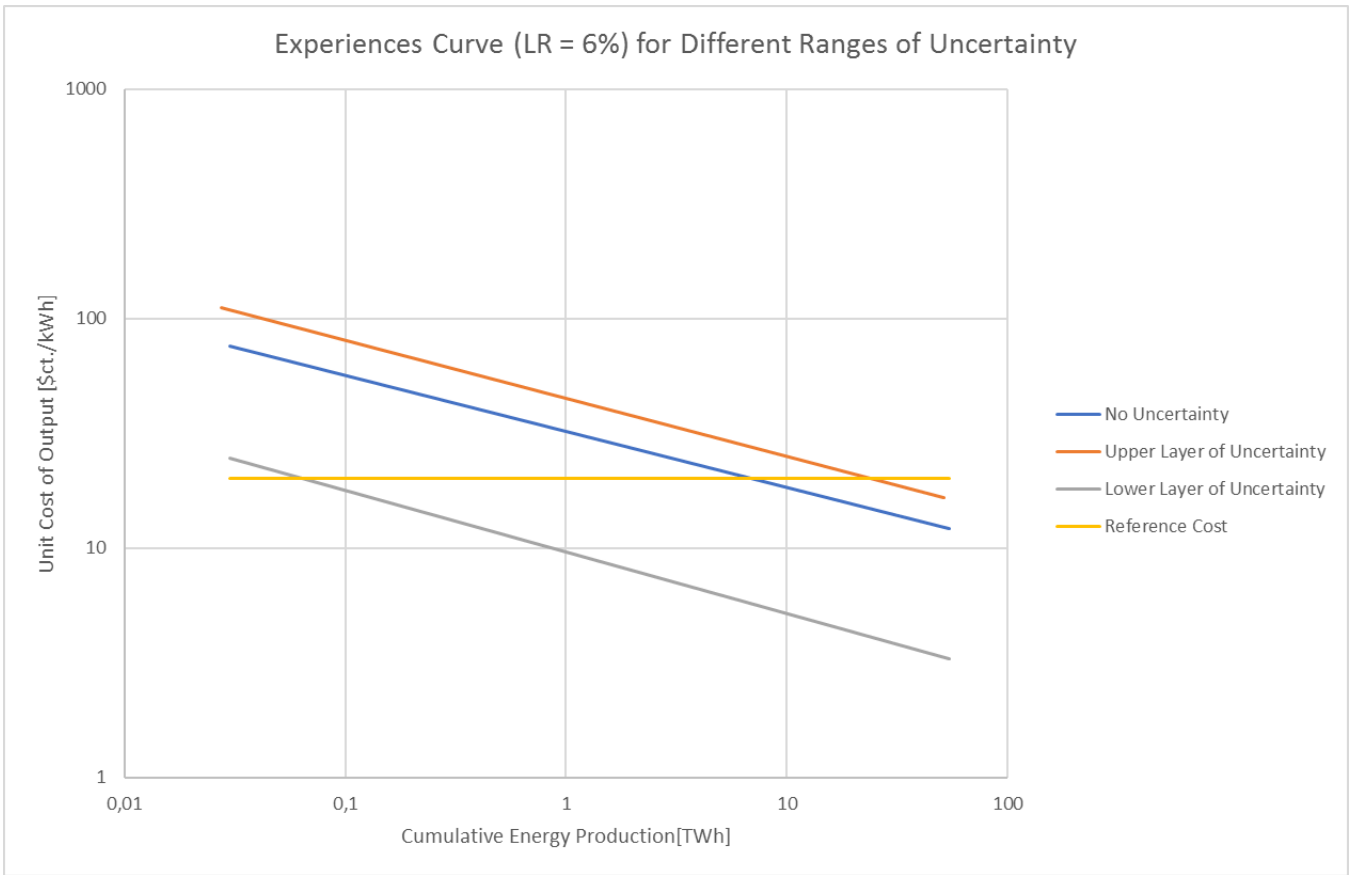




Figures N.3 Experience Curves for Fast Growth (Discount Rate 18%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

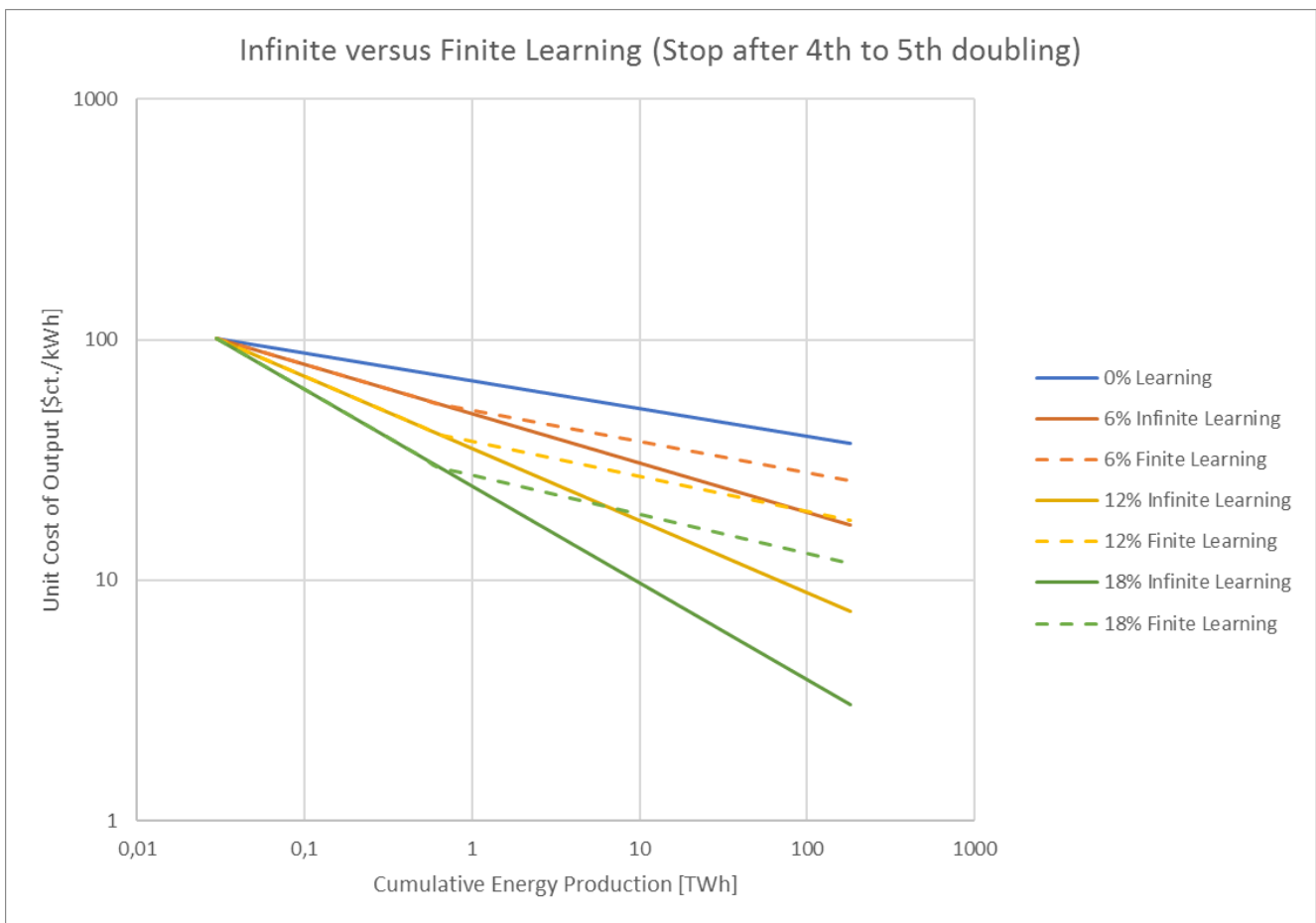
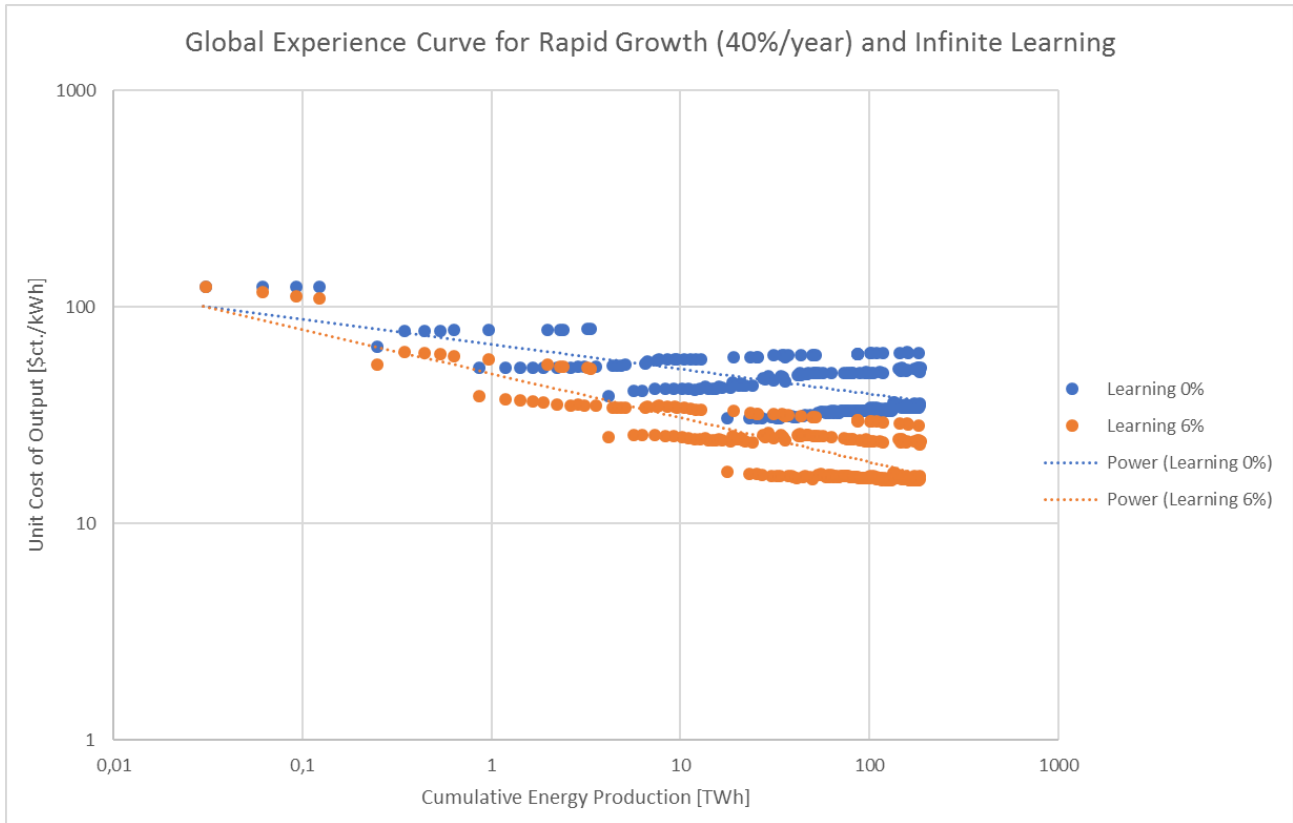
N.2.4. Fast Growth (Discount Rate 10%)

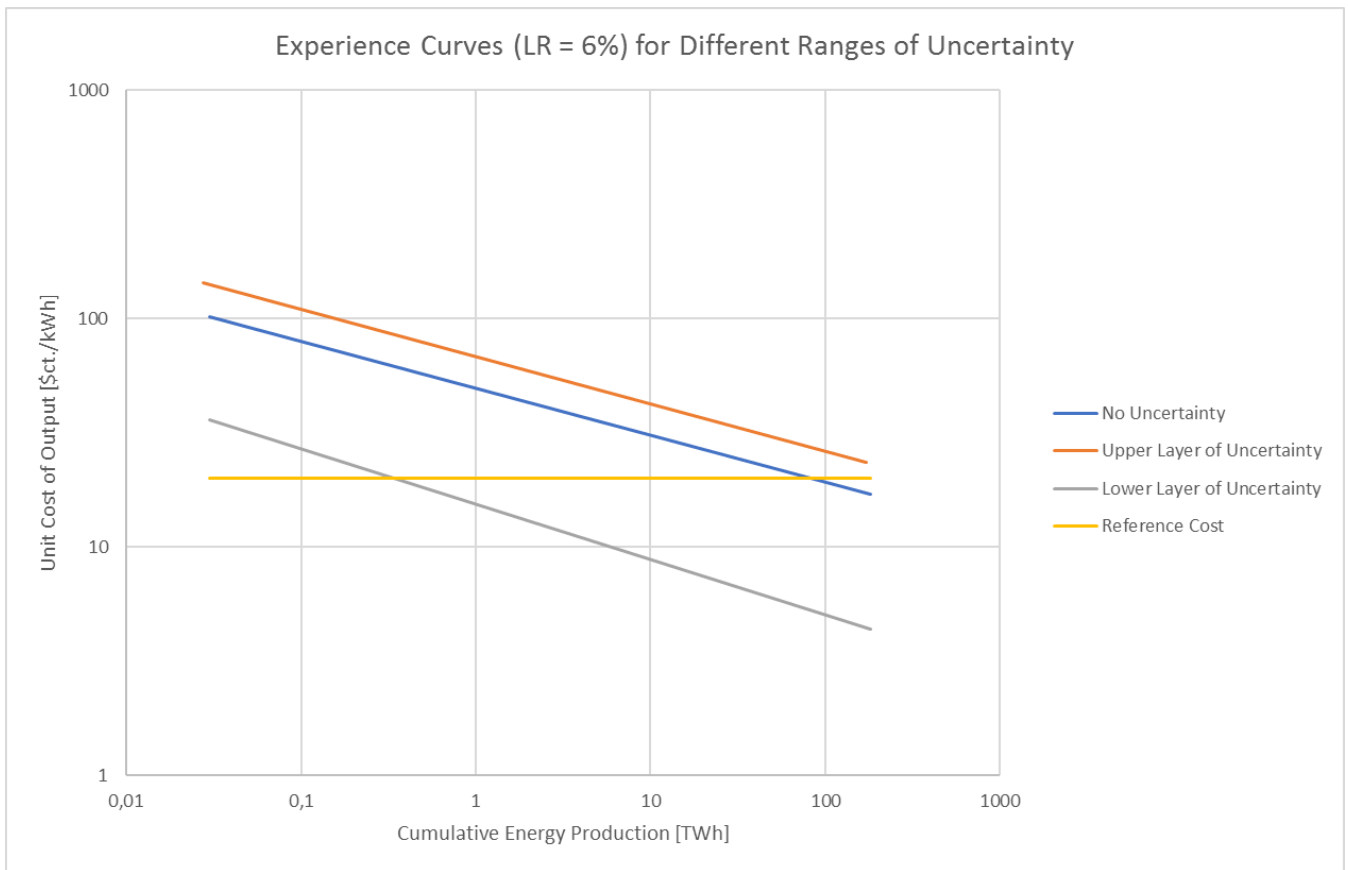




Figures N.4 Experience Curves for Fast Growth (Discount Rate 10%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

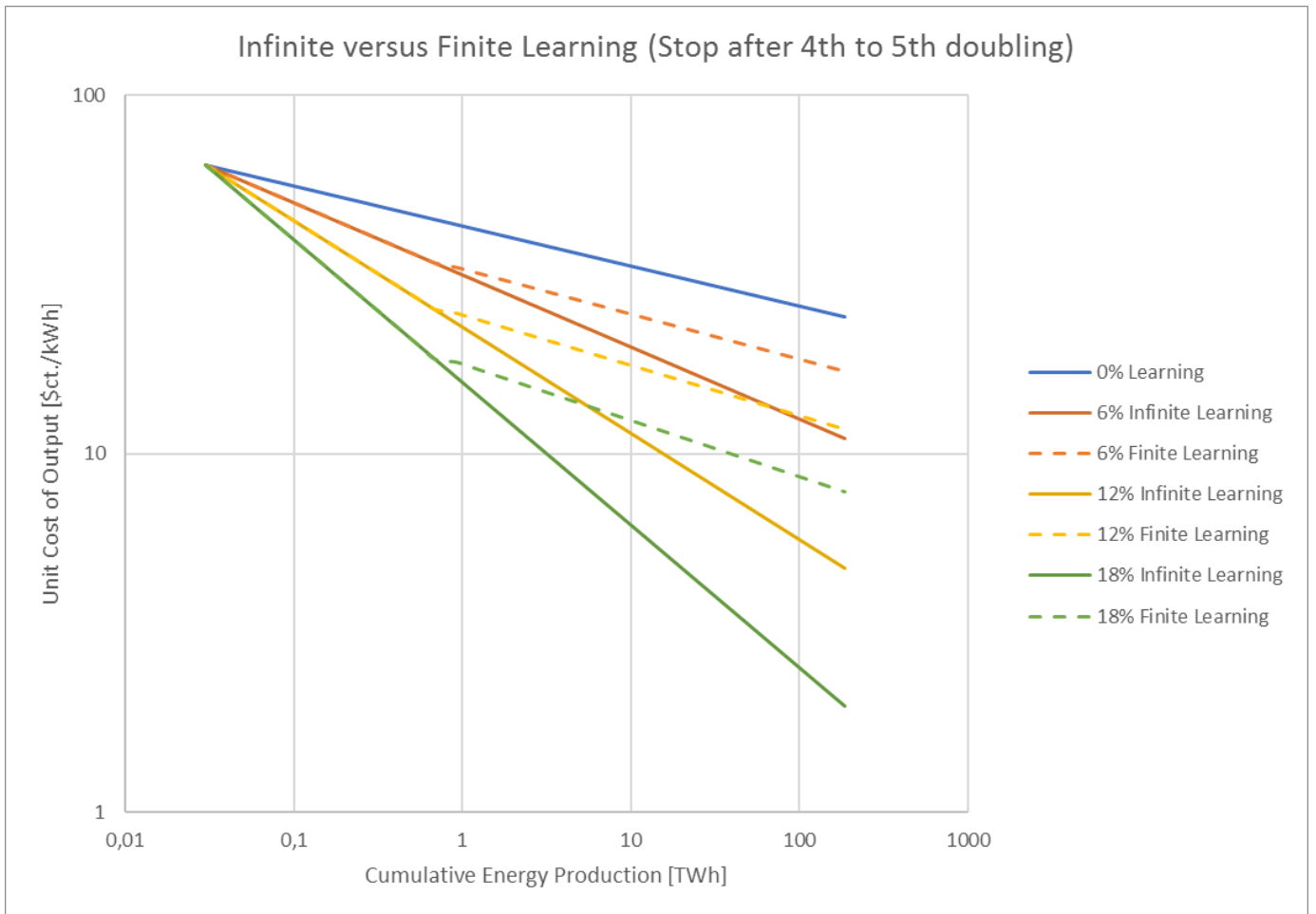
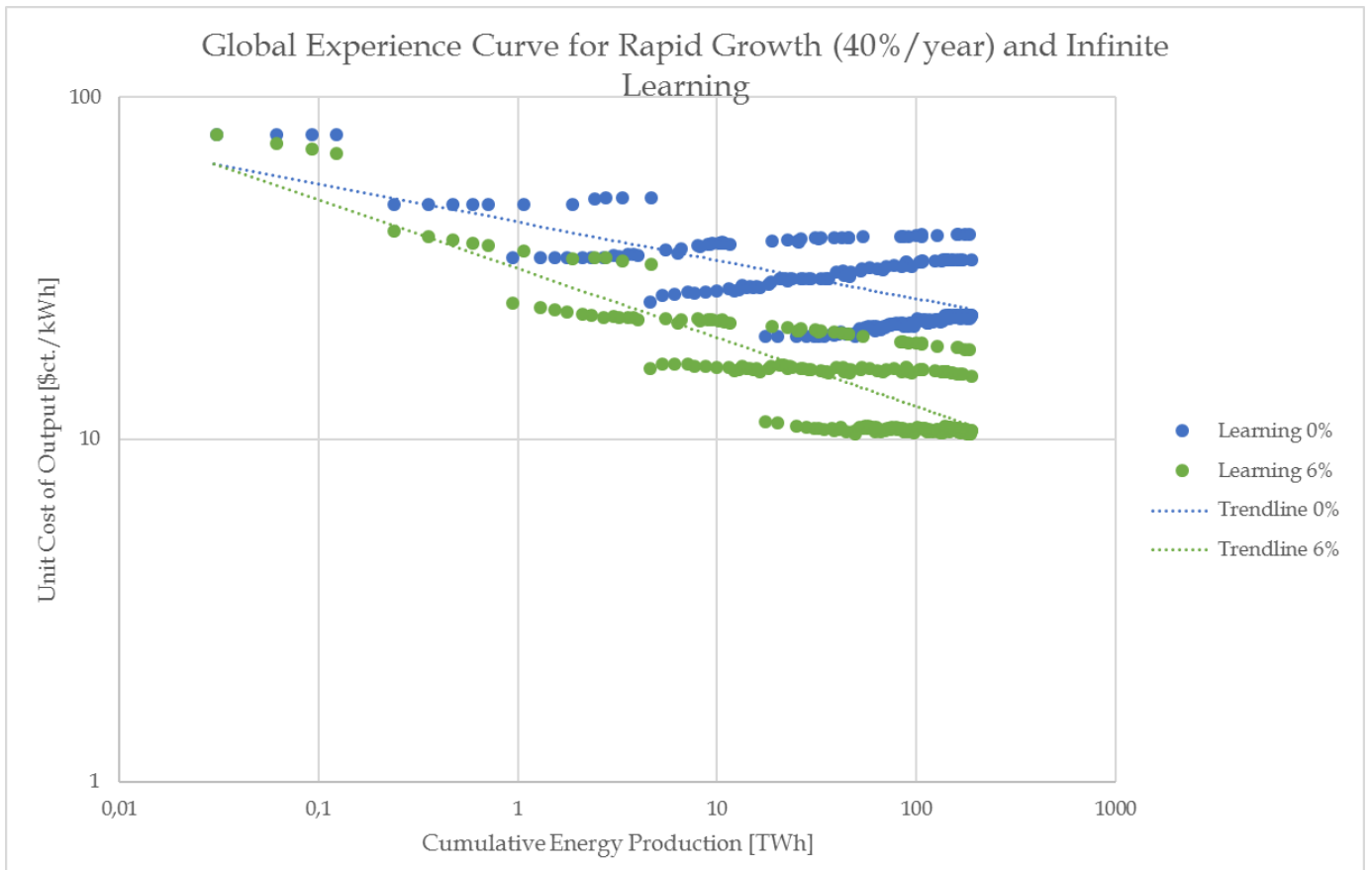
N.2.5. Rapid Growth (Discount Rate 18%)

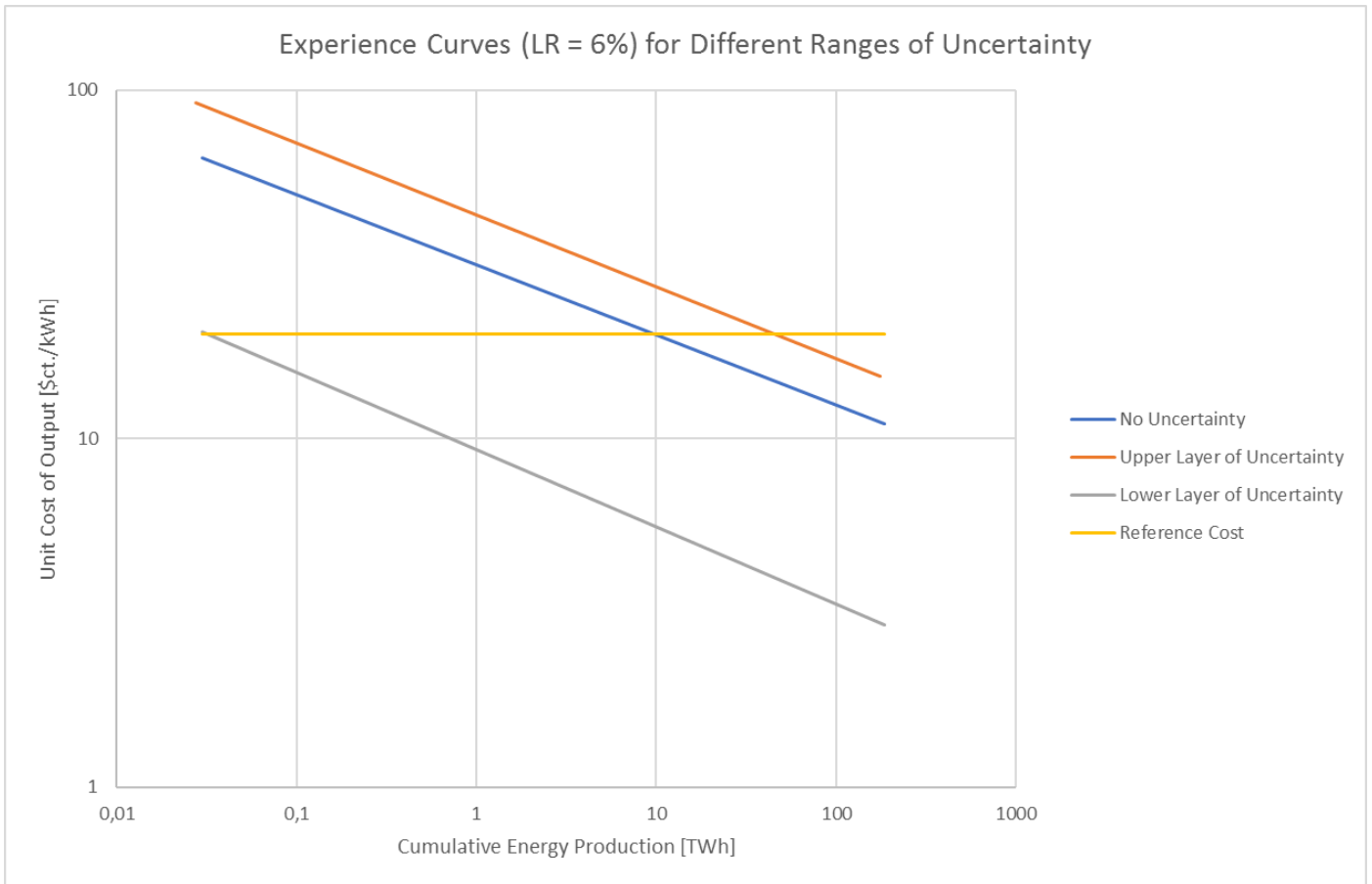




Figures N.5 Experience Curves for Rapid Growth (Discount Rate 18%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

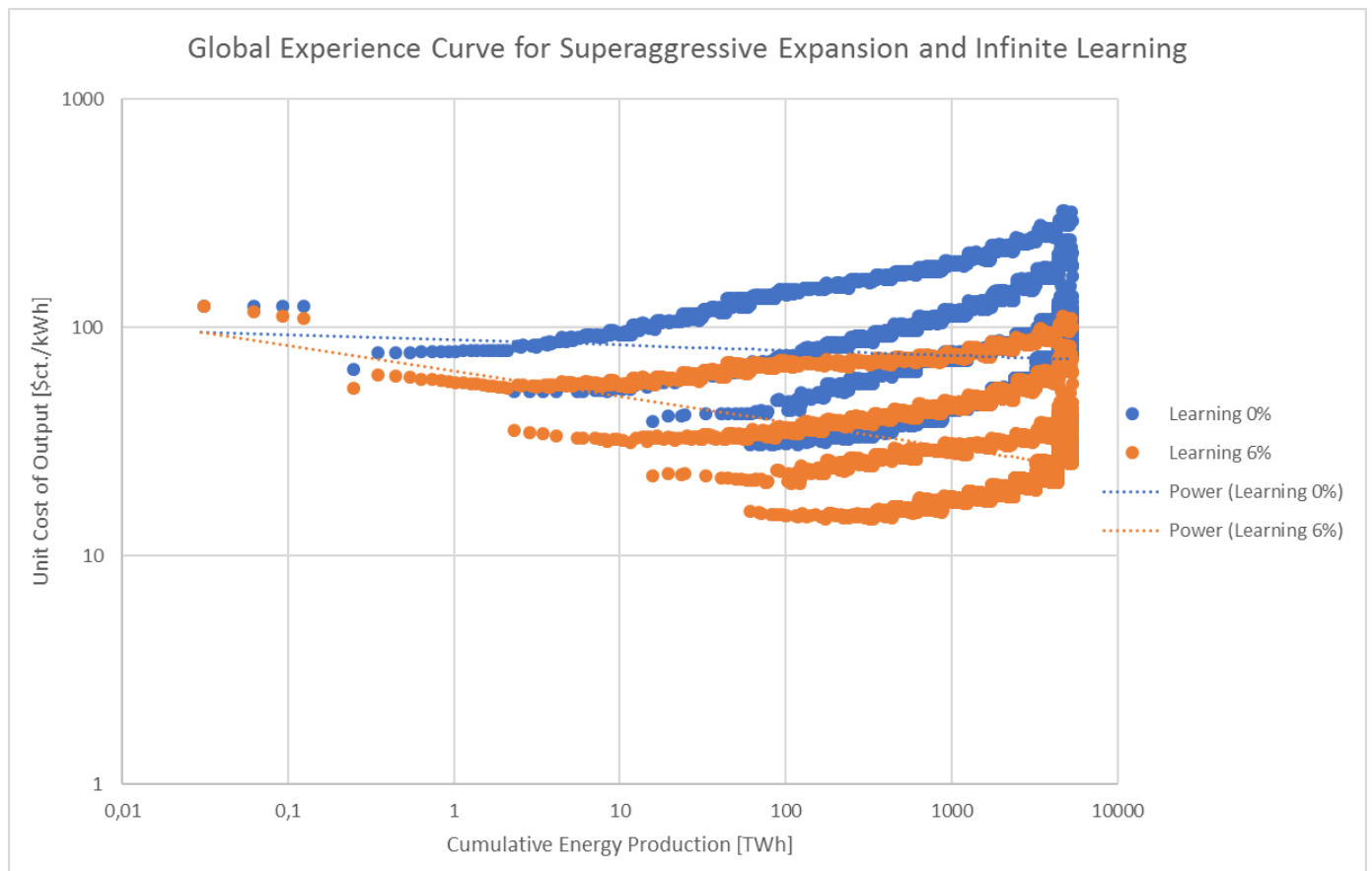
N.2.6. Rapid Growth (Discount Rate 10%)

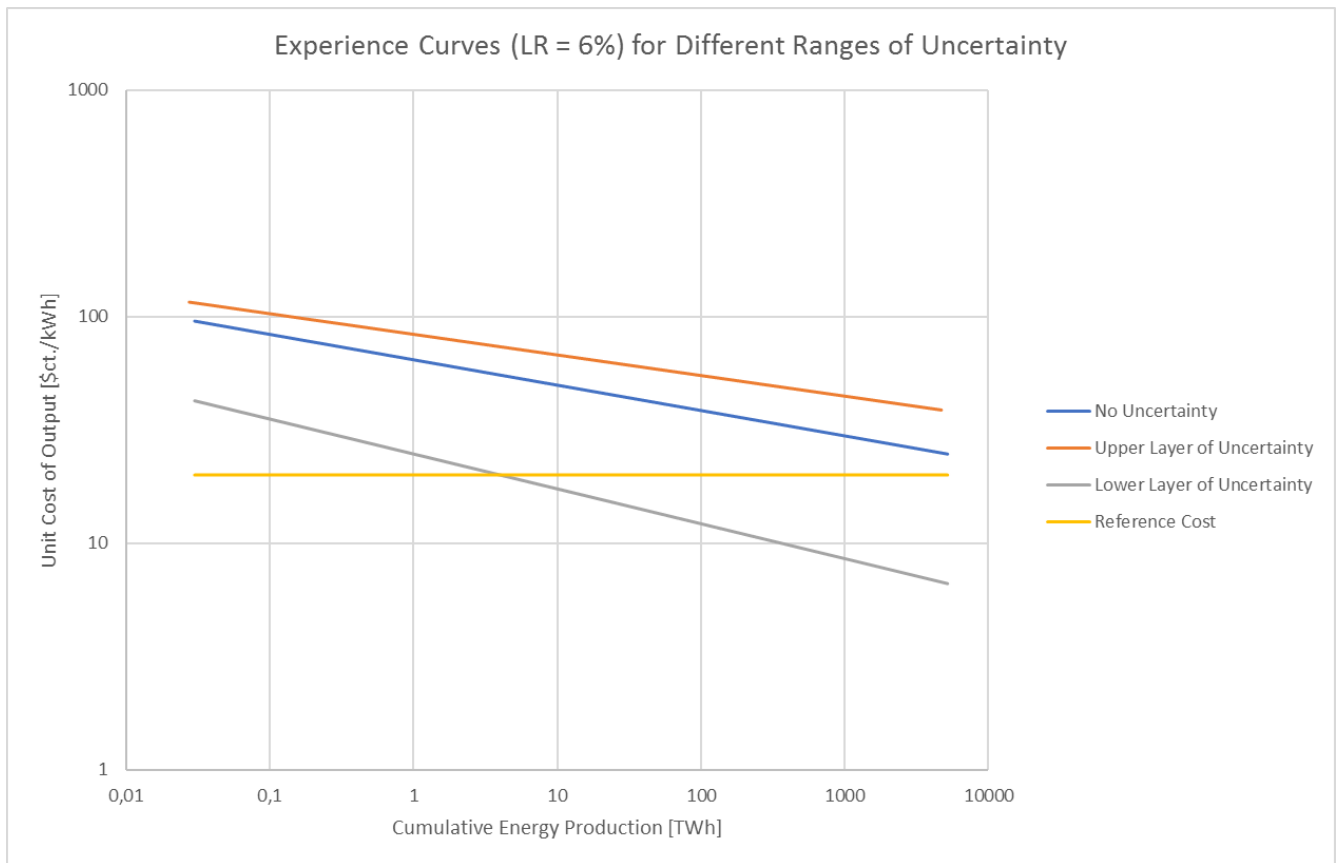




Figures N.6 Experience Curves for Rapid Growth (Discount Rate 10%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

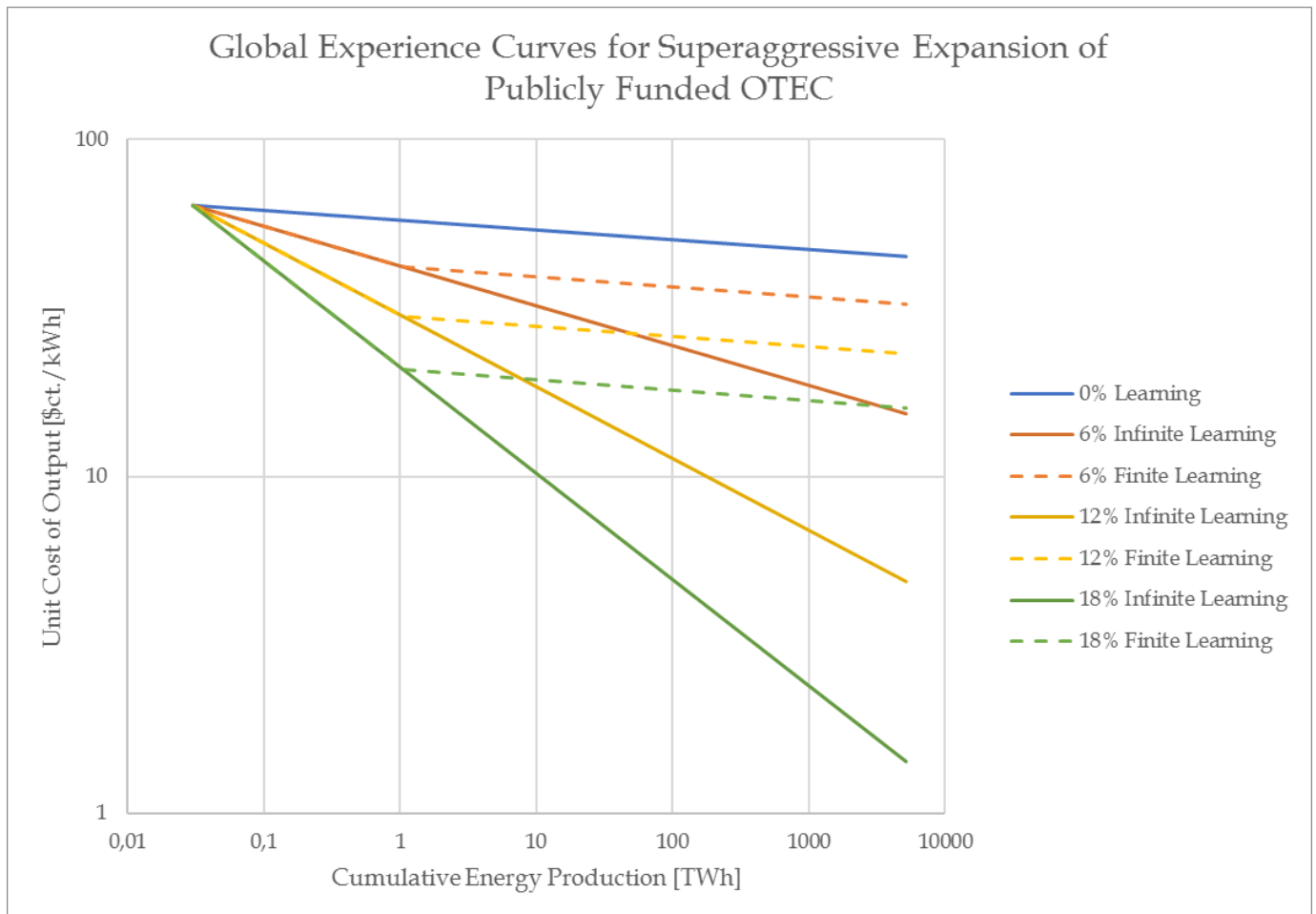
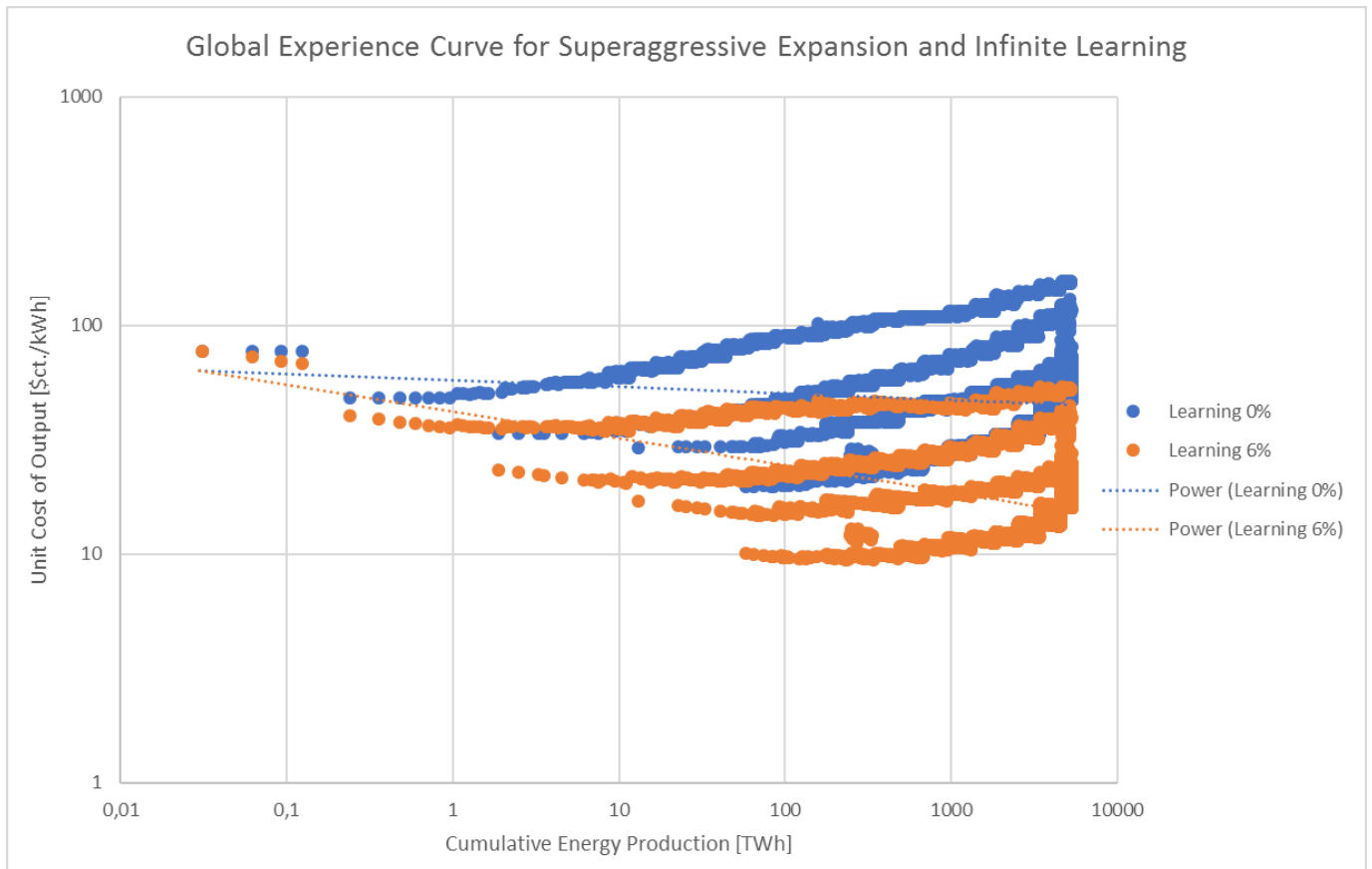
N.2.7. Superaggressive Expansion (Discount Rate 18%)

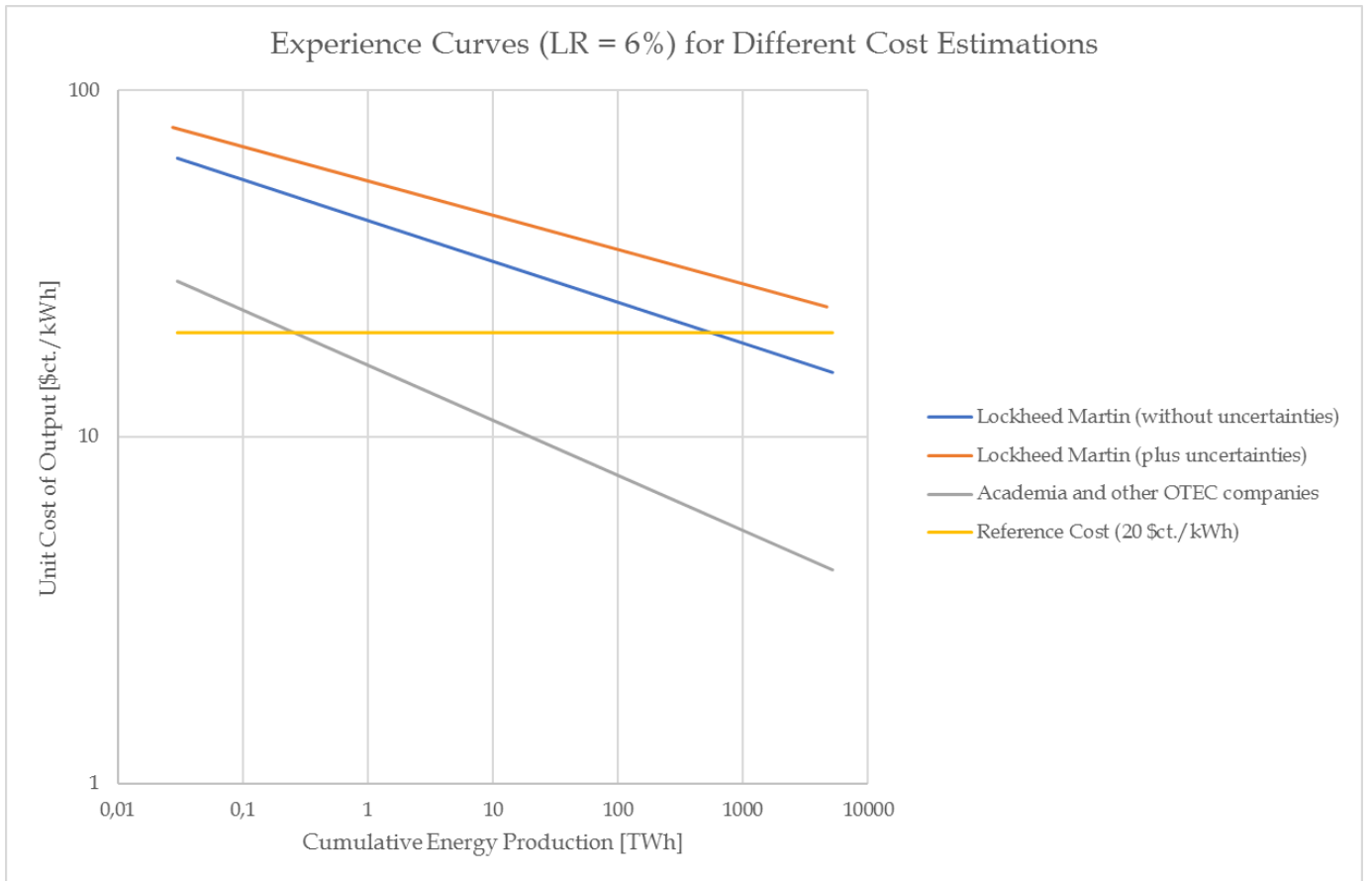




Figures N.7 Experience Curves for Superaggressive Expansion (Discount Rate 18%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

N.2.8. Superaggressive Expansion (Discount Rate 10%)





Figures N.8 Experience Curves for Superaggressive Expansion (Discount Rate 10%). Figures Show Approximation of Trendlines, Infinite vs. Finite Learning and the Impact of Different Cost Estimates (Own Illustration).

N.3. Mathematical Expressions of Experience Curves

N.3.1. Modest Growth

| Modest Growth | Infinite Learning | | Finite Learning | |
|---------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Learning Rate | Private | Public | Private | Public |
| 6% | $68,906 * x^{-0,302}$ | $44,685 * x^{-0,306}$ | - | - |
| 12% | $48,95 * x^{-0,397}$ | $31,744 * x^{-0,401}$ | - | - |
| 18% | $33,943 * x^{-0,499}$ | $22,012 * x^{-0,503}$ | - | - |
| 0% | $68,698 * x^{-0,201}$ | $44,288 * x^{-0,195}$ | - | - |
| 6% | $50,235 * x^{-0,29}$ | $32,385 * x^{-0,284}$ | $52,235 * x^{-0,251}$ | $33,942 * x^{-0,247}$ |
| 12% | $35,982 * x^{-0,385}$ | $23,197 * x^{-0,397}$ | $39,976 * x^{-0,305}$ | $25,56 * x^{-0,303}$ |
| 18% | $25,173 * x^{-0,487}$ | $16,229 * x^{-0,481}$ | $29,641 * x^{-0,361}$ | $18,866 * x^{-0,363}$ |
| 6% | $16,311 * x^{-0,343}$ | $9,728 * x^{-0,285}$ | - | - |
| 12% | $11,684 * x^{-0,438}$ | $6,968 * x^{-0,38}$ | - | - |
| 18% | $8,174 * x^{-0,54}$ | $4,875 * x^{-0,482}$ | - | - |

Table N.5 Mathematical Expressions of Experience Curves for Modest Growth. Colours Indicate the Cost Estimates for the Reference Case (Blue), Upper Layer (Orange) and Lower Layer (Grey) of Uncertainty.

N.3.2. Fast Growth

| Fast Growth | Infinite Learning | | Finite Learning | |
|---------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Learning Rate | Private | Public | Private | Public |
| 6% | $68,053 * x^{-0,253}$ | $44,813 * x^{-0,253}$ | - | - |
| 12% | $48,344 * x^{-0,343}$ | $31,834 * x - 0,349$ | - | - |
| 18% | $33,523 * x^{-0,445}$ | $22,075 * x^{-0,45}$ | - | - |
| 0% | $67,646 * x^{0,153}$ | $44,228 * x^{-0,154}$ | - | - |
| 6% | $49,465 * x^{-0,242}$ | $32,341 * x^{-0,244}$ | $51,971 * x^{-0,178}$ | $33,731 * x^{-0,184}$ |
| 12% | $35,431 * x^{-0,337}$ | $23,166 * x^{-0,339}$ | $39,24 * x^{-0,205}$ | $25,27 * x^{-0,215}$ |
| 18% | $24,788 * x^{-0,439}$ | $16,207 * x^{-0,441}$ | $29,045 * x^{-0,234}$ | $18,549 * x^{-0,245}$ |
| 6% | $15,802 * x^{-0,23}$ | $9,586 * x^{-0,268}$ | - | - |
| 12% | $11,318 * x^{-0,385}$ | $6,866 * x^{-0,363}$ | - | - |
| 18% | $7,9184 * x^{-0,487}$ | $4,804 * x^{-0,465}$ | - | - |

Table N.6 Mathematical Expressions of Experience Curves for Fast Growth. Colours Indicate the Cost Estimates for the Reference Case (Blue), Upper Layer (Orange) and Lower Layer (Grey) of Uncertainty.

N.3.3. Rapid Growth

| Rapid Growth | Infinite Learning | | Finite Learning | |
|---------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Learning Rate | Private | Public | Private | Public |
| 6% | $68,085 * x^{-0,208}$ | $43,737 * x^{-0,206}$ | - | - |
| 12% | $48,366 * x^{-0,303}$ | $31,07 * x^{0,301}$ | - | - |
| 18% | $33,538 * x^{-0,405}$ | $21,545 * x^{-0,403}$ | - | - |
| 0% | $67,489 * x^{-0,115}$ | $43,239 * x^{-0,112}$ | - | - |
| 6% | $49,35 * x^{-0,205}$ | $31,618 * x^{-0,201}$ | $50,931 * x^{-0,13}$ | $32,784 * x^{-0,126}$ |
| 12% | $35,35 * x^{-0,3}$ | $22,648 * x^{-0,297}$ | $37,728 * x^{-0,146}$ | $24,407 * x^{-0,141}$ |
| 18% | $24,73 * x^{-0,402}$ | $15,844 * x^{-0,398}$ | $27,361 * x^{-0,163}$ | $17,796 * x^{-0,157}$ |
| 6% | $15,436 * x^{-0,243}$ | $9,301 * x^{-0,222}$ | - | - |
| 12% | $11,056 * x^{-0,338}$ | $6,662 * x^{-0,317}$ | - | - |
| 18% | $7,735 * x^{-0,44}$ | $4,661 * x^{-0,419}$ | - | - |

Table N.7 Mathematical Expressions of Experience Curves for Rapid Growth. Colours Indicate the Cost Estimates for the Reference Case (Blue), Upper Layer (Orange) and Lower Layer (Grey) of Uncertainty.

N.3.4. Superaggressive Expansion

| Superaggressive Expansion | Infinite Learning | | Finite Learning | |
|---------------------------|-----------------------|-----------------------|-----------------------|----------------------|
| Learning Rate | Private | Public | Private | Public |
| 6% | $83,591 * x^{-0,091}$ | $54,846 * x^{-0,099}$ | - | - |
| 12% | $59,382 * x^{-0,186}$ | $38,962 * x^{-0,194}$ | - | - |
| 18% | $41,177 * x^{-0,288}$ | $27,017 * x^{-0,296}$ | - | - |
| 0% | $88,262 * x^{-0,023}$ | $57,653 * x^{-0,029}$ | - | - |
| 6% | $64,54 * x^{-0,112}$ | $42,158 * x^{-0,118}$ | $64,949 * x^{-0,023}$ | $41,966 * x^{-0,03}$ |
| 12% | $46,229 * x^{-0,207}$ | $30,197 * x^{-0,213}$ | $46,836 * x^{-0,024}$ | $29,914 * x^{-0,03}$ |
| 18% | $32,342 * x^{-0,309}$ | $21,126 * x^{0,315}$ | $33,003 * x^{-0,025}$ | $20,82 * x^{-0,031}$ |
| 6% | $24,783 * x^{-0,154}$ | $16,123 * x^{-0,159}$ | - | - |
| 12% | $17,752 * x^{-0,249}$ | $11,549 * x^{-0,254}$ | - | - |
| 18% | $12,413 * x^{-0,351}$ | $8,0796 * x^{-0,356}$ | - | - |

Table N.8 Mathematical Expressions of Experience Curves for Superaggressive Expansion. Colours Indicate the Cost Estimates for the Reference Case (Blue), Upper Layer (Orange) and Lower Layer (Grey) of Uncertainty.

N.4. Dynamic Global Supply Curves

N.4.1. Modest Growth (Discount Rate 18%)

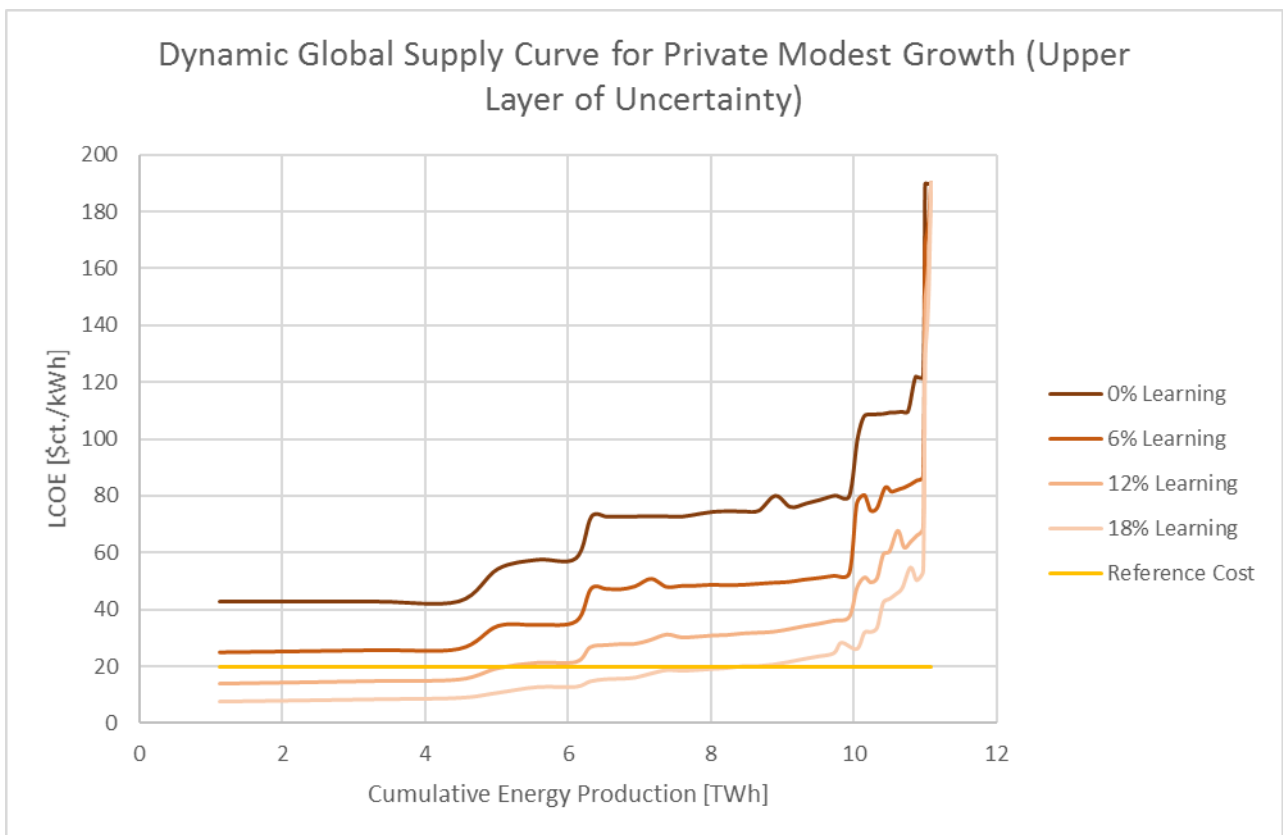
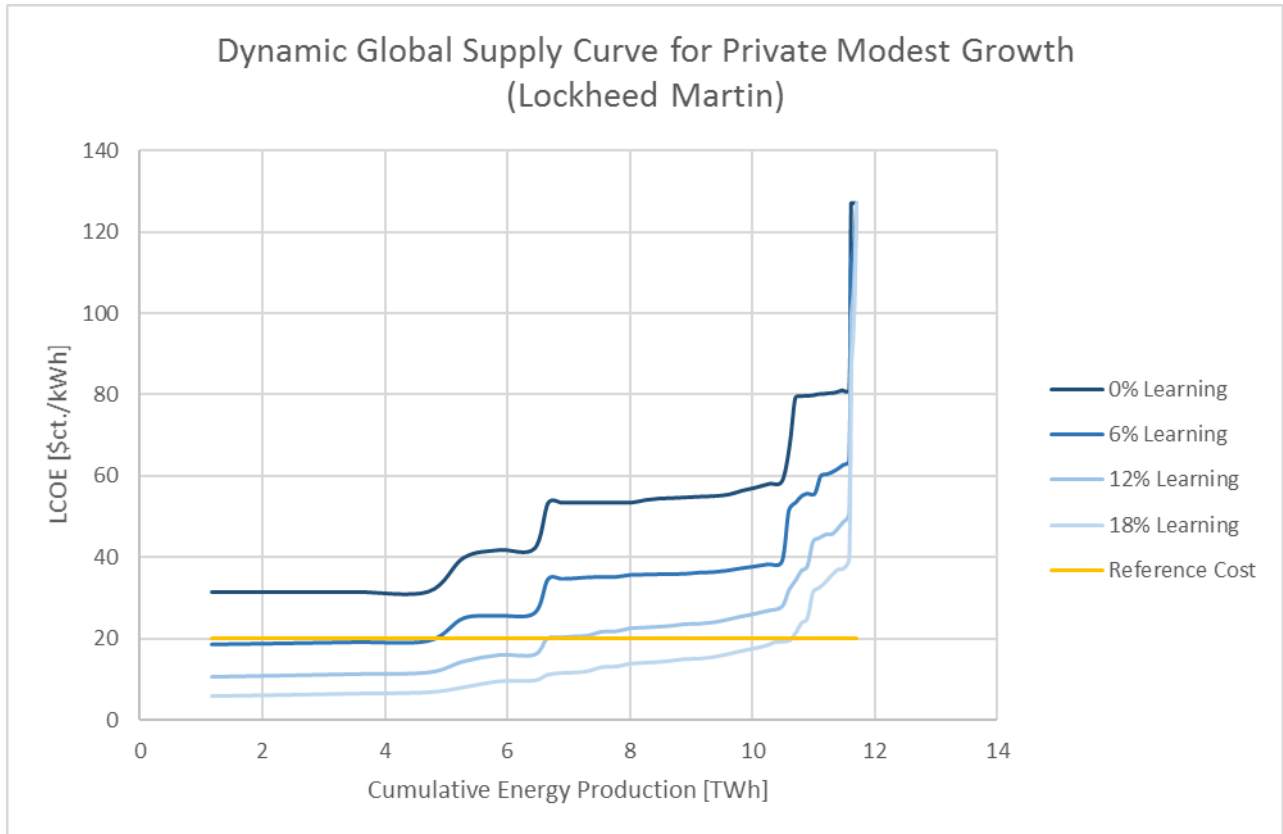


Figure N.9 Dynamic Global Supply Curves for Private Modest Growth (Own Illustration).

N.4.2. Modest Growth (Discount Rate 10%)

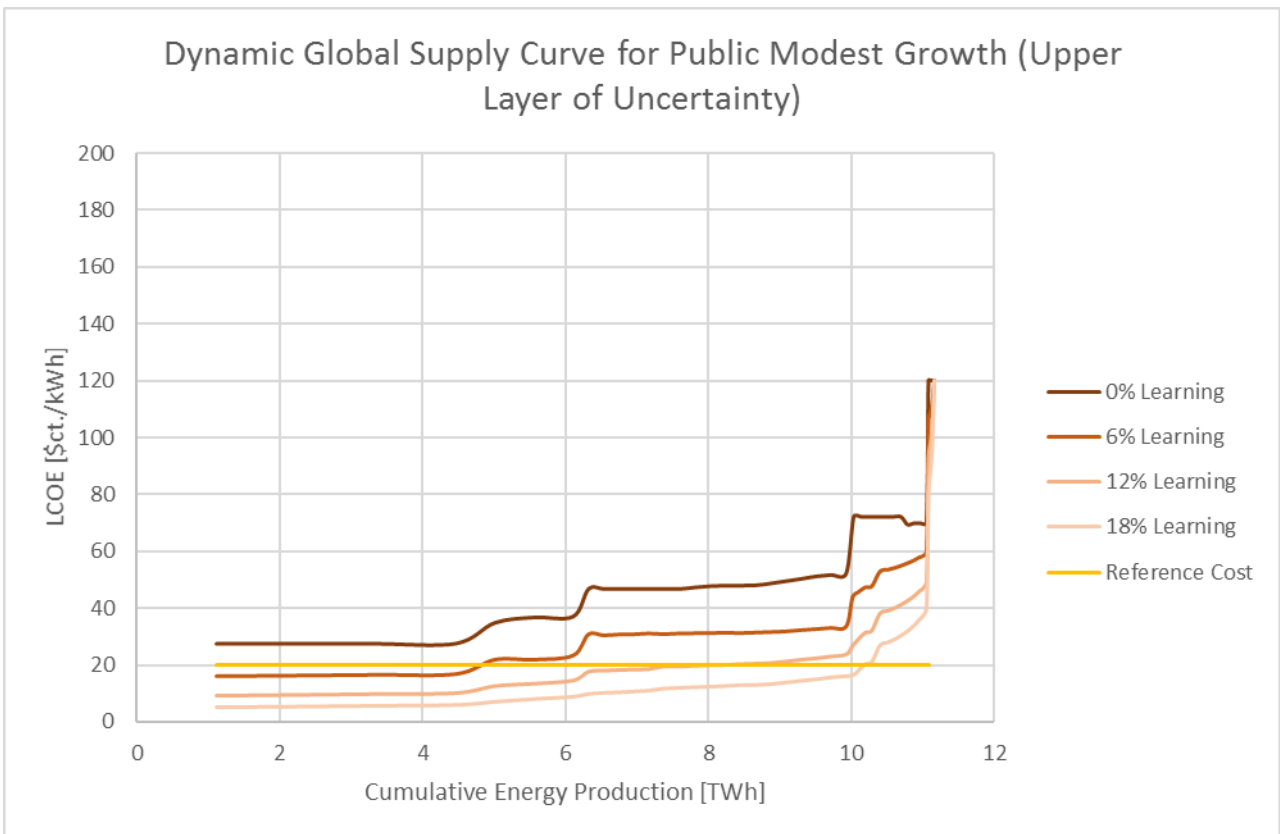
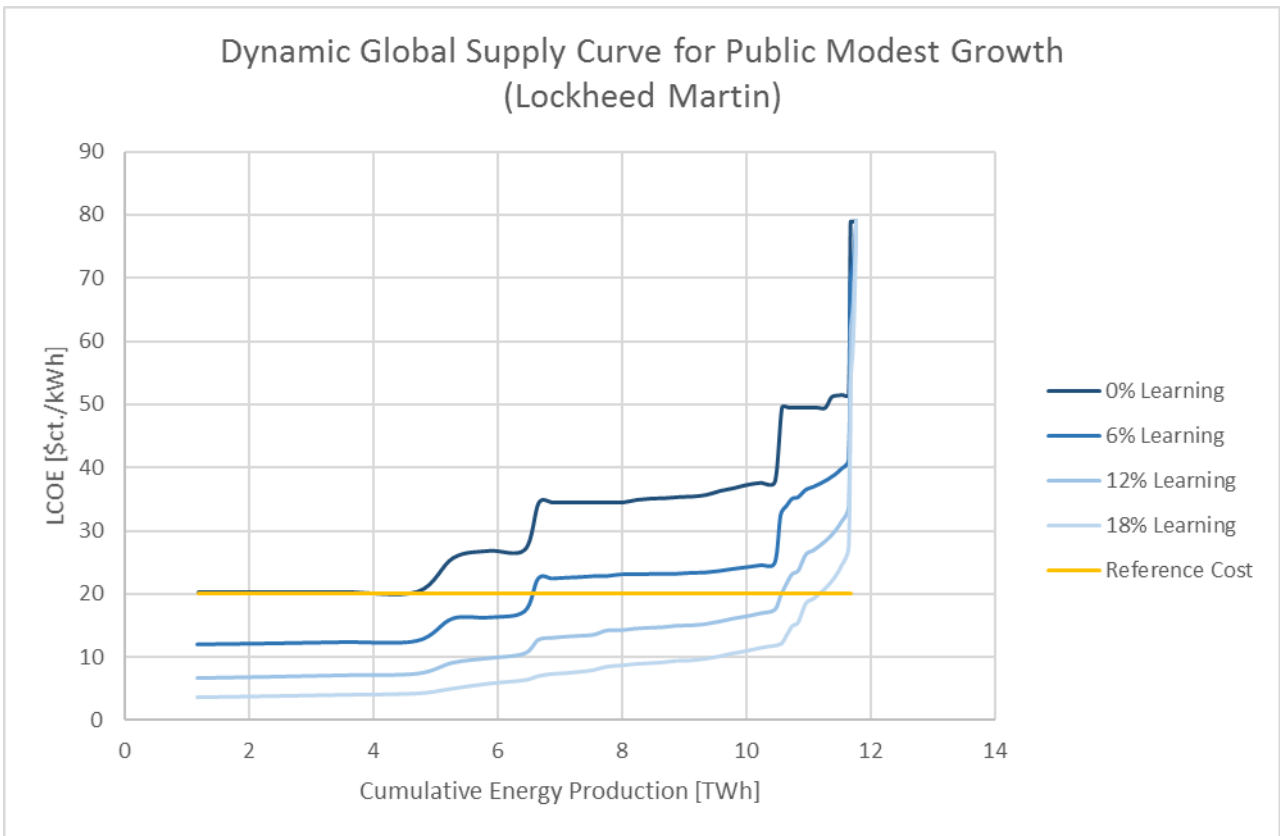


Figure N.10 Dynamic Global Supply Curves for Public Modest Growth (Own Illustration).

N.4.3. Fast Growth (Discount Rate 18%)

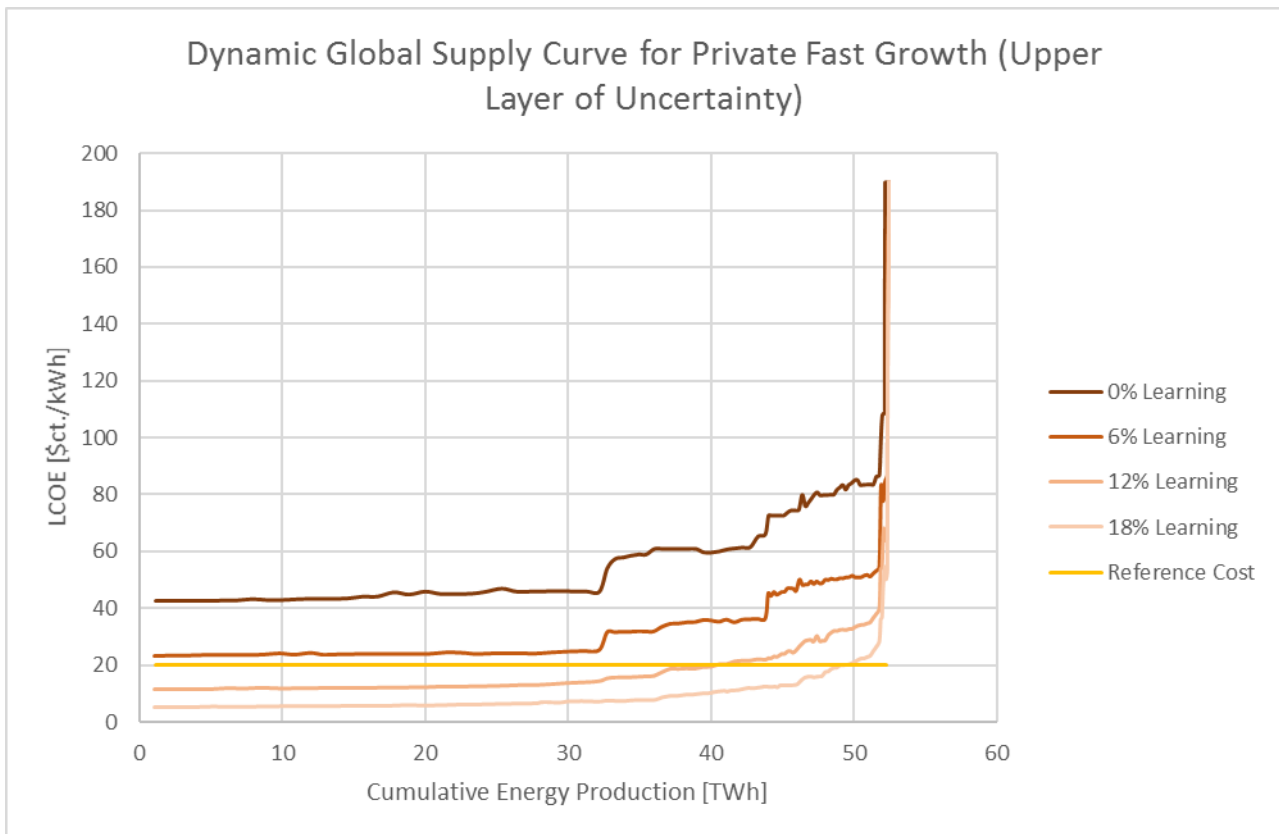
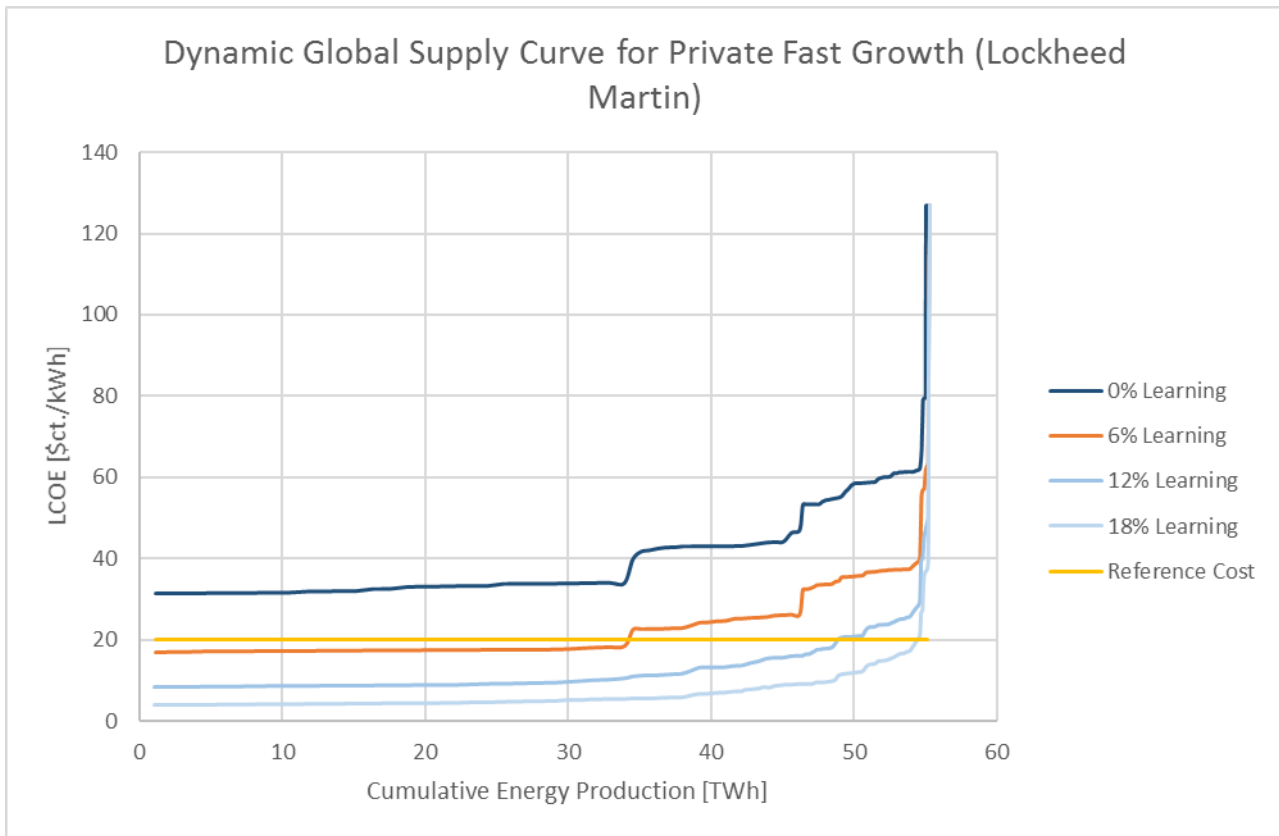


Figure N.11 Dynamic Global Supply Curves for Private Fast Growth (Own Illustration).

N.4.4. Fast Growth (Discount Rate 10%)

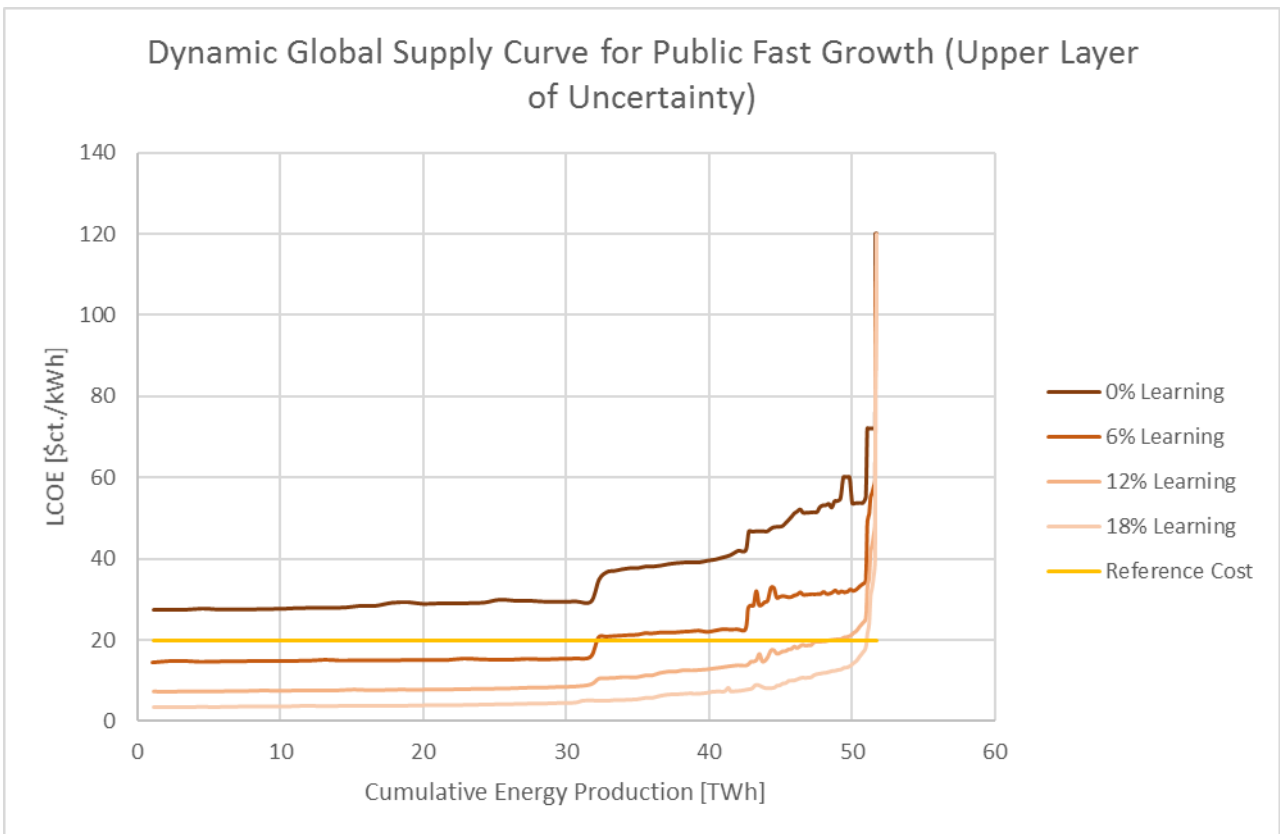
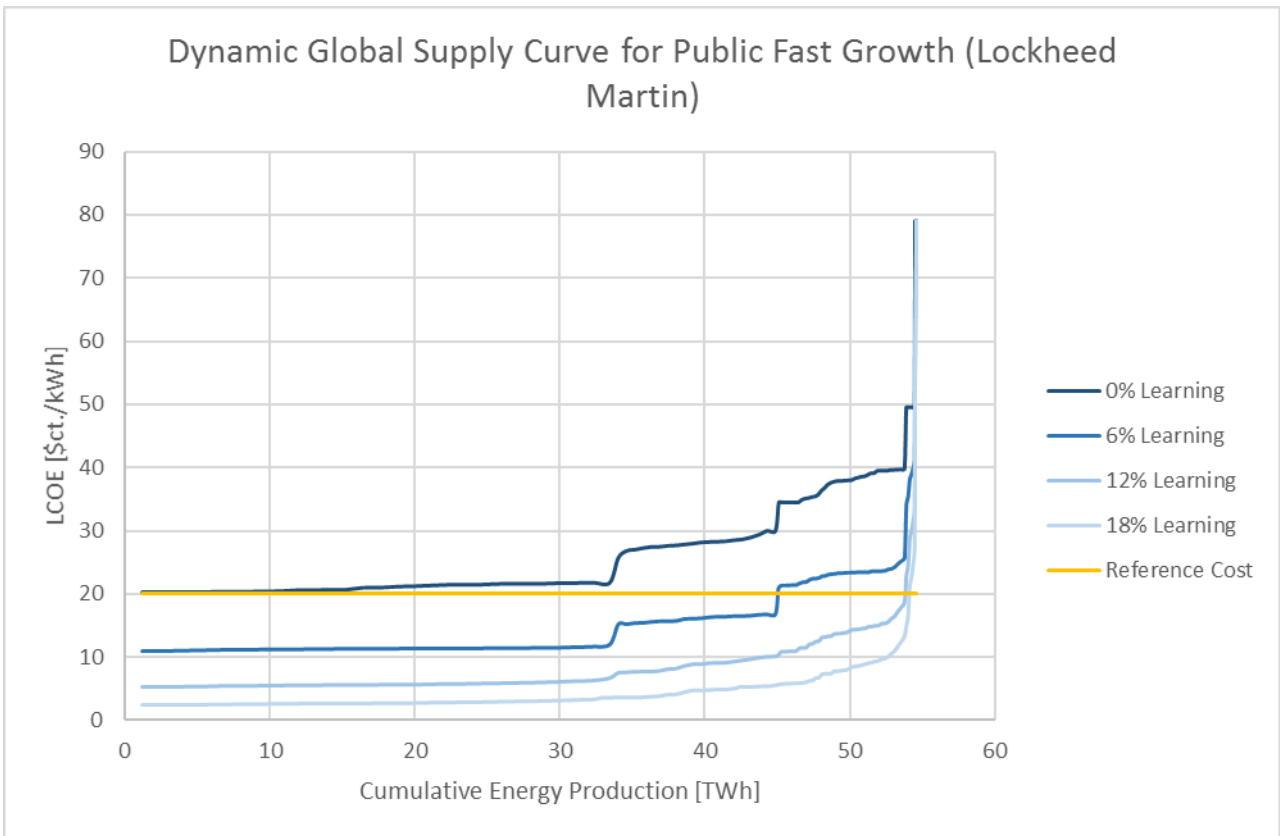


Figure N.12 Dynamic Global Supply Curves for Public Fast Growth (Own Illustration).

N.4.5. Rapid Growth (Discount Rate 18%)

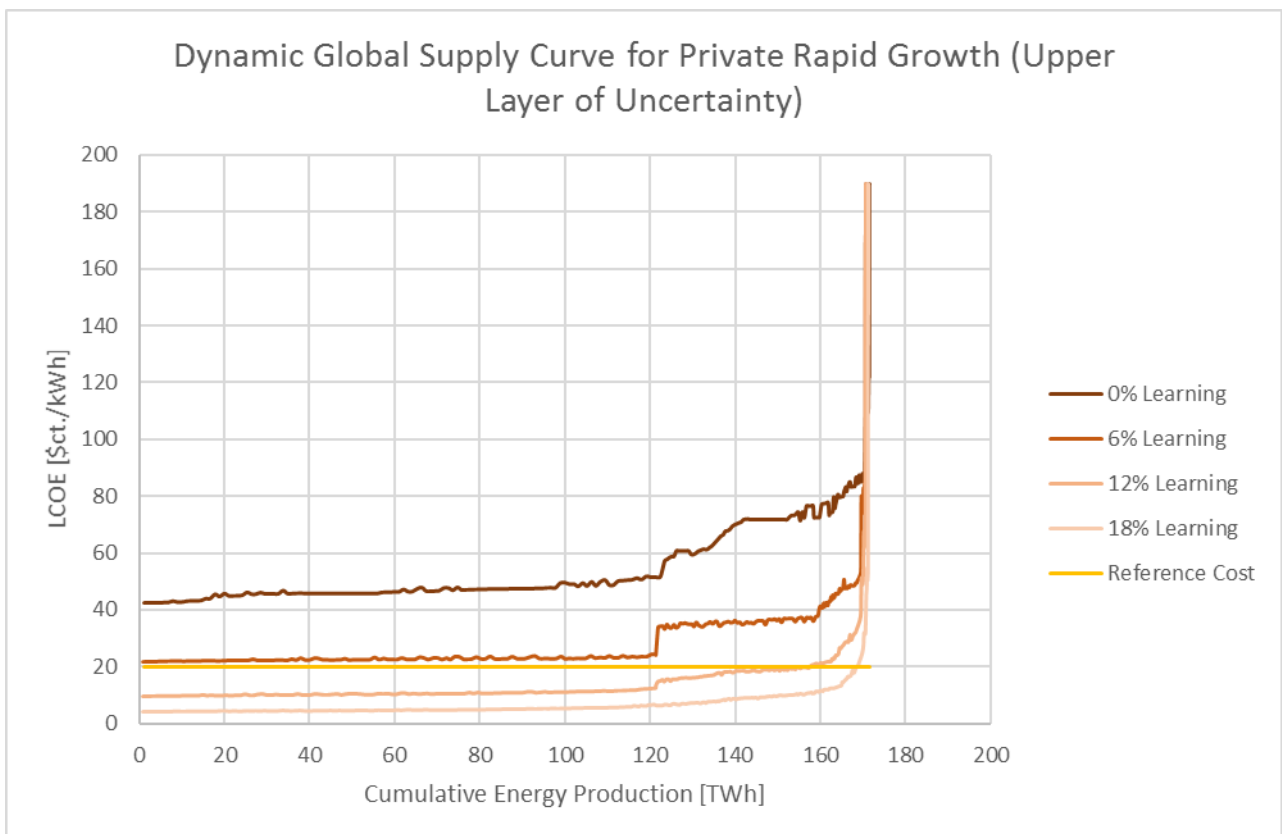
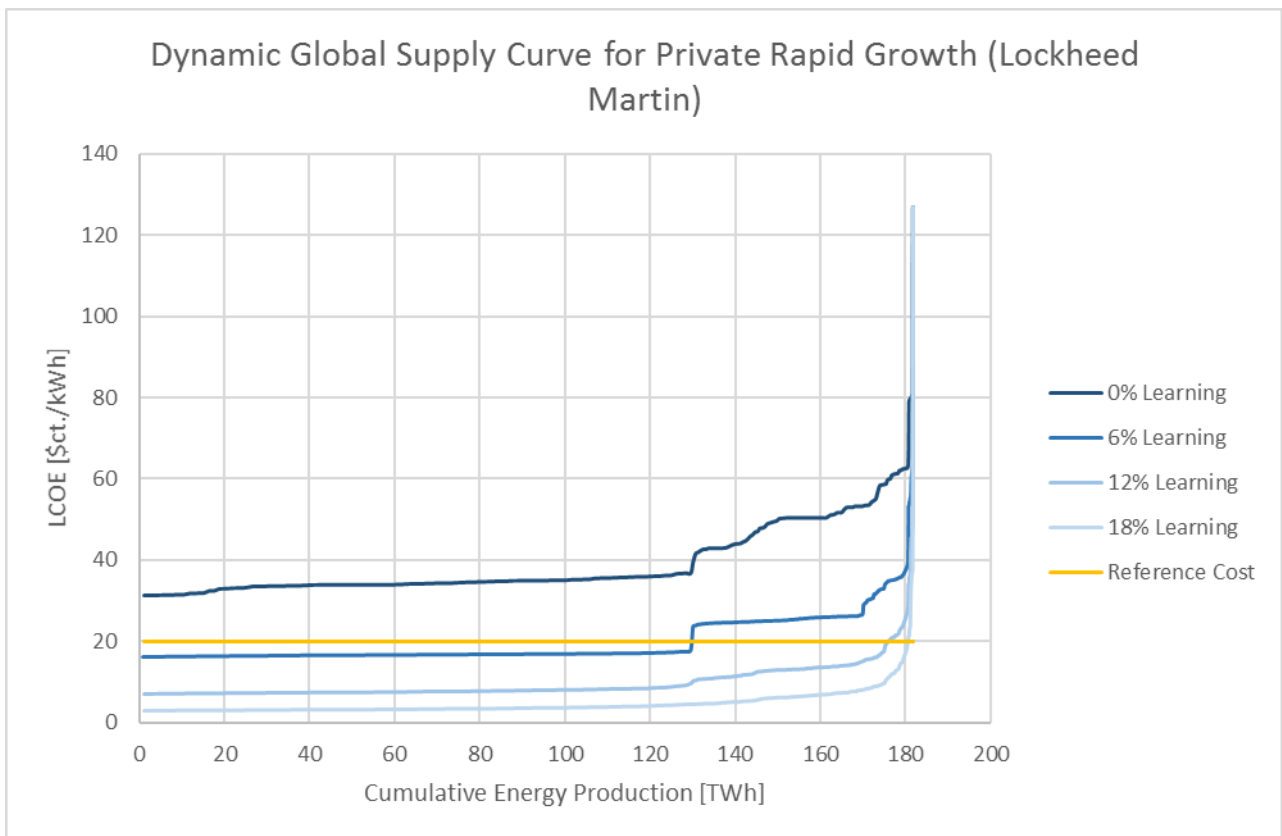


Figure N.13 Dynamic Global Supply Curves for Private Rapid Growth (Own Illustration).

N.4.6. Rapid Growth (Discount Rate 10%)

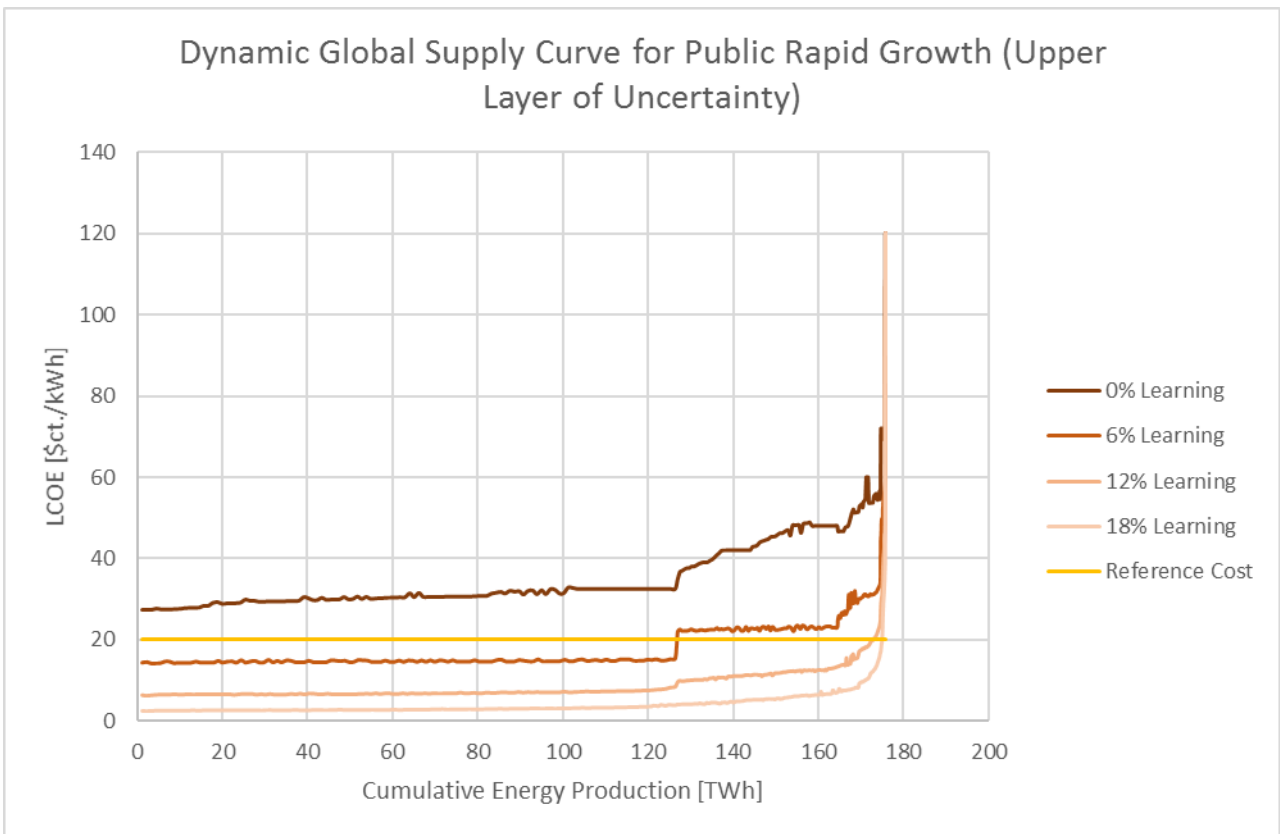
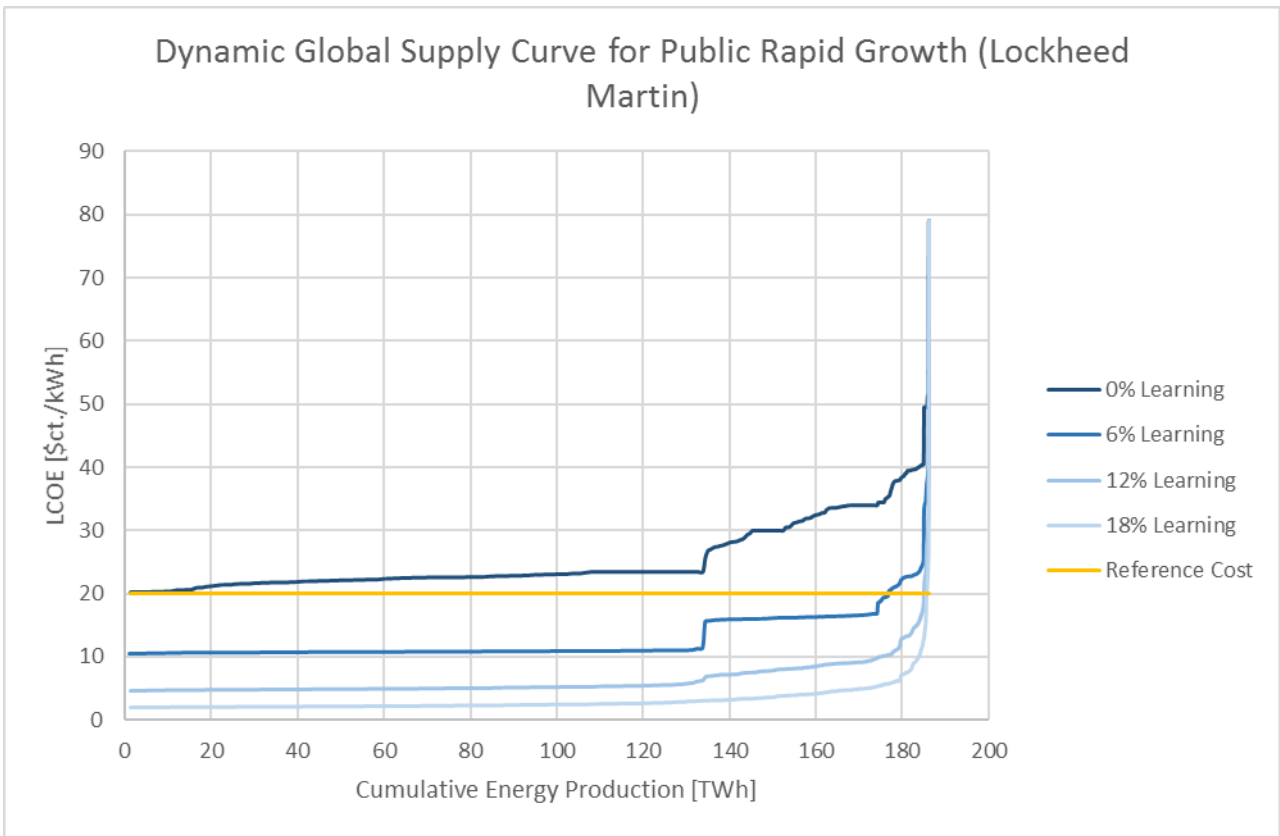


Figure N.14 Dynamic Global Supply Curves for Public Rapid Growth (Own Illustration).

N.4.7. Superaggressive Expansion (Discount Rate 18%)

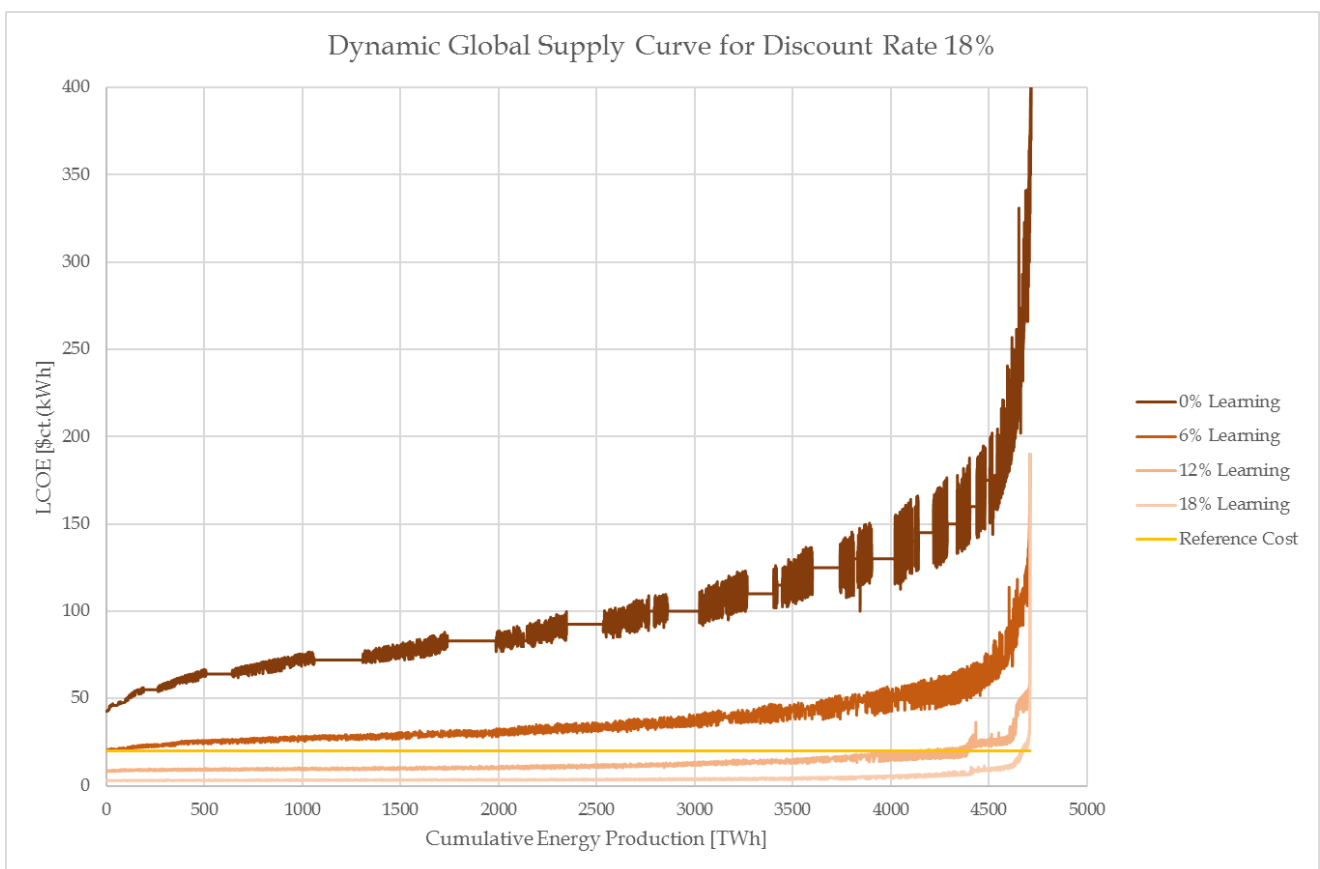
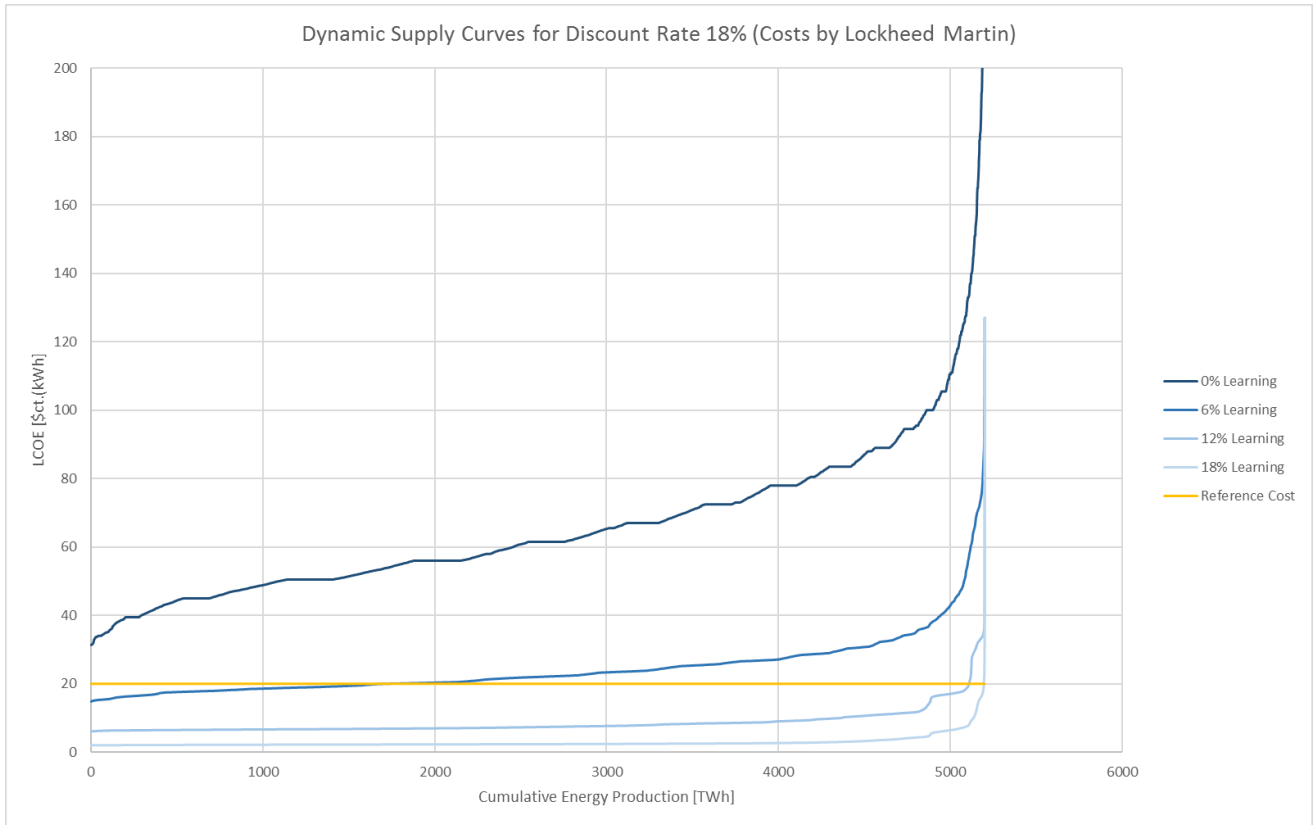


Figure N.15 Dynamic Global Supply Curves for Private Superaggressive Expansion (Own Illustration).

N.4.8. Superaggressive Expansion (Discount Rate 10%)

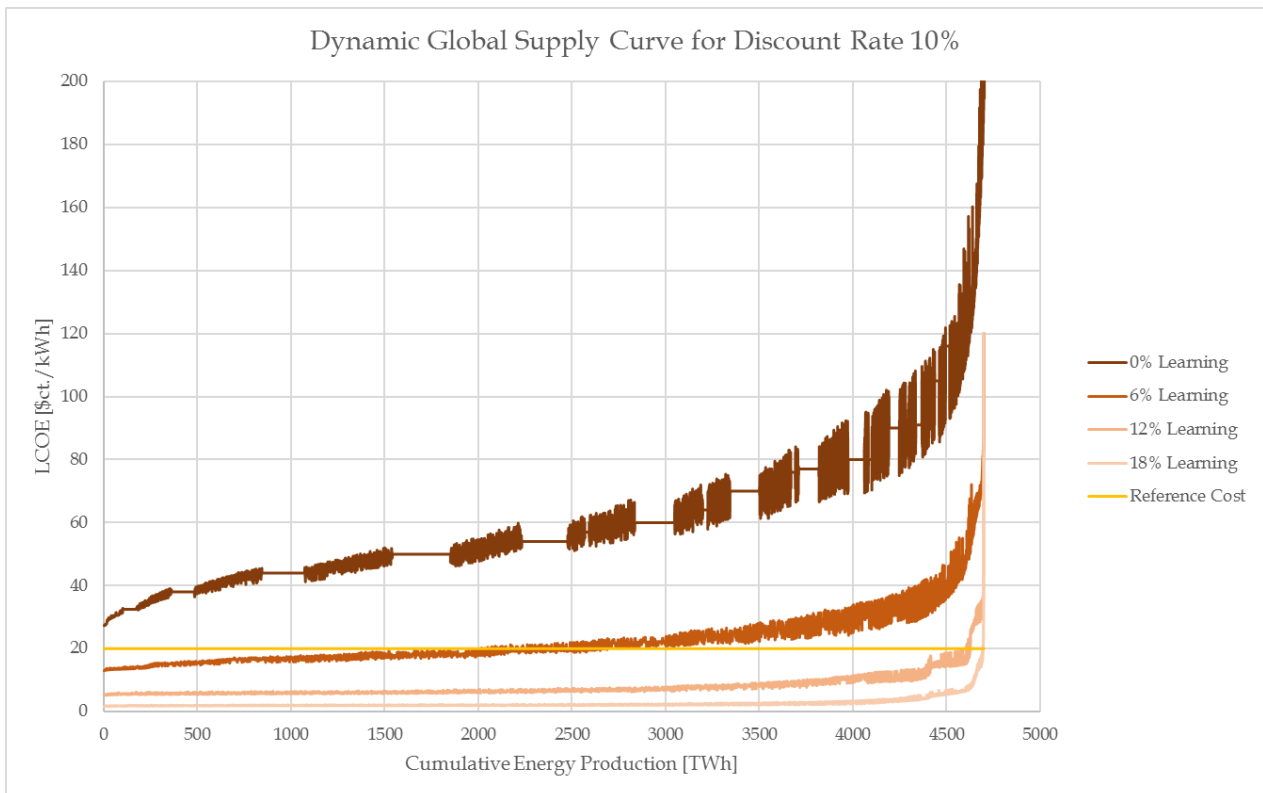
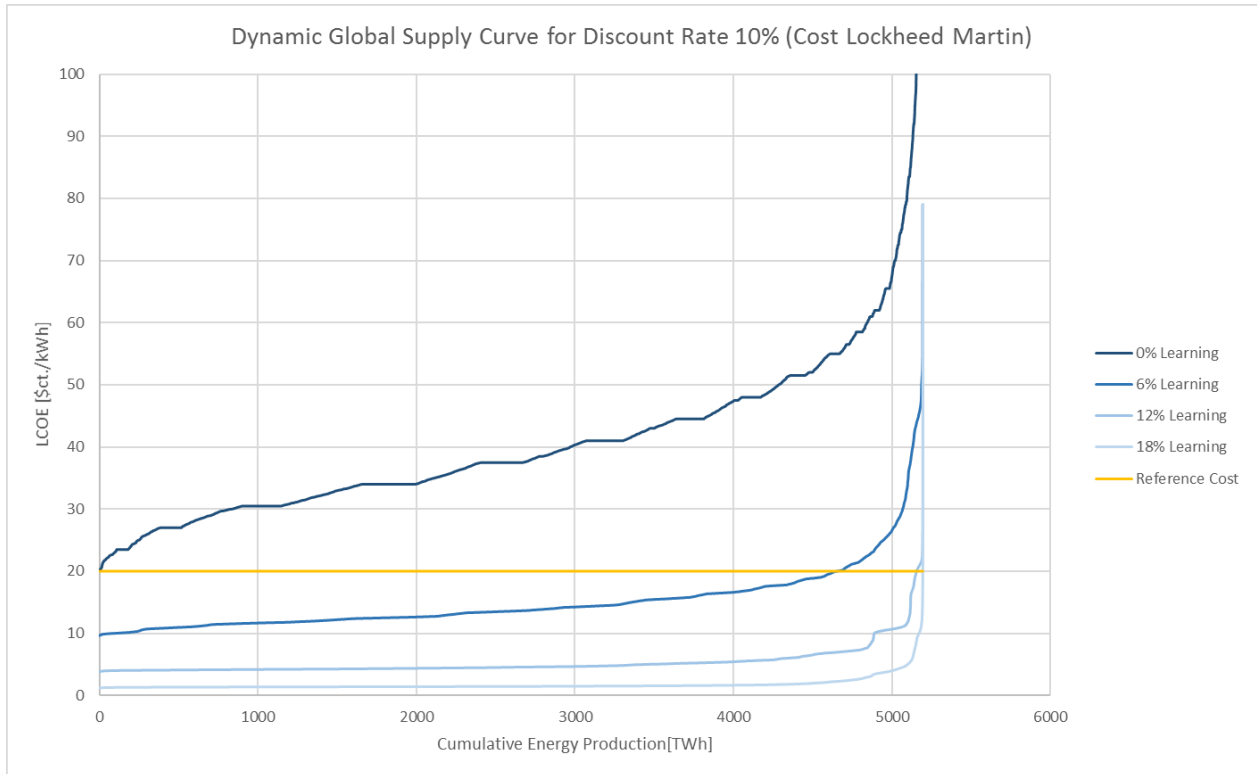


Figure N.16 Dynamic Global Supply Curves for Public Superaggressive Expansion (Own Illustration).

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