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How a 100% renewable power supply can be achieved and how to finance it?

Prof. Dr. Olav Hohmeyer

Europa-Universität Flensburg

Phnom Penh, Cambodia, October 26th, 2017

Structure of the Presentation

- The Seychelles example:
  - 100% renewable power supply
- Financing proposal to the NAMA facility
  - Additional financing possibilities from the Green Climate Fund (GCF)
- Results of a first 100% RE study on Cambodia (WWF et al.)
- 100% RE power supply a chance for Cambodia?

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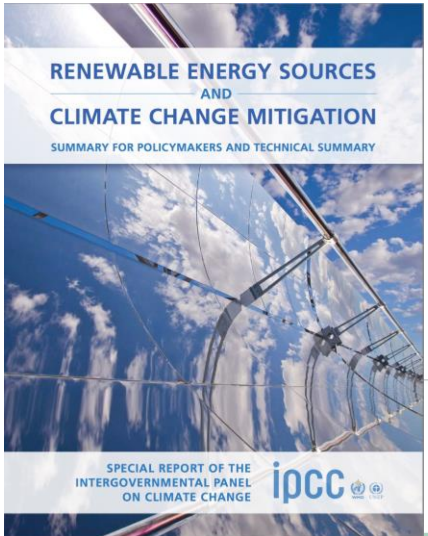
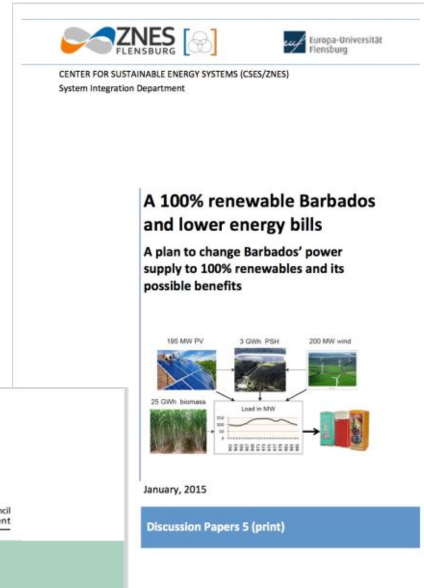
General Background of the Presentation

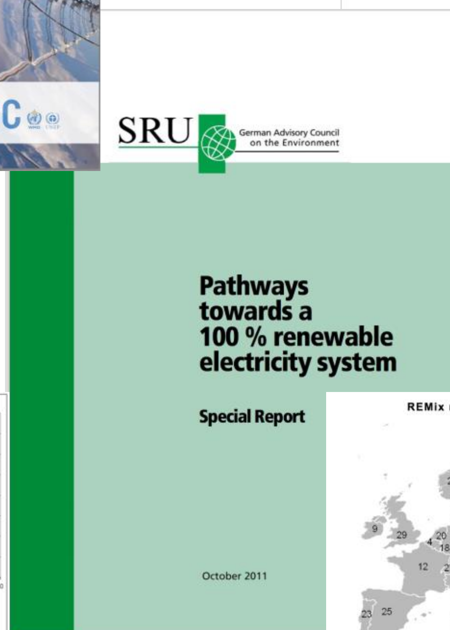


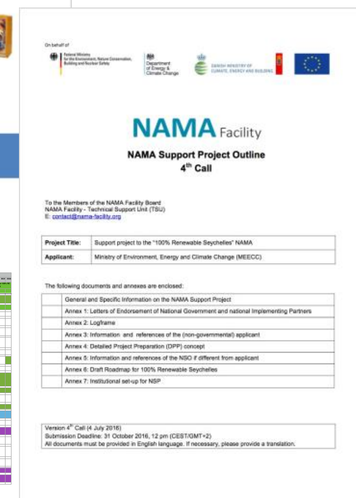
2011

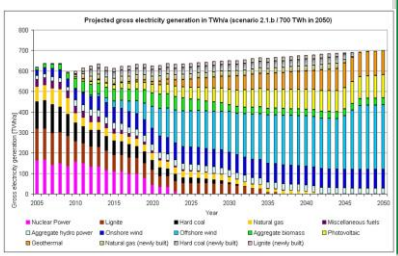


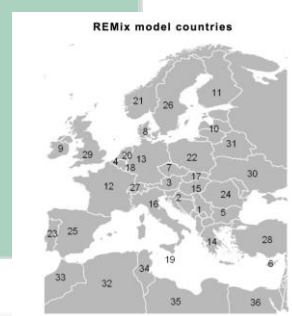
2015

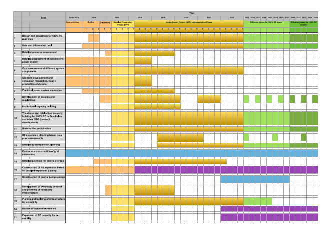
2016











2011

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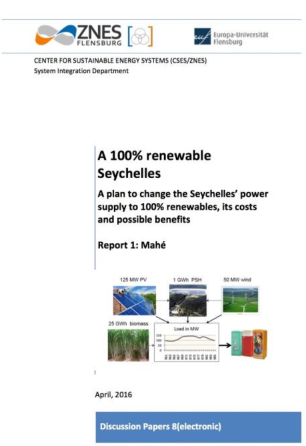
A 100% renewable energy future for Mahé


ZNES FLENSBURG

Europa-Universität Flensburg

CENTER FOR SUSTAINABLE ENERGY SYSTEMS (CSES/ZNES)
System Integration Department

A 100% renewable Seychelles

A plan to change the Seychelles' power supply to 100% renewables, its costs and possible benefits

Report 1: Mahé

125 MW PV
1 GWh PSH
50 MW wind
25 GWh biomass
Load in MW

April, 2016

Discussion Papers 8(electronic)

Prof. Dr. Olav Hohmeyer

Europa-Universität Flensburg

Phnom Penh, Cambodia, October 26th, 2017

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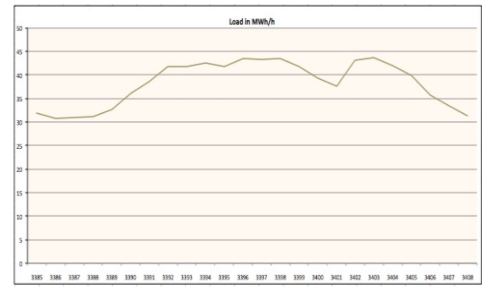
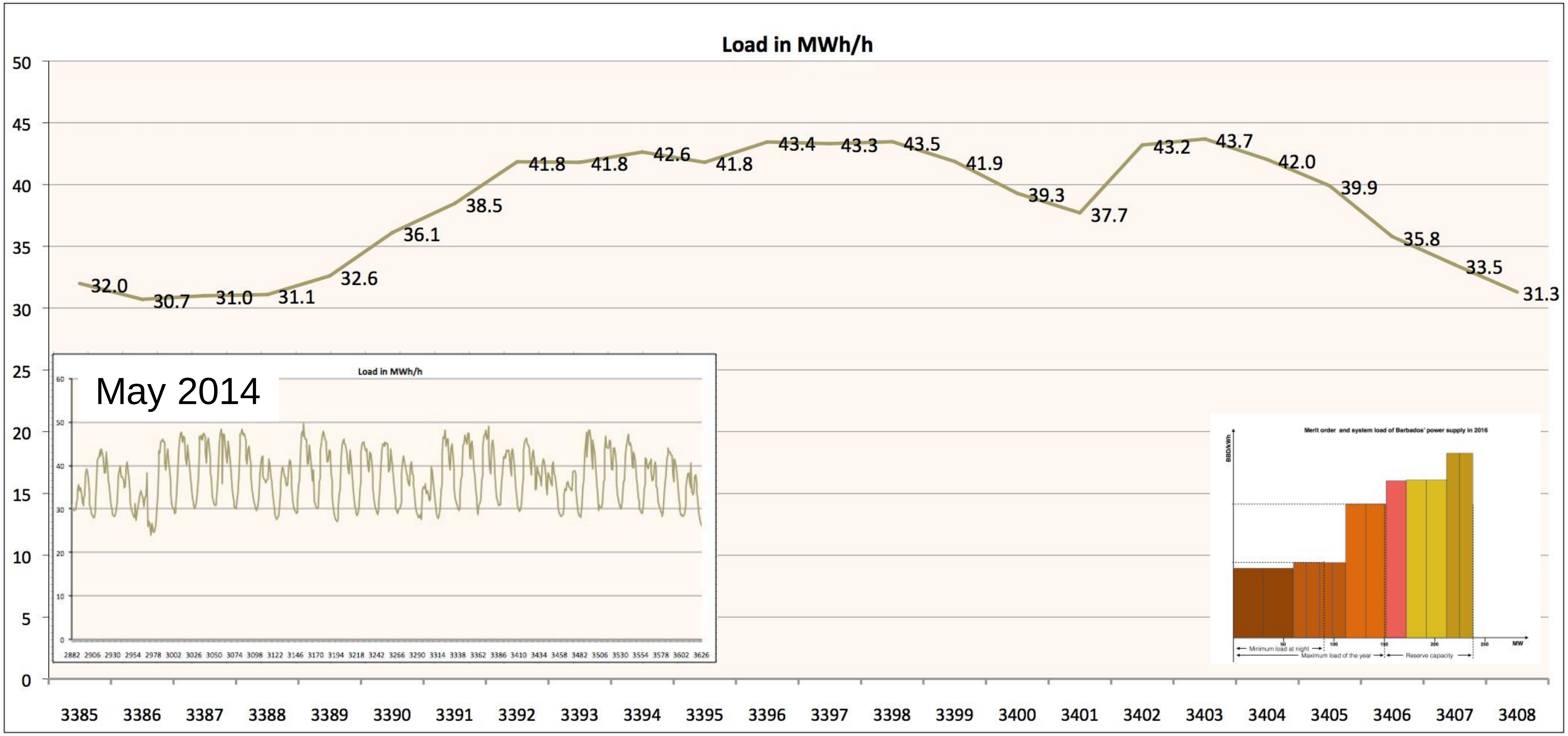
Present electricity demand and supply in Mahé

1.	Electricity production 2014:	320 GWh/a	Load curve May 22nd
2.	Peak load:	51.6 MW	
3.	Total operating expenses:	730.2 M SCR	
4.	Fuel costs:	651.1 M SCR	
5.	Total costs per kWh:	2.33 SCR/kWh	(1 USD = 13.7 SCR)
6.	Fuel costs per kWh:	2.08 SCR/kWh	(0.15 USD/kWh)
7.	Average rate charged (2014)	3.85 SCR/kWh	(0.28 USD/kWh)
8.	Virtually all PUC production based on HFO/diesel		
	14 low and high speed diesel	74 MW (diesel)	
	8 wind turbines	6 MW	



Hourly load curve for Mahé (May 22nd) serviced by diesel generators today

In the present system load is easy to predict and easy to service.
Easy to balance the system every hour.



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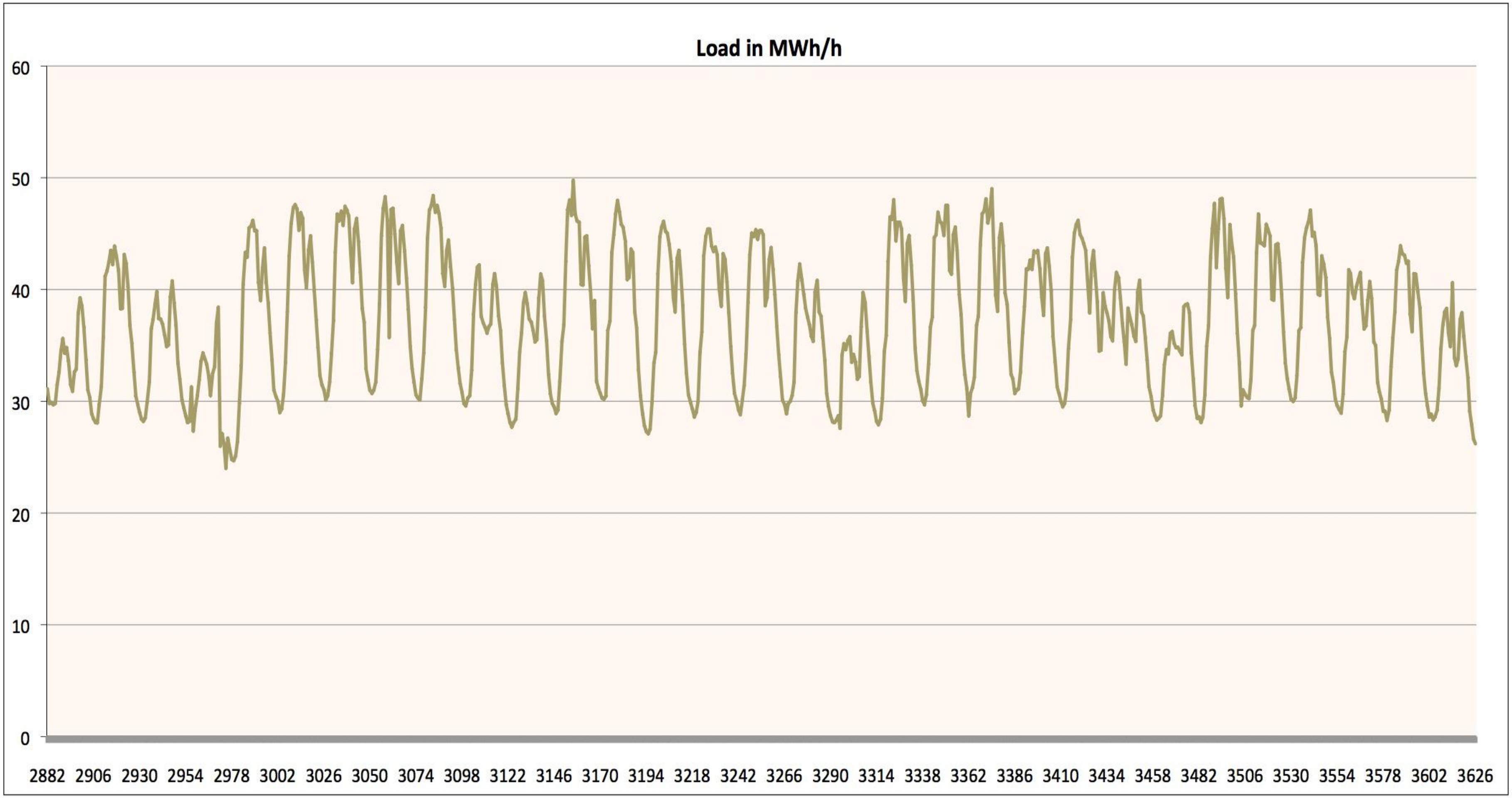
Hourly load curve for Mahé in May 2014



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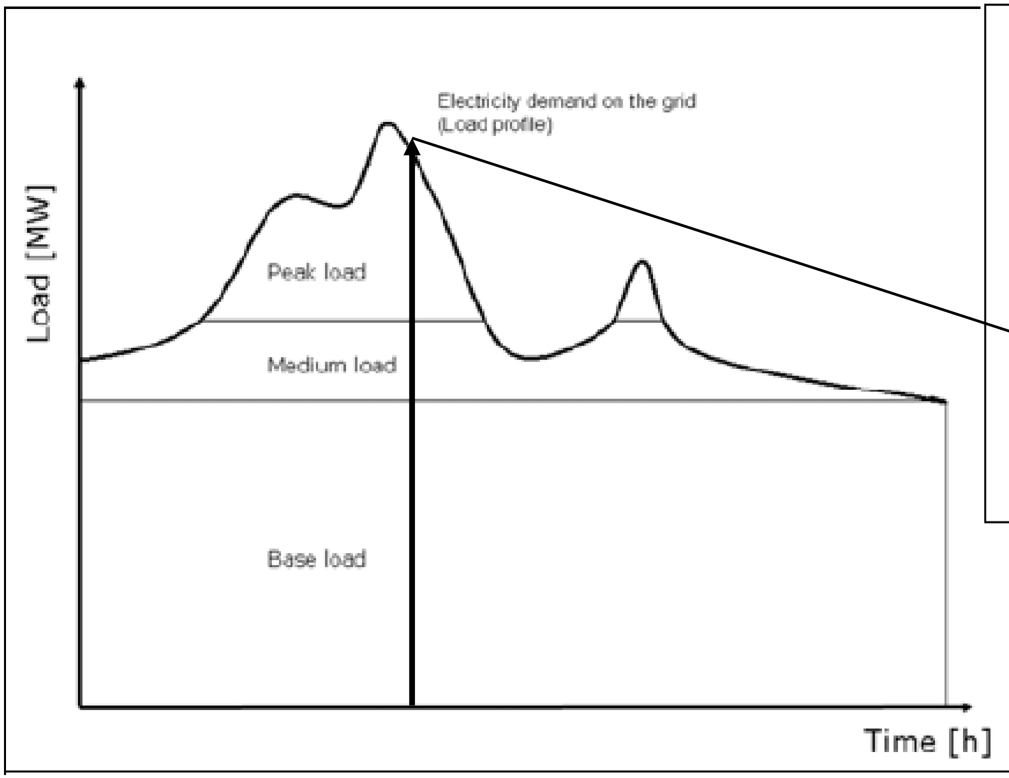
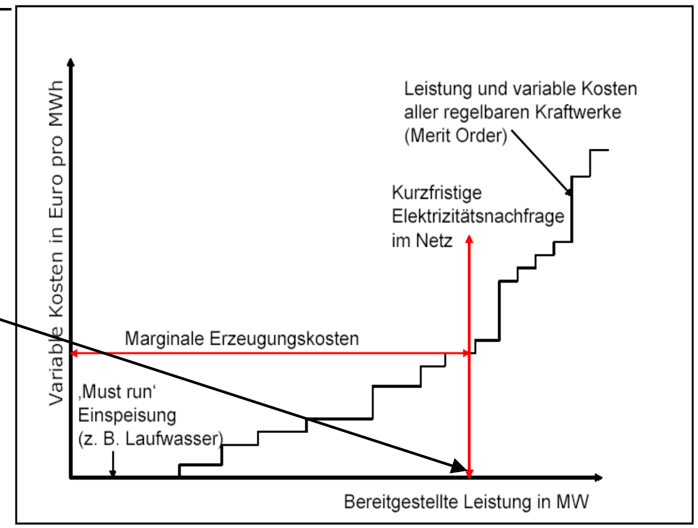
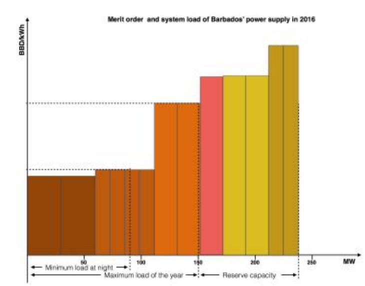
Servicing load in the past: All units can be fully controlled

Schematic graphic of how daily electricity demand is met in the current electricity system



Merit order

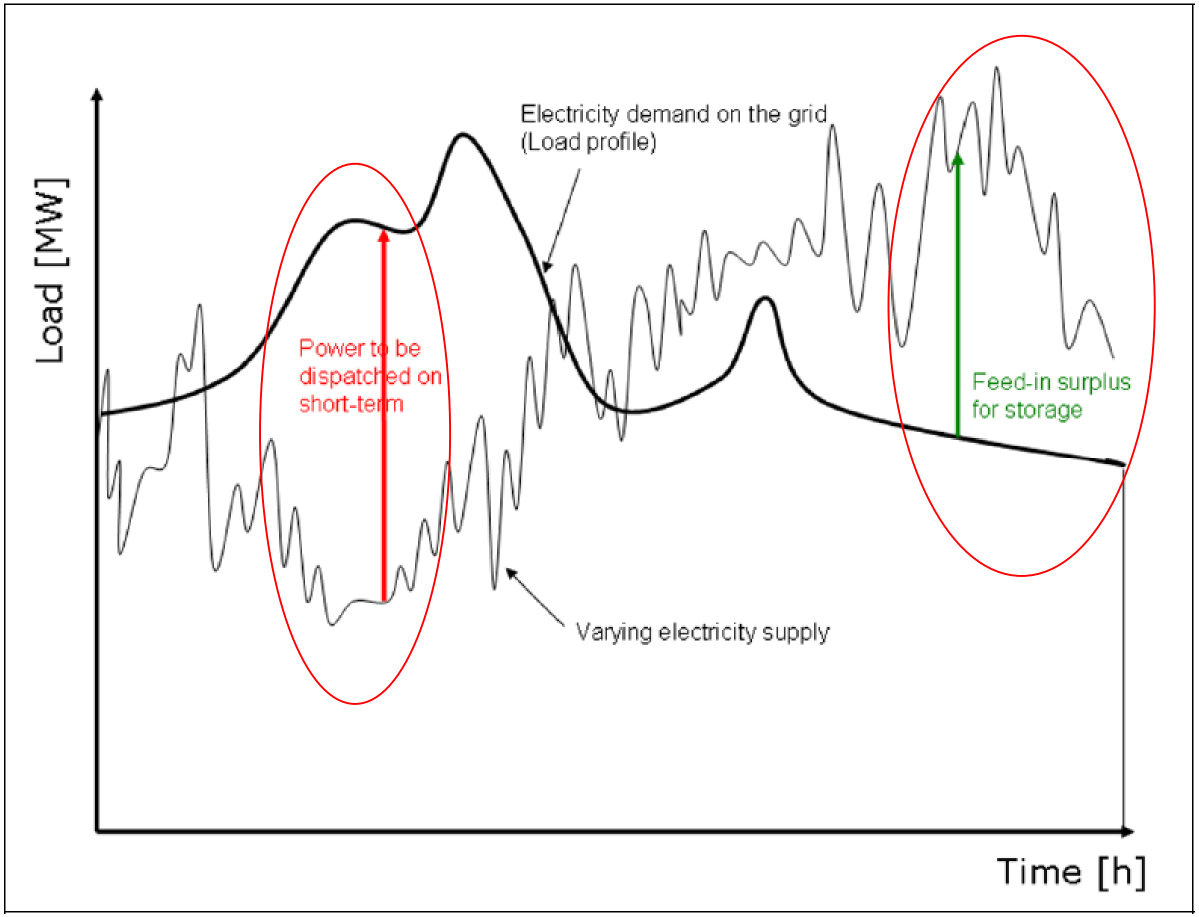




Source: SRU 2011, p.142

The new challenge:
Service residual load (= load – PV – wind)

Meeting daily electricity demand in an electricity system with a high proportion of wind power



Source: SRU 2011, p.144

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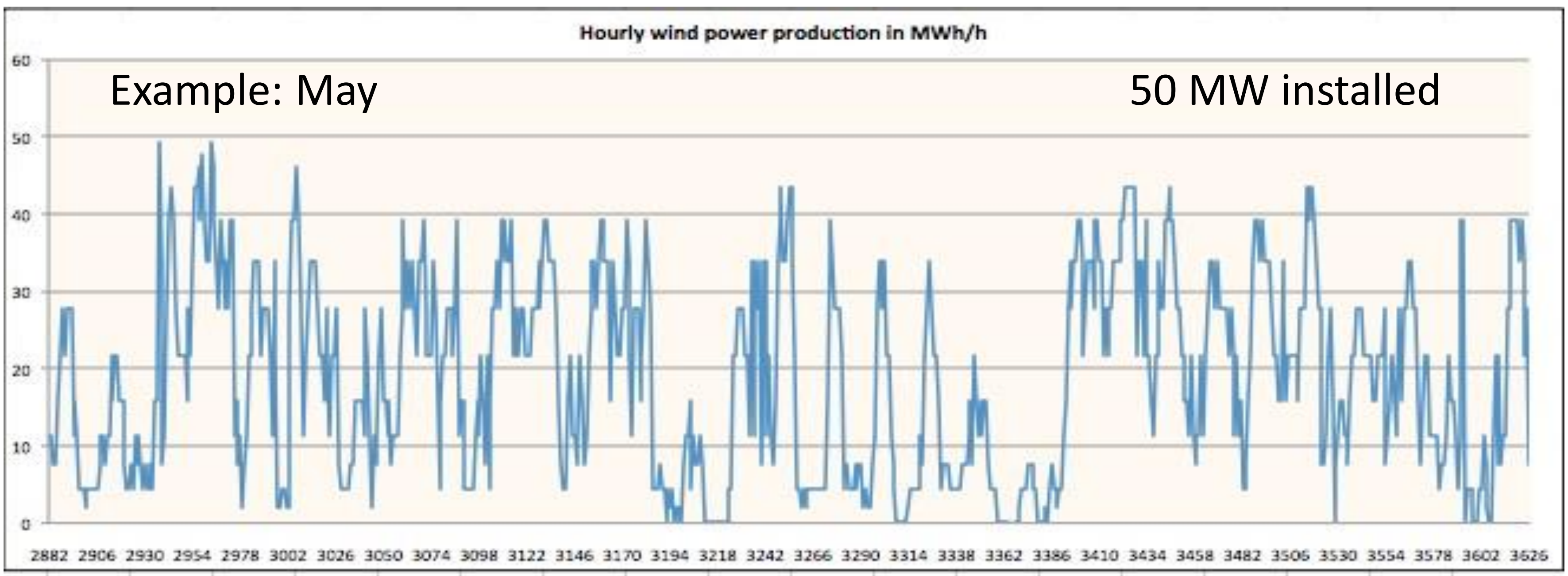
Wind energy on Mahé

1. Size of the island: 152 km^2
2. Theoretical potential on shore: 1.5 GW
3. Costs per kWh (wind 2010): 0.827 SCR/kWh



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PV on Mahé

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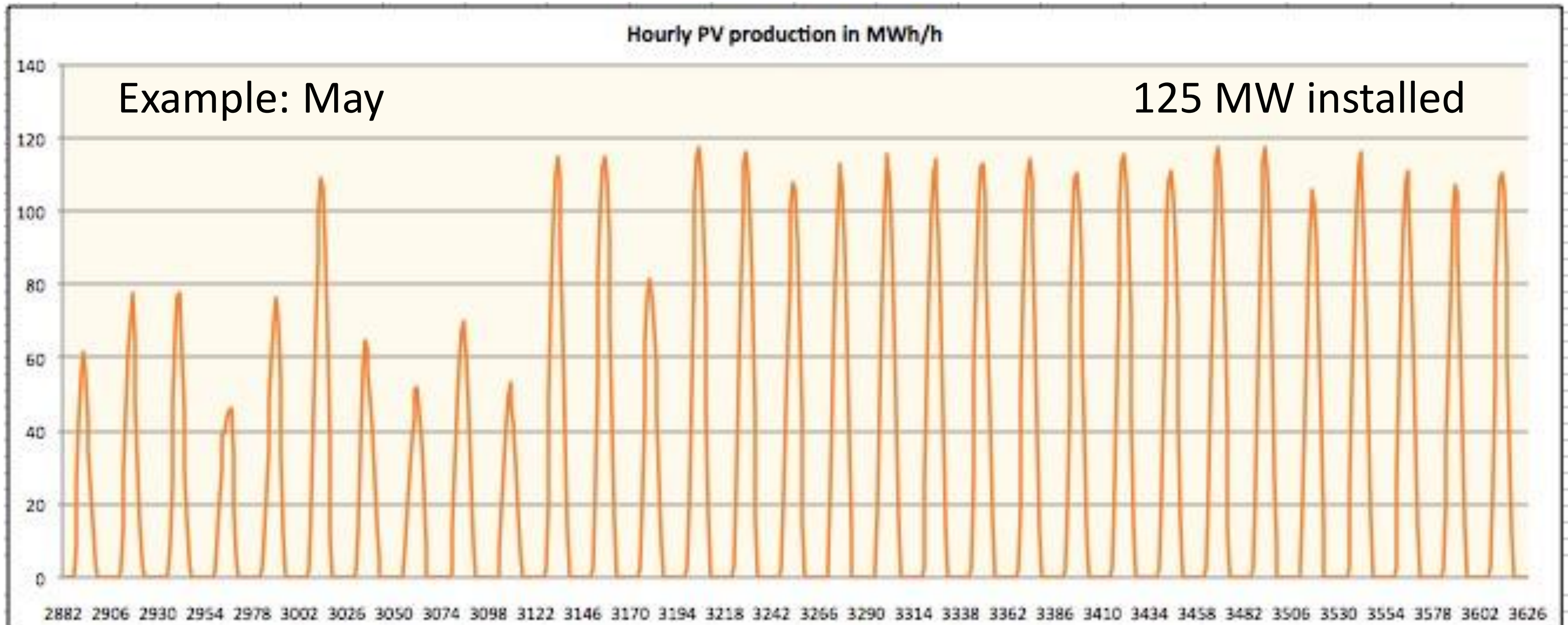
1. Size of the island: 157 km²
2. Theoretical PV potential: 1 950 GW
3. Costs per kWh: 1.49 SCR/kWh



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A plausible 100% renewable power system for Mahé

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EUM

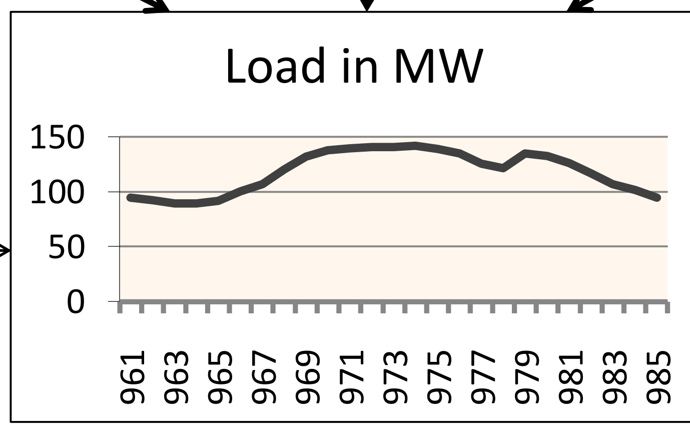
125 MW PV

1 GWh PSH

50 MW wind

Wind farm

25 GWh biomass



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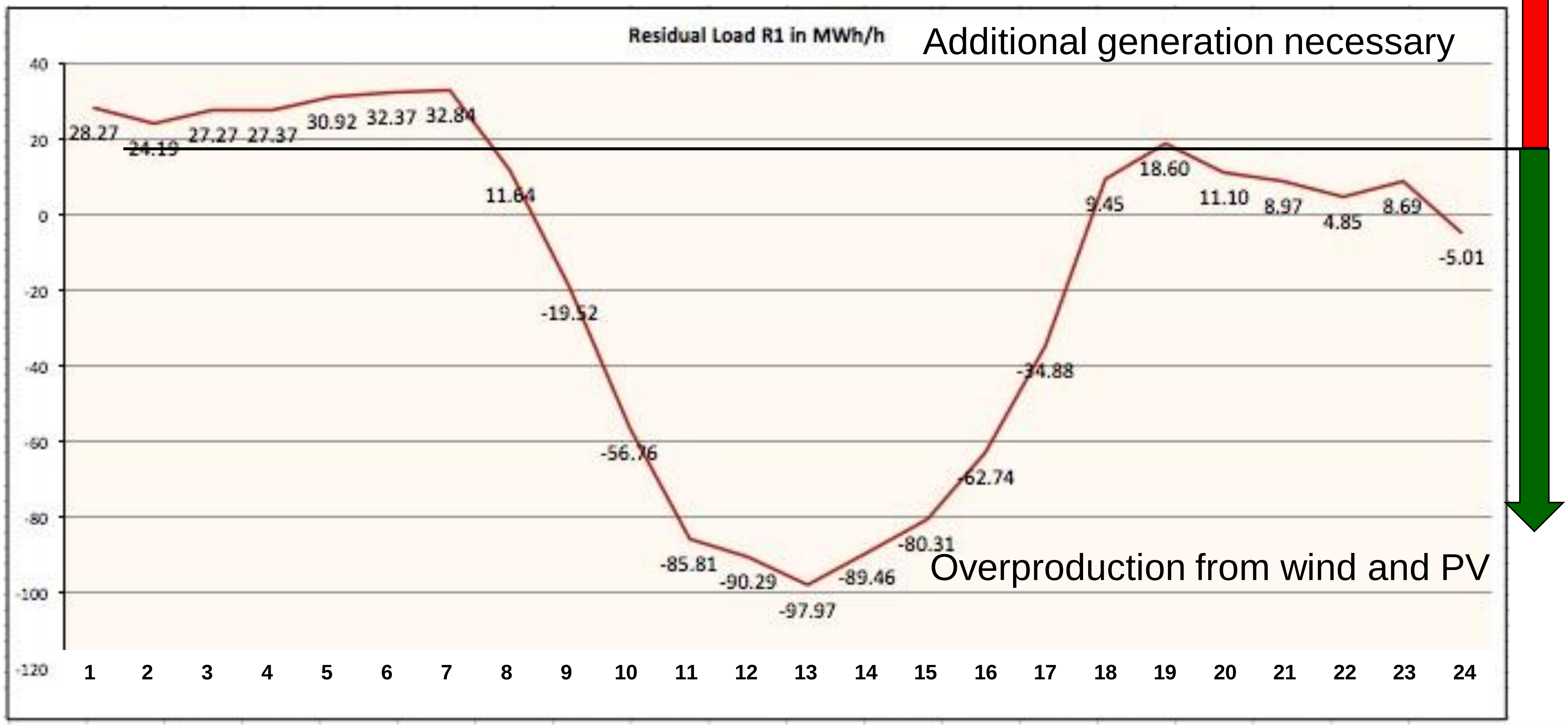
Residual load in a 100% REN Mahé (May 22nd)

Universität Flensburg EUM

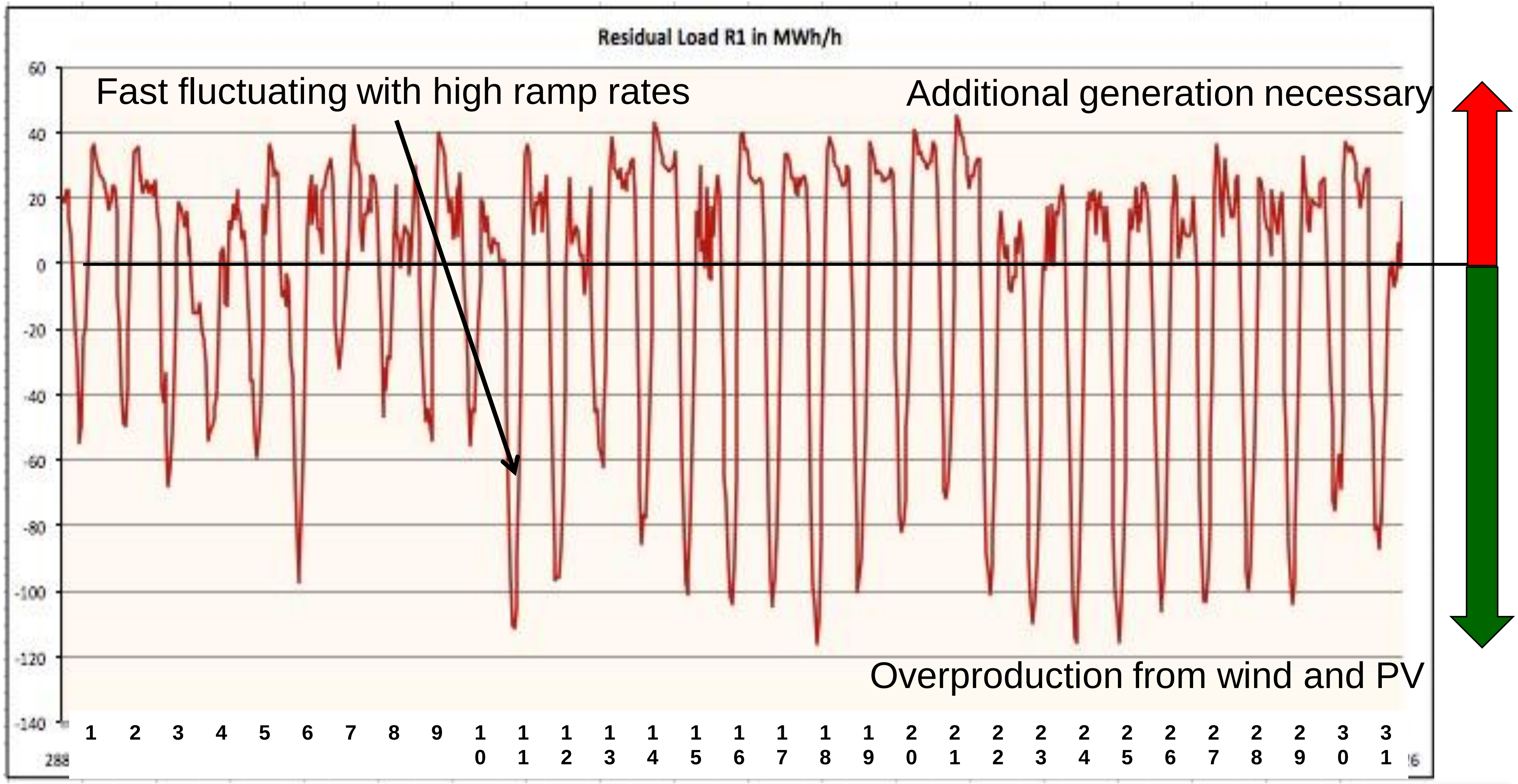
In the future residual system load is difficult to predict and difficult to service.
Difficult to balance the system every hour.



Residual load for May 2014

(Using load data from 2014 and wind and solar data from 2010)

Servicing residual load requires very flexible controllable generators



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Use of biomass in May to match the load not met by wind, PV or pump storage

Universität Flensburg
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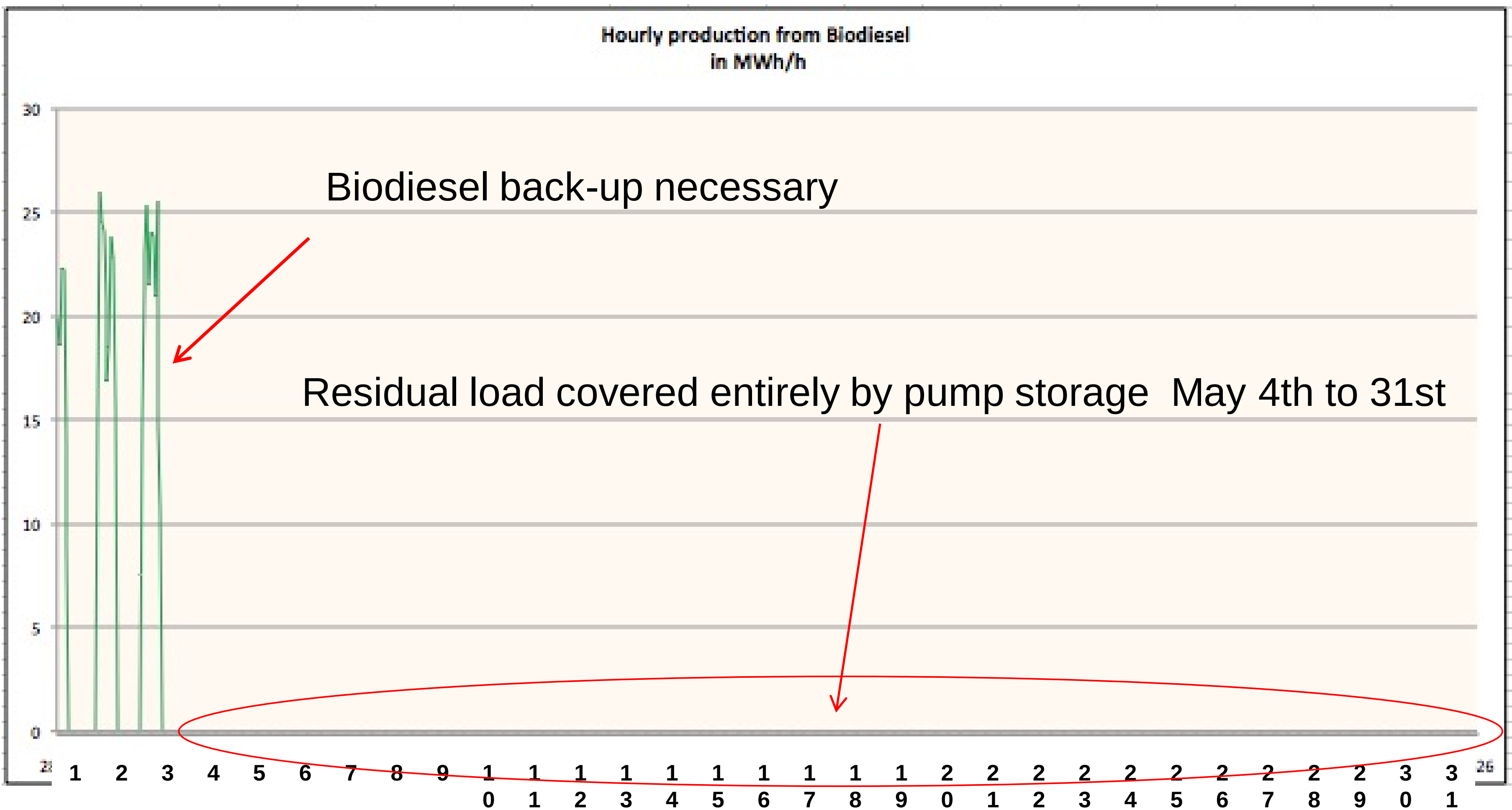

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Electricity costs for 100% renewable Mahé (25 GWh biomass, 1 GWh storage)

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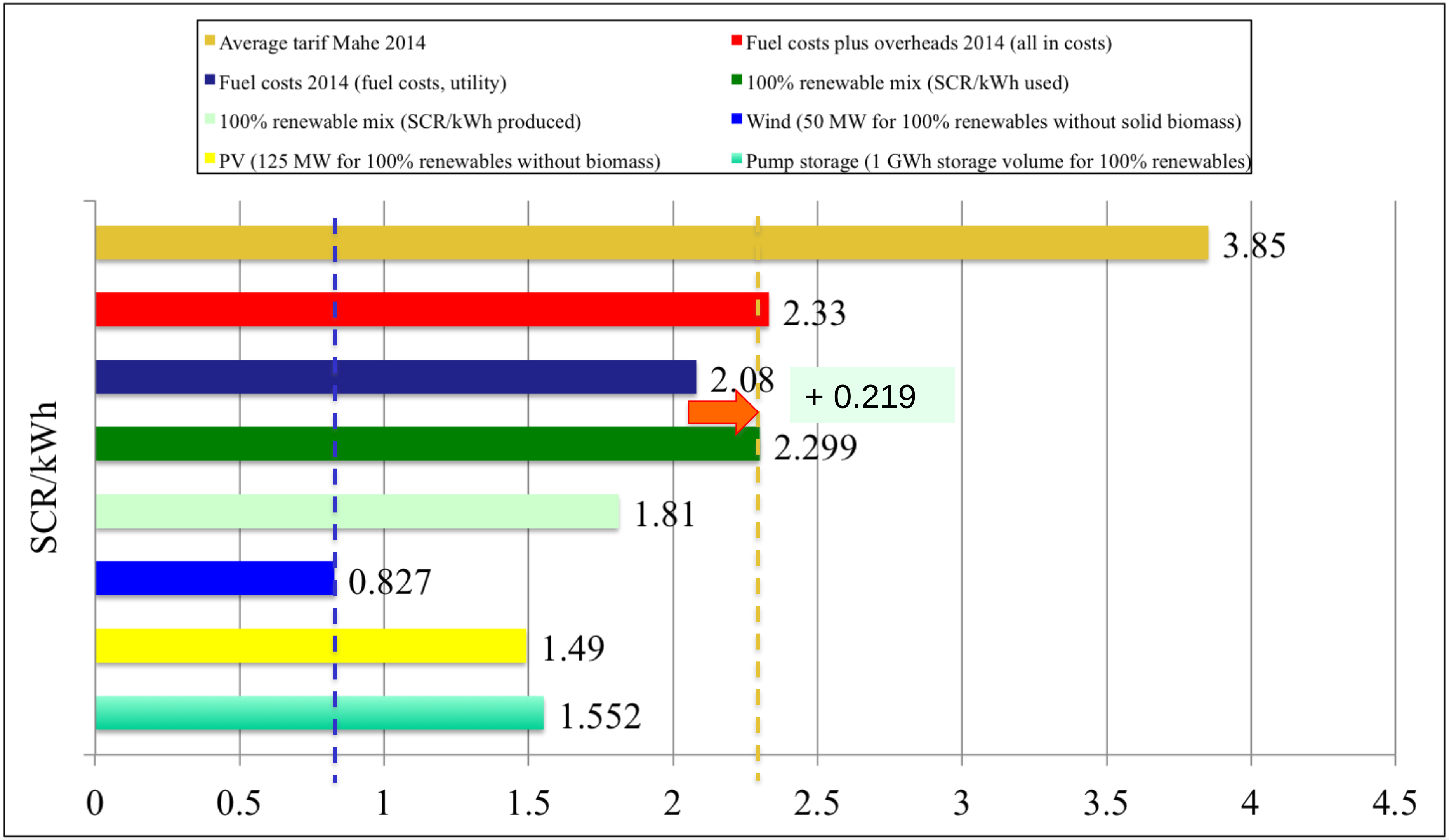

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Import reduction - A main advantage

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EUM

Net import reductions?

- Diesel import reductions - 650 Million SCR/a
- PV, wind, pump storage imports + 80 Million SCR/a
- **Net import reduction per year - 570 Million SCR/a**
- **Net tax increase per year + 158 Million SCR/a**

(Net import reduction equals about 3-4% of 2014 GDP)

Conclusions

- 100% renewable power for Mahé (as well as for Praslin and La Digue) is possible
- It slightly increases costs (3-9%) as compared to 2014
- A 100% renewable energy can boost the economy due to reduced imports (2.9% of GDP 2014)
- The tax income will substantially increase (150 M SCR/a)

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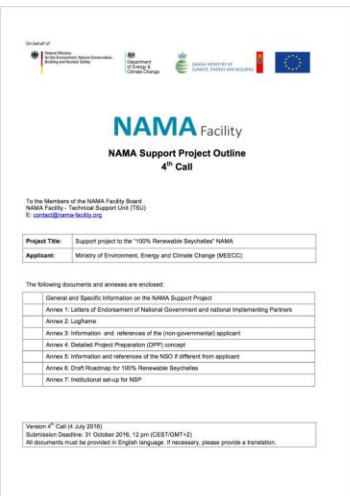
The financing proposal for a 100% renewable energy NAMA for the Seychelles
A role model for Cambodia?



On behalf of

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Department of Energy & Climate Change

Danish Ministry of Climate, Energy and Building

NAMA Facility

NAMA Support Project Outline
4th Call

To the Members of the NAMA Facility Board
NAMA Facility - Technical Support Unit (TSU)
E: contact@nama-facility.org

Project Title:	Support project to the "100% Renewable Seychelles" NAMA
Applicant:	Ministry of Environment, Energy and Climate Change (MEECC)

The following documents and annexes are enclosed:

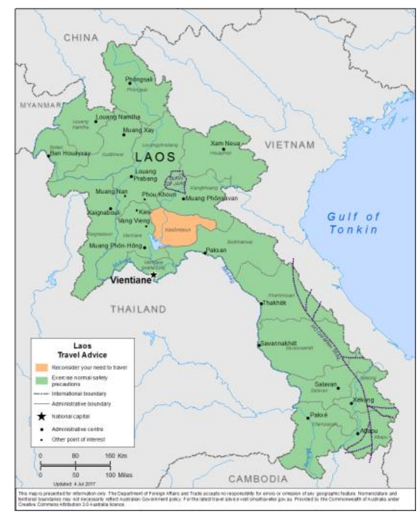
	General and Specific Information on the NAMA Support Project
	Annex 1: Letters of Endorsement of National Government and national Implementing Partners
	Annex 2: Logframe
	Annex 3: Information and references of the (non-governmental) applicant
	Annex 4: Detailed Project Preparation (DPP) concept
	Annex 5: Information and references of the NSO if different from applicant
	Annex 6: Draft Roadmap for 100% Renewable Seychelles
	Annex 7: Institutional set-up for NSP

Version 4th Call (4 July 2016)
Submission Deadline: 31 October 2016, 12 pm (CEST/GMT+2)
All documents must be provided in English language. If necessary, please provide a translation.

Prof. Dr. Olav Hohmeyer

Europa-Universität Flensburg

Phnom Penh, Cambodia, October 19th, 2017



Funding opportunity of the NAMA Facility

- Funded by Germany, Great Britain, Denmark and the European Union
- Finances "NAMA support projects" (NSPs) with 5-20 million Euro
- Combination of technical (TC) and financial cooperation (FC)
- Maximum implementation period is 3-5 years
- Annual competitive rounds (Calls)
- 4th round with a volume of 60 million Euro currently open with a deadline of October 31, 2016.
- Key requirements: implementation readiness, mitigation potential, transformational change
- So far funded approximately 10% of submitted proposals
  - 14 NSPs funded, widely spread around the world

Source: NAMA Facility

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General application sequence
The example of the NAMA Facility's 4th call

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31 October 2016, noon (12 pm (CEST/GMT+2)
Submission of NSP Outlines

Nov 2016 – early Spring 2017
External assessment of submitted NSP Outlines including an on-site assessment of short-listed NSPs

Spring 2017
Donors' decision on funding the Detailed Preparation Phase of selected NSPs

Spring 2017
Contracting of Detailed Preparation Phase (DPP)

Up to 18 months
Detailed Preparation Phase (DPP) and **submission of full-fledged Proposal**

Spring 2018/ autumn 2018/ spring 2019
Donors' decision on funding implementation of NSPs

3-5 years
NSP Implementation

Fifth Call expected to be announced at COP 23

Source: NAMA Facility

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Barbados

Selection criteria to be addressed in NSP outline

Eligibility criteria

- Timely submission
- Completeness of documents (including endorsement letters)
- Documents provided in English
- Funding volume for implementation EUR 5-20 million
- Implementation duration of 3-5 years
- Envisaged DPP duration of max. 18 months
- ODA-eligibility of the country
- Eligibility of the applicant

Ambition criteria

- Does the project aim at bringing a country/sector on a low-carbon track?
- Potential for transformational change
- Financial ambition
- Mitigation potential

Feasibility criteria

- Can the project be implemented successfully?
- Project rationale
- Project design
- DDP concept

Source: NAMA Facility

Submission procedures: 2 Options for applicant and co-applicant exist

Option 1

APPLICANT

National Ministry
= Submitter of outline

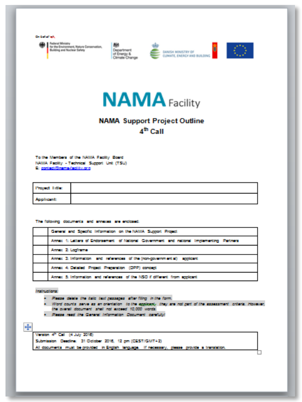
+

CO-APPLICANT

Legal entity
= Contracting Partner for DPP

Option 1

Submission →



Case 1
Co-Applicant and NSO* can be **the same** entity

Case 2
Co-Applicant and NSO* can be **different** entities

*NAMA Support Organisation

That means in the case of the Seychelles:
MEECC submits

Option 2

National Ministry
= Endorses NSP and its submission by legal entity

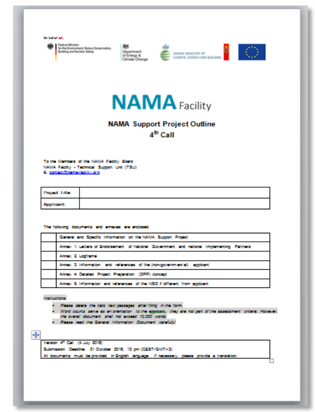
+

APPLICANT

Legal entity
= Contracting Partner for DPP

Option 2

Submission →



Case 1
Co-Applicant and NSO* can be **the same** entity

Case 2
Co-Applicant and NSO* can be **different** entities

*NAMA Support Organisation

That means in the case of the Seychelles:
UNPD or other entity submits

Source: NAMA Facility

Sensible issues to be considered for the NSP

GHG mitigation potential
often not substantiated, or overestimated

Barrier analysis
often incomplete: not analysing the targeted sector or country context but only the specific NSP

Technical and economic viability
Rationale for technology missing, business model lacking

Financial mechanism
institutional set-up not defined, rationale for the specific mechanism missing, insufficient phase-out concept

Source: NAMA Facility

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NAMA Facility Organisational Structure and roles to be defined (by the applying country)

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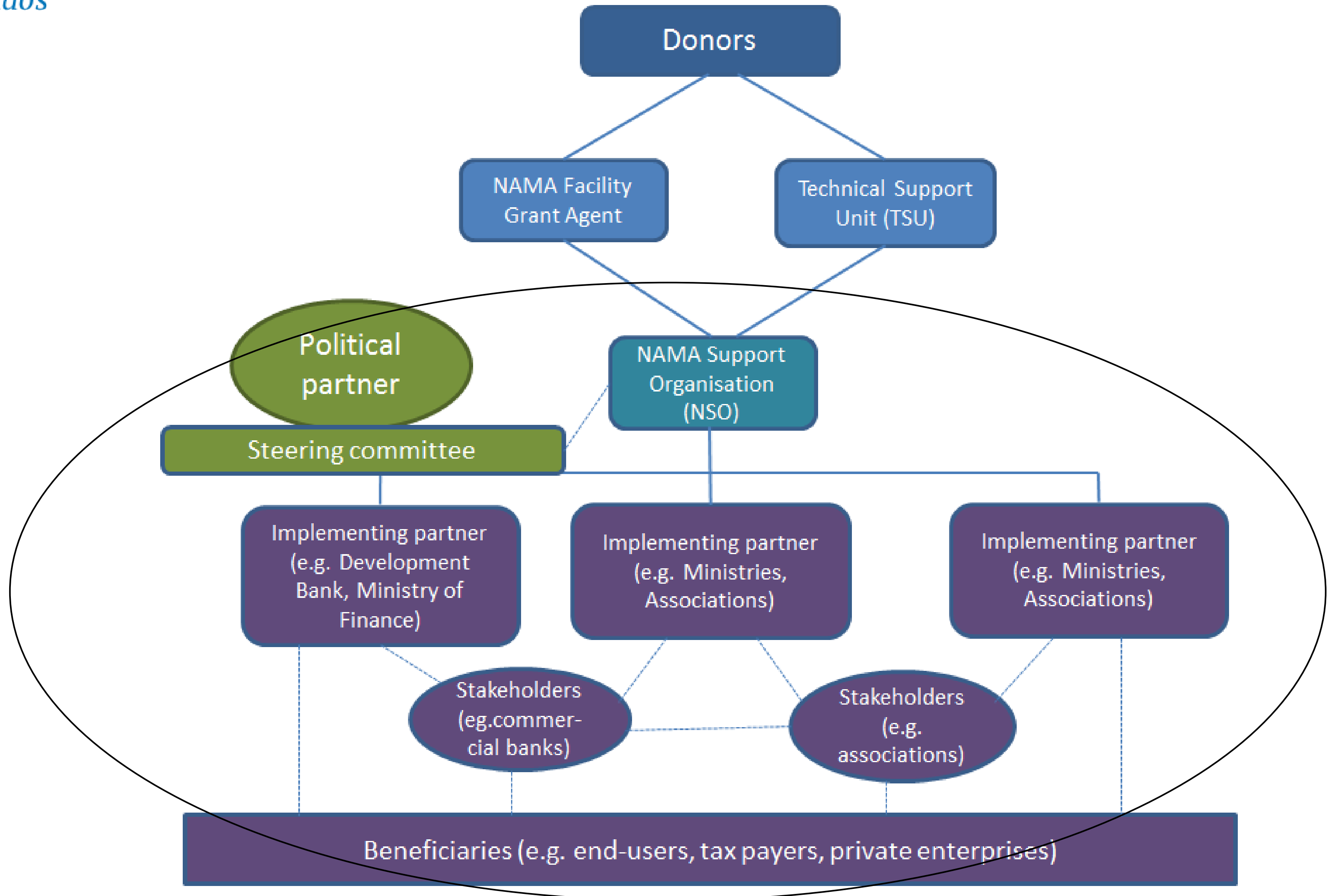

Source: NAMA Facility

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NAMA Support Project Decision Cycle of the NAMA Facility

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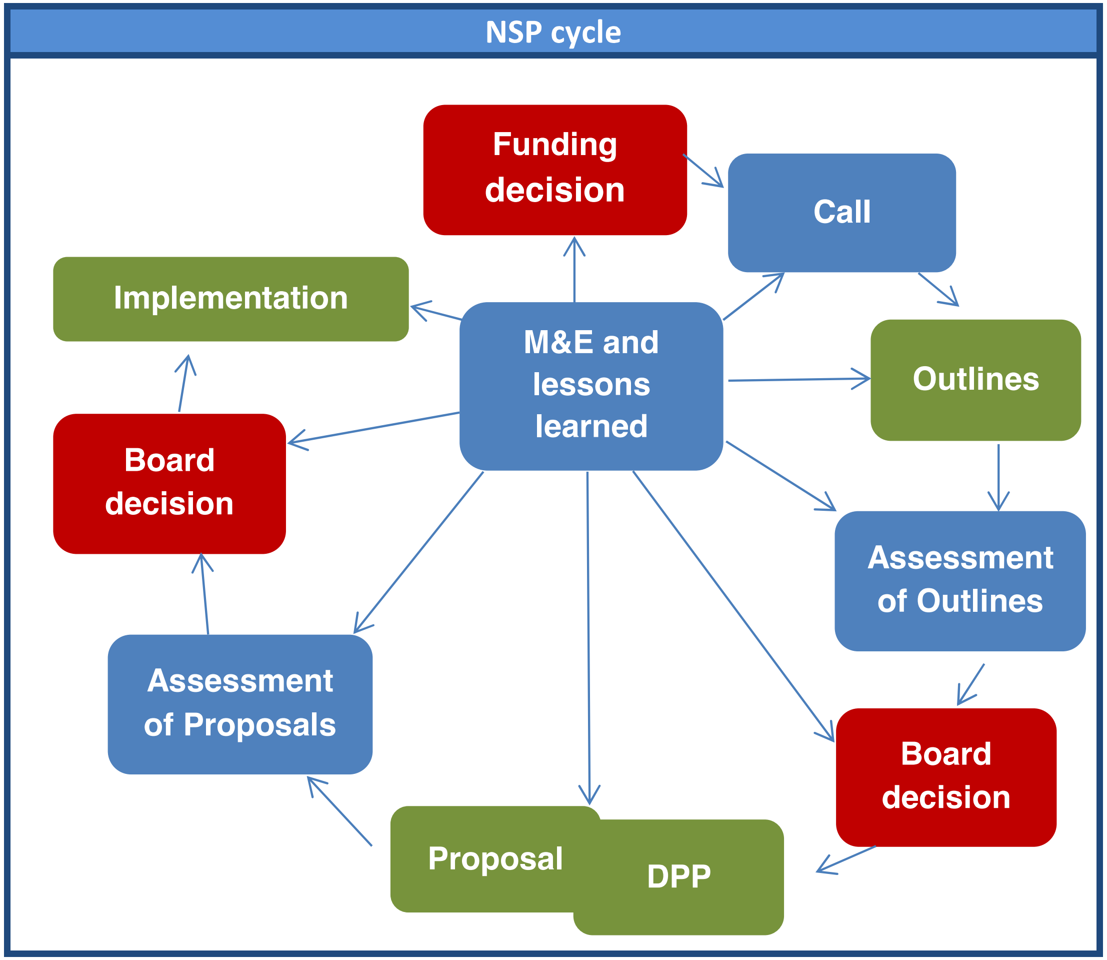
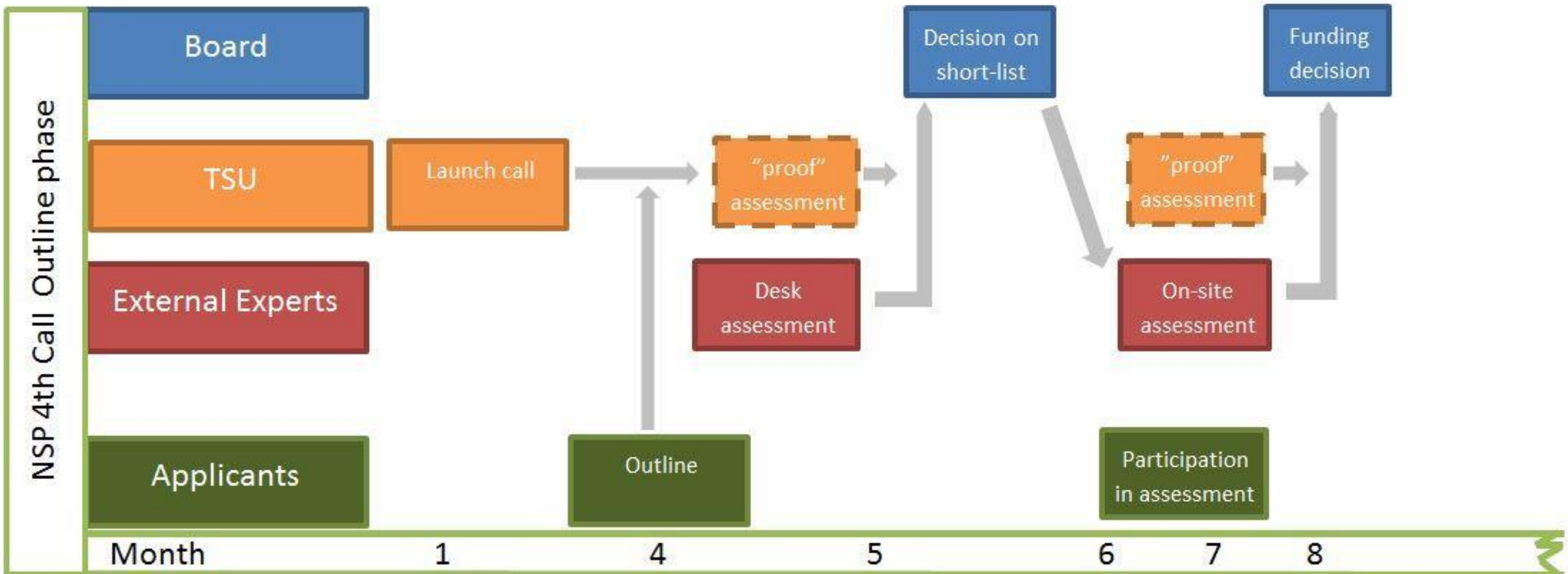


Legend:
- Applicants/NSOs
- TSU / "NFGA" and/or external evaluators/assessors
- Board

Source: NAMA Facility

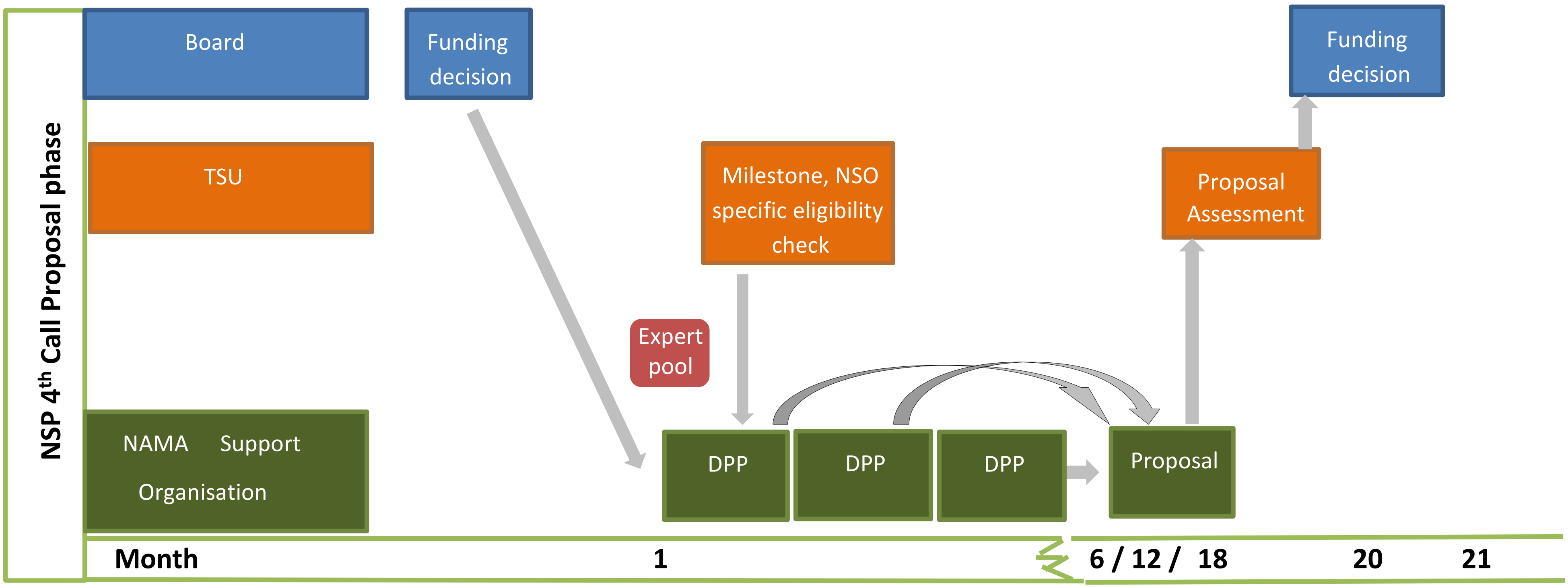
NSP Outline Phase – Decision in Five Month
5th call will look similar



Deadline for Outline submission
31 October 2016, noon

Source: NAMA Facility

Detailed Preparation Phase (DPP) Proposal Phase of 6 to 18 Month Possible



Source: NAMA Facility

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NSP embedded in wider 100% RE NAMA
The case of the Seychelles

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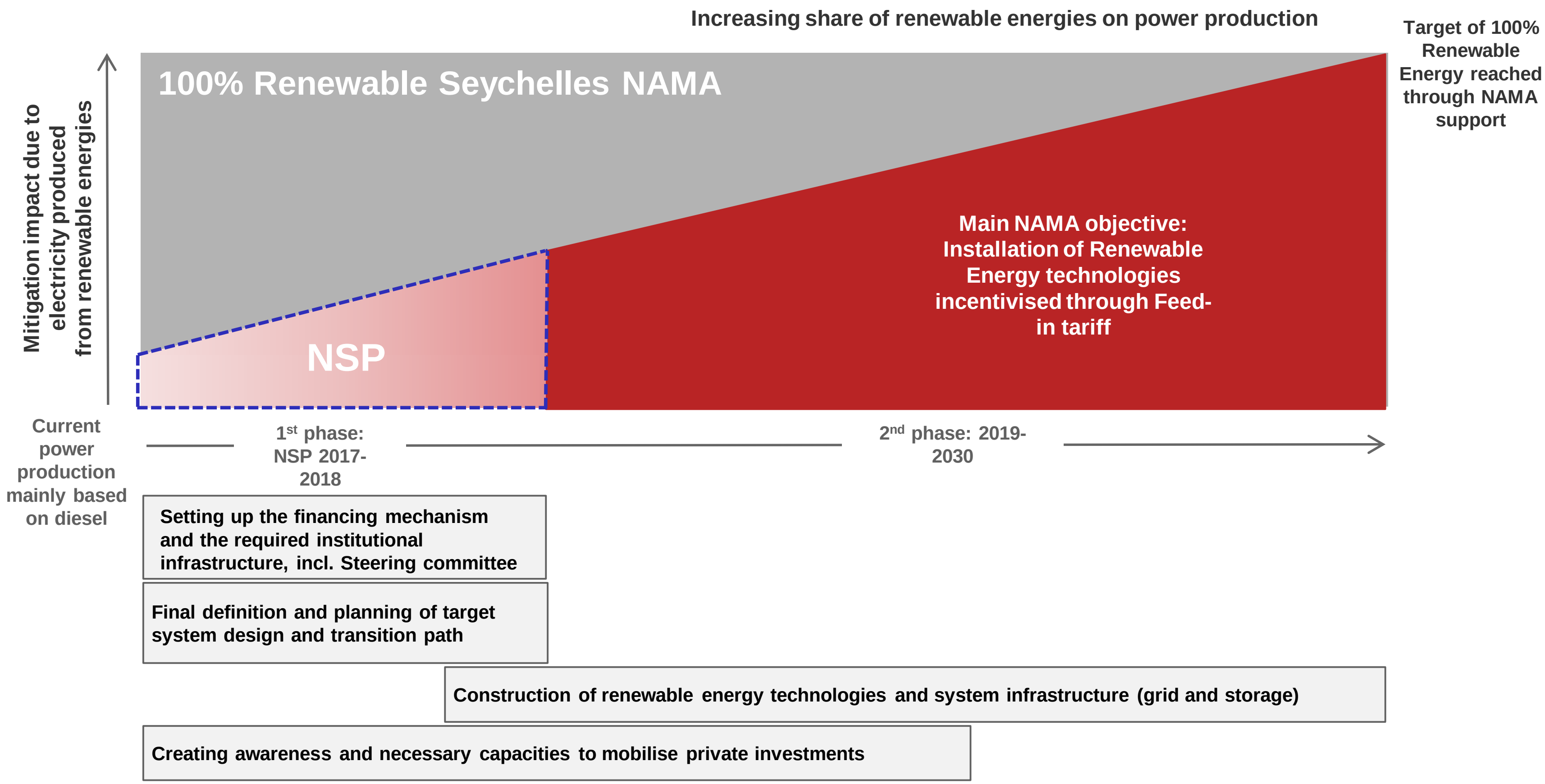

Source: The green werk 2016

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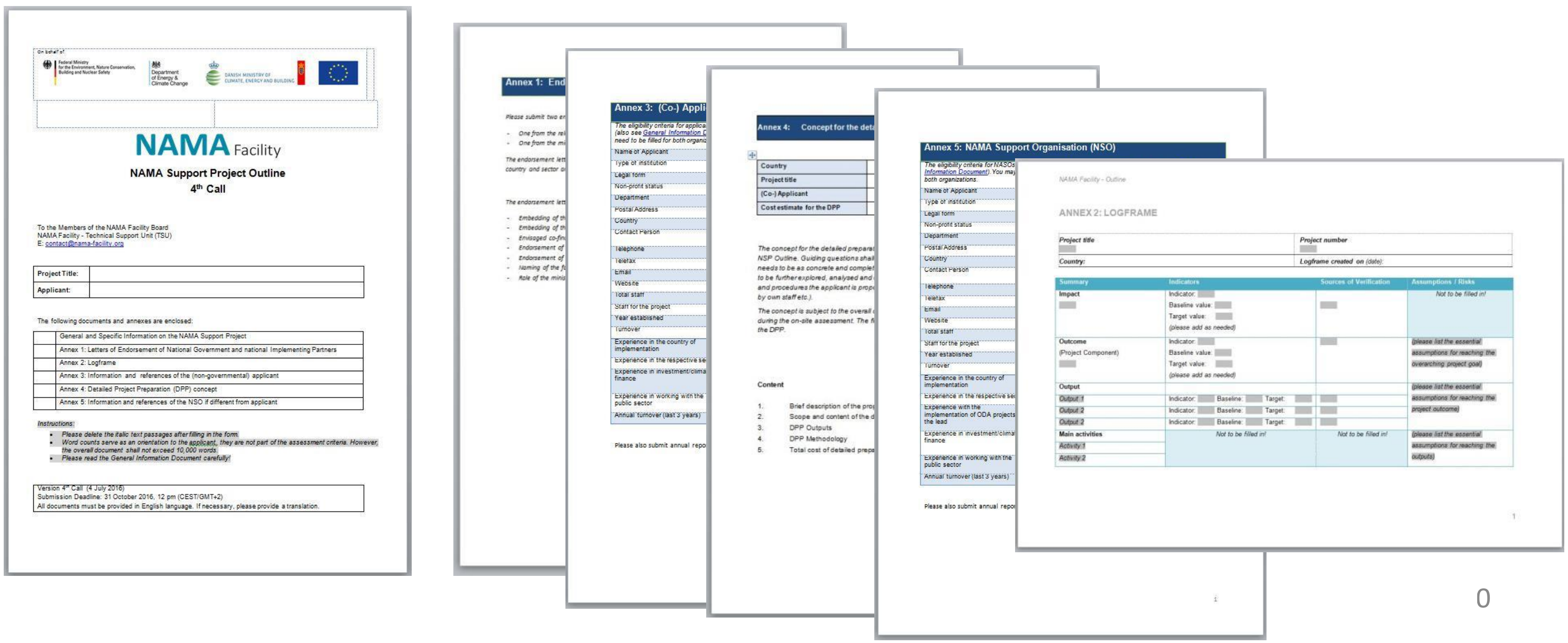
NSP Outline is Standardized and Short

- NSP Outline template
- 5 Annexes
- max. 20 pages /10,000 words, word counts serve as orientation



Source: NAMA Facility

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NAMA Support Project was applied for 2016

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On behalf of

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Department of Energy & Climate Change

DANISH MINISTRY OF CLIMATE, ENERGY AND BUILDING

DPP: 187,000 €

NSP: 18.748.000 €

NAMA Facility

NAMA Support Project Outline

4th Call

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	Annex 7: List of references

1. General Information on the NAMA Support Project

1.1 Project data	Project title	Support project to the "100% Renewable Seychelles" NAMA
	Country of implementation	Republic of Seychelles
	Sector focus	☐ *Agriculture* ☐ *Forestry* ☐ *Land use* ☐ *Transport* ☐ *Energy Efficiency* ☒ *Renewable energy* ☐ *Waste/waste water* ☐ Other
	Duration of project implementation	*57 months* (Q2 2018 – Q4 2022)
	Duration of detailed preparation (DPP)	*12 months*
	NSP volume (EUR)	Preparation (DPP): *199,630 EUR* Implementation: *18,748,000 EUR + 187,480 EUR for M&E (indicative estimate)* **Total: 19,135,110 EUR**
	Publication	*Are you willing to have your submission (country, sector) listed on the NAMA Facility website?* Yes ☒ No ☐ *Your choice has no influence on the evaluation of your application*
	Emission reduction credits	NAMA Facility Funding is used directly for greenhouse gas mitigation and/or carbon sinks, which will contribute to generating emission allowances, emission credits, or any other type of CO_2 compensation certificates: Yes ☐ No ☒ If yes, will the credits be permanently cancelled in an approved register: Yes ☐ No ☐

Source: The green werk 2016

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The Seychelles NAMA Support Project application was almost successful

NAMA Facility

NAMA Support Project Outline
4th Call

To the Members of the NAMA Facility Board
NAMA Facility - Technical Support Unit (TSU)
E: contact@nama-facility.org

Project Title:	Support project to the "100% Renewable Seychelles" NAMA
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Eligibility criteria

Ambition criteria

Feasibility criteria

Ambition: perfect
Feasibility: great
Eligibility: almost perfect

Rejected because:

Seychelles lost ODA-status in 2017

But we know now how any ODA country could get NAMA Facility funding for a similar NAMA!

Source: NAMA Facility

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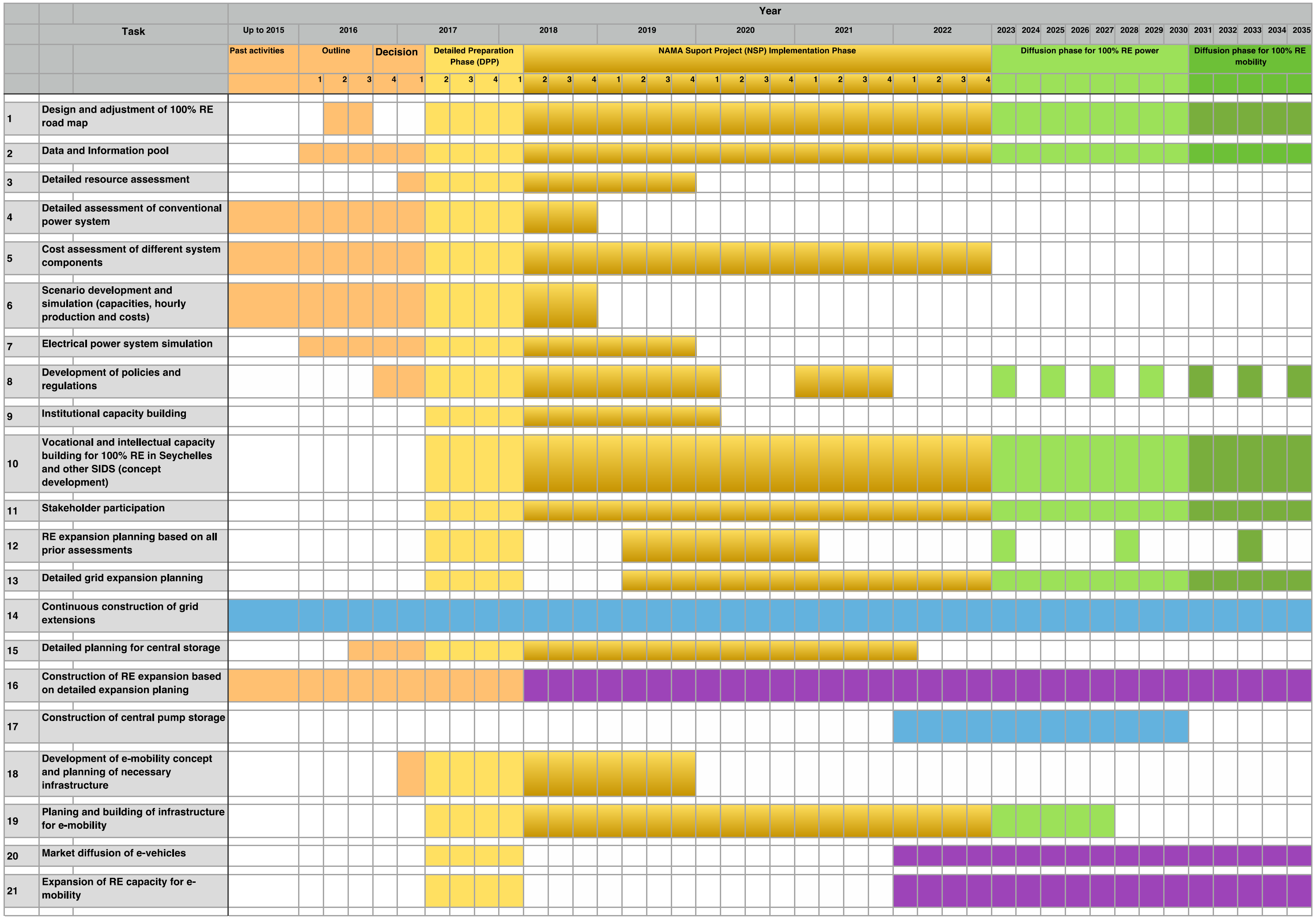
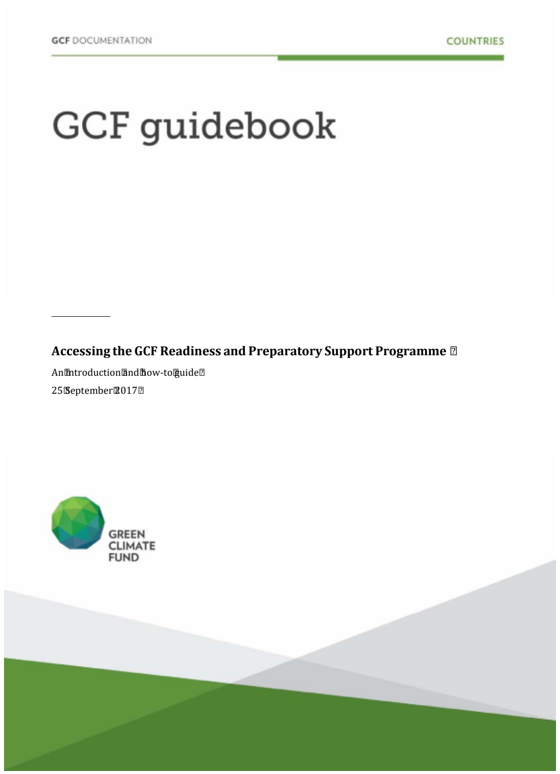
A detailed road map to 100% RE Seychelles by 2035 was included



Source: The green werk 2016

Green Climate Fund (GCF) as additional funding and financing source for 100% RE


GCF DOCUMENTATION
COUNTRIES
GCF guidebook
Accessing the GCF Readiness and Preparatory Support Programme
An introduction and how-to guide
25 September 2017
GREEN CLIMATE FUND

GCF Readiness and Preparatory Support Programme provide:

- Up to 1 million USD/a for NDA and capacity building
- (Up to 3 million USD for adaptation plans)

Annual support can be used (among other purposes) for setting up a national strategic framework including the preparation of country programmes (similar to NAMA Facility support)

GCF then provides extensive low interest loans for key investment (e.g. necessary infrastructure for 100% RE)

Source: GCF guidebook 2017

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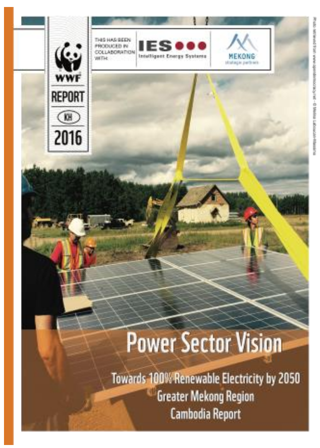
Barbados

Results of a first 100% RE study on Cambodia done by WWF

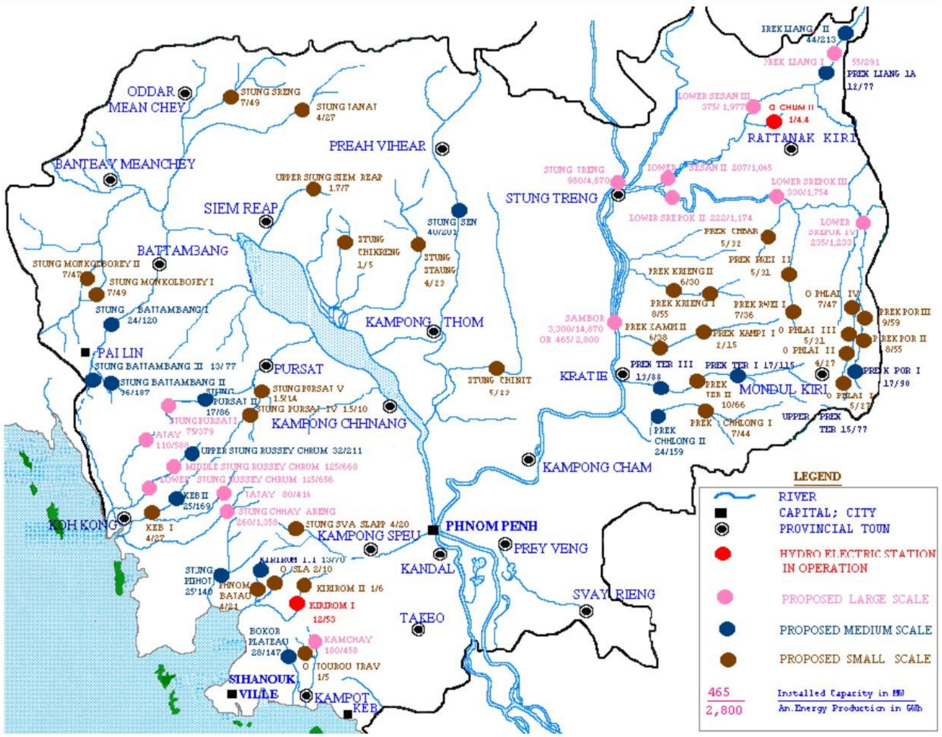


Prof. Dr. Olav Hohmeyer
Europa-Universität Flensburg

Phnom Penh, Cambodia, October 26th, 2017

Cambodia has good hydropower and solar energy resources, wind resource is modest

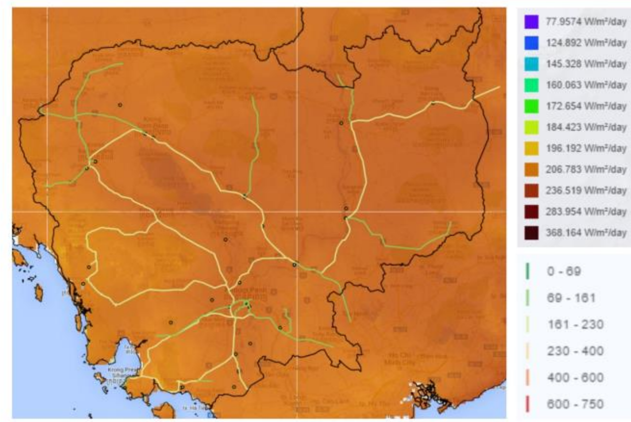
Figure 12 **Possible Hydro Sites in Cambodia**



Source: Power Development Plan, MIME

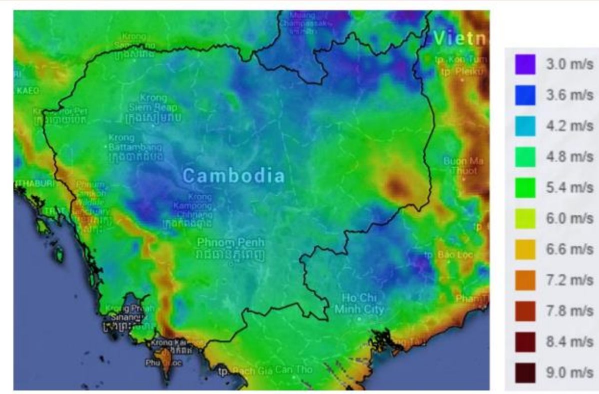
Source: IES and MKE 2017

Figure 21 **3TIER's Global Solar Dataset (3km in W/m^2) for GHI and Cambodia's Transmission Network (2013)**



Source: 3TIER's Global Solar Dataset (accessed via IRENA Global Atlas)

Figure 15 **3TIER's Global Wind Dataset 5km onshore wind speed at 80m height[9]**



Source: 3TIER's Global Wind Dataset (accessed via IRENA Global Atlas)

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Cambodia's hydropower and solar resources are good, while wind and biomass can contribute some

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Table 1 Summary of Estimated Renewable Energy Potential (Compiled from Various Sources and Analysis)

Renewable Energy Resource	Potential (MW)	Source and comments
Hydro (Large)	10,000	See section 3.4.
Hydro (Small)	700	World Small Hydropower Development Report (2013).
Pump Storage	0	Lack of studies available.
Solar	At least 11,000	IES assessment based on DNI and GHI resource maps and associated data as described in section 3.6.
Wind Onshore	500 and up	Power Sector Vision for the Mekong Region: the Blue Circle (2015).
Wind Offshore	Evidence for potential, but assumed 0 MW	Refer to resource maps in section 3.5.
Biomass	2,392	IES projections based on data from Renewable Energy Developments and Potential in the Greater Mekong Subregion (ADB, 2015).
Biogas	1,591	
Geothermal	0	Lack of studies available.
Ocean	0	Lack of studies available.

Source: IES and MKE 2017

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The seasonality of solar and hydropower seem to fit well together

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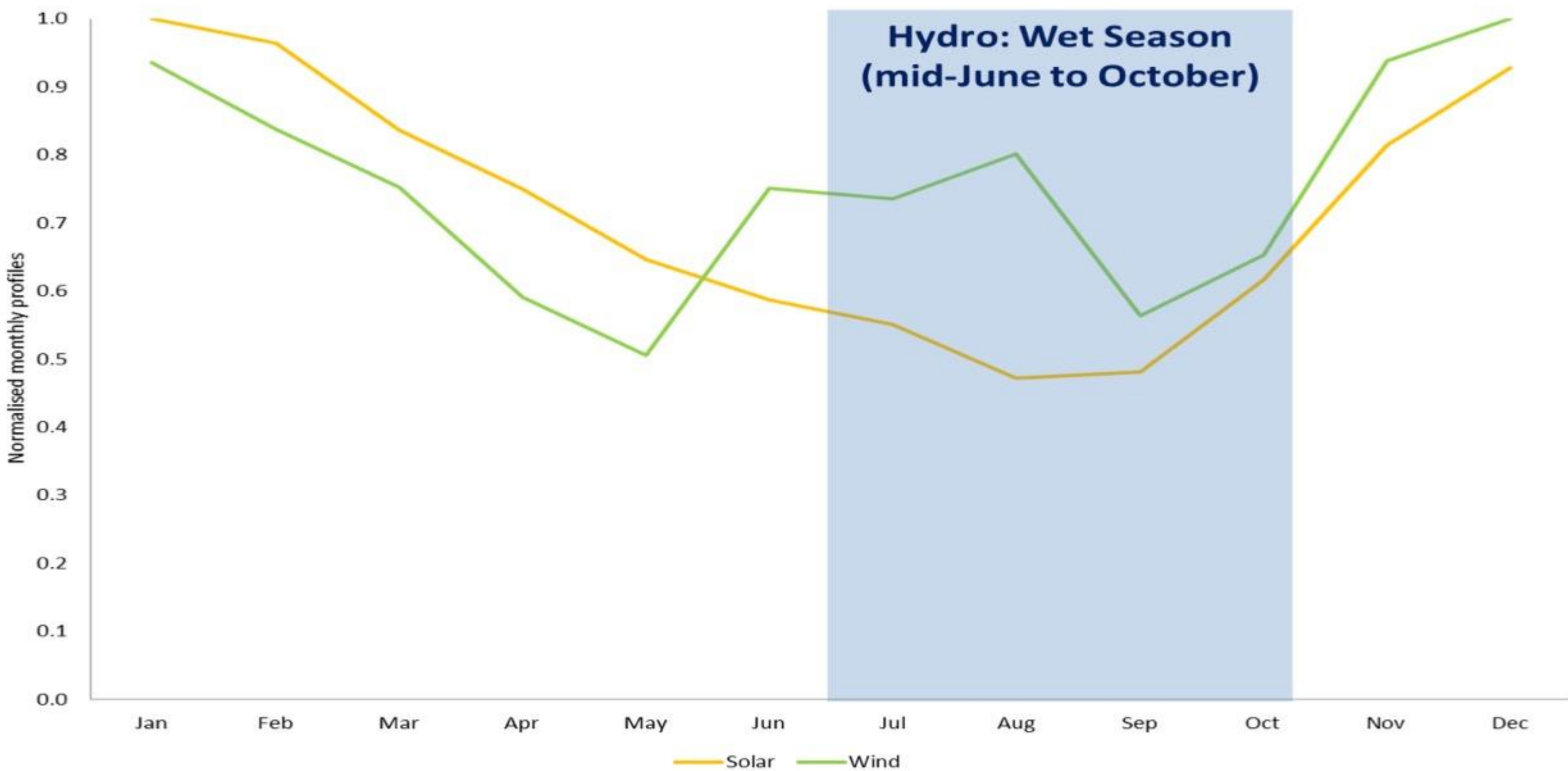
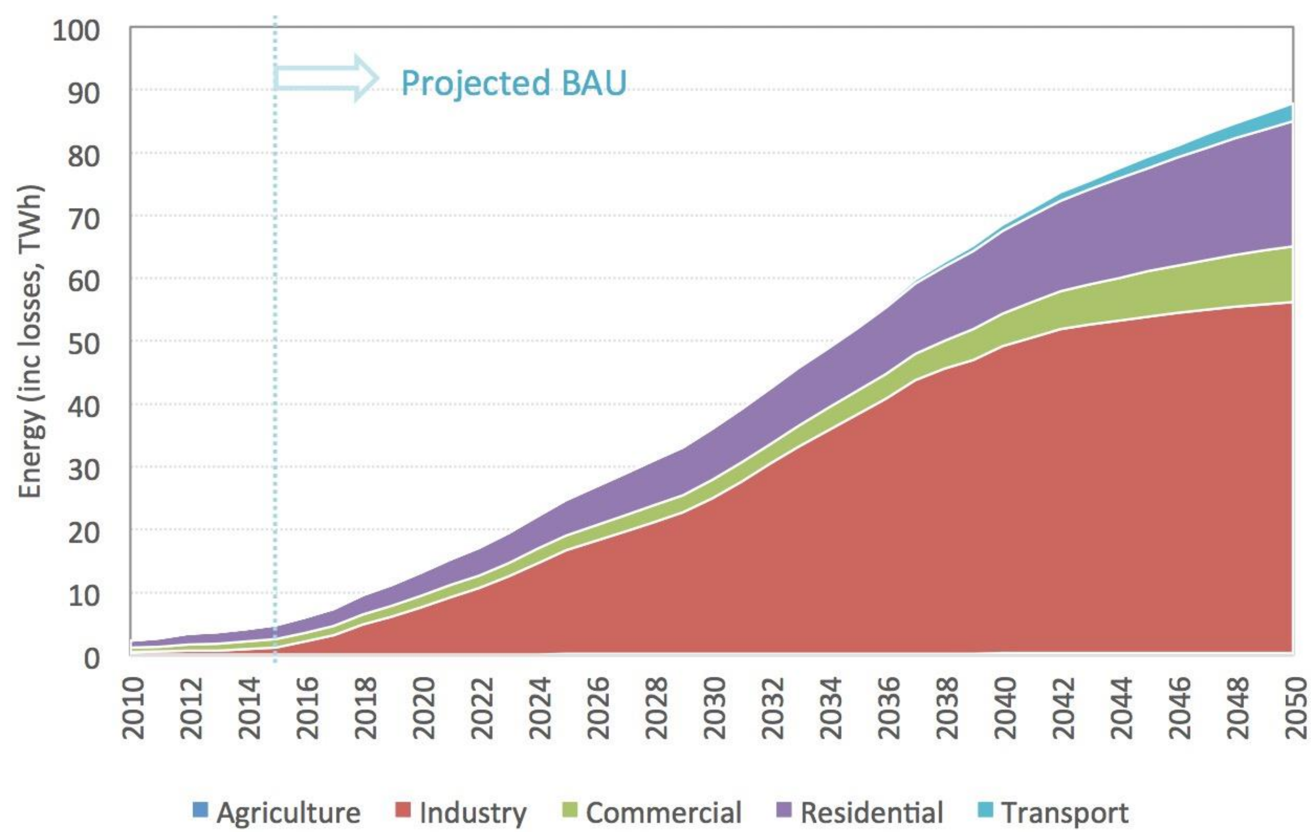
Figure 22 Seasonal Solar and Wind Profiles and Wet Season



Source: IES and MKE 2017

A high increase in electricity demand will need to be met by 2050

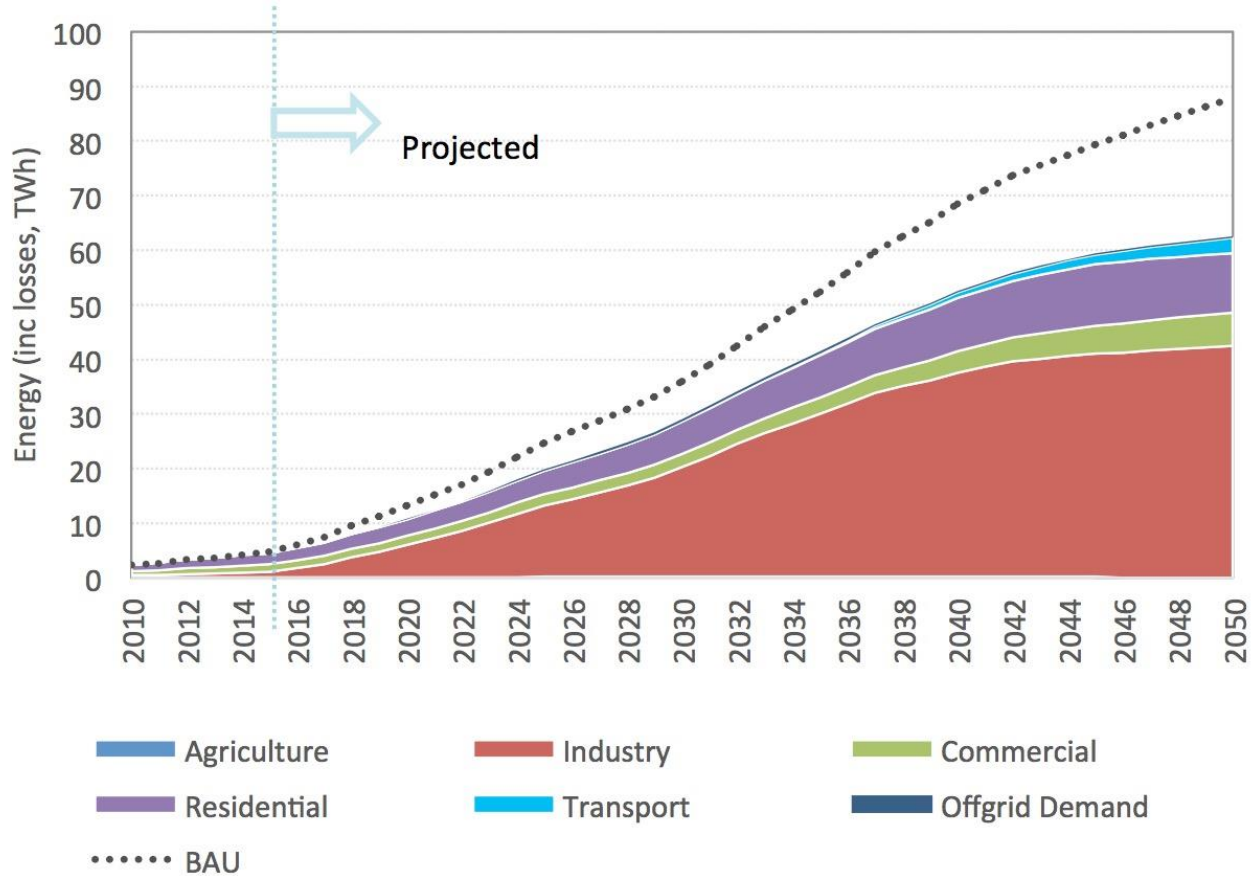
Figure 30 Cambodia Projected Electricity Demand (2015-50, BAU)



Source: IES and MKE 2017

Increased efficiency may reduce power demand by about 30%

Figure 43 Cambodia Projected Electricity Demand (2015-50, SES)



Source: IES and MKE 2017

In the business-as-usual case **coal** is supposed to cover about 53% of the future power production

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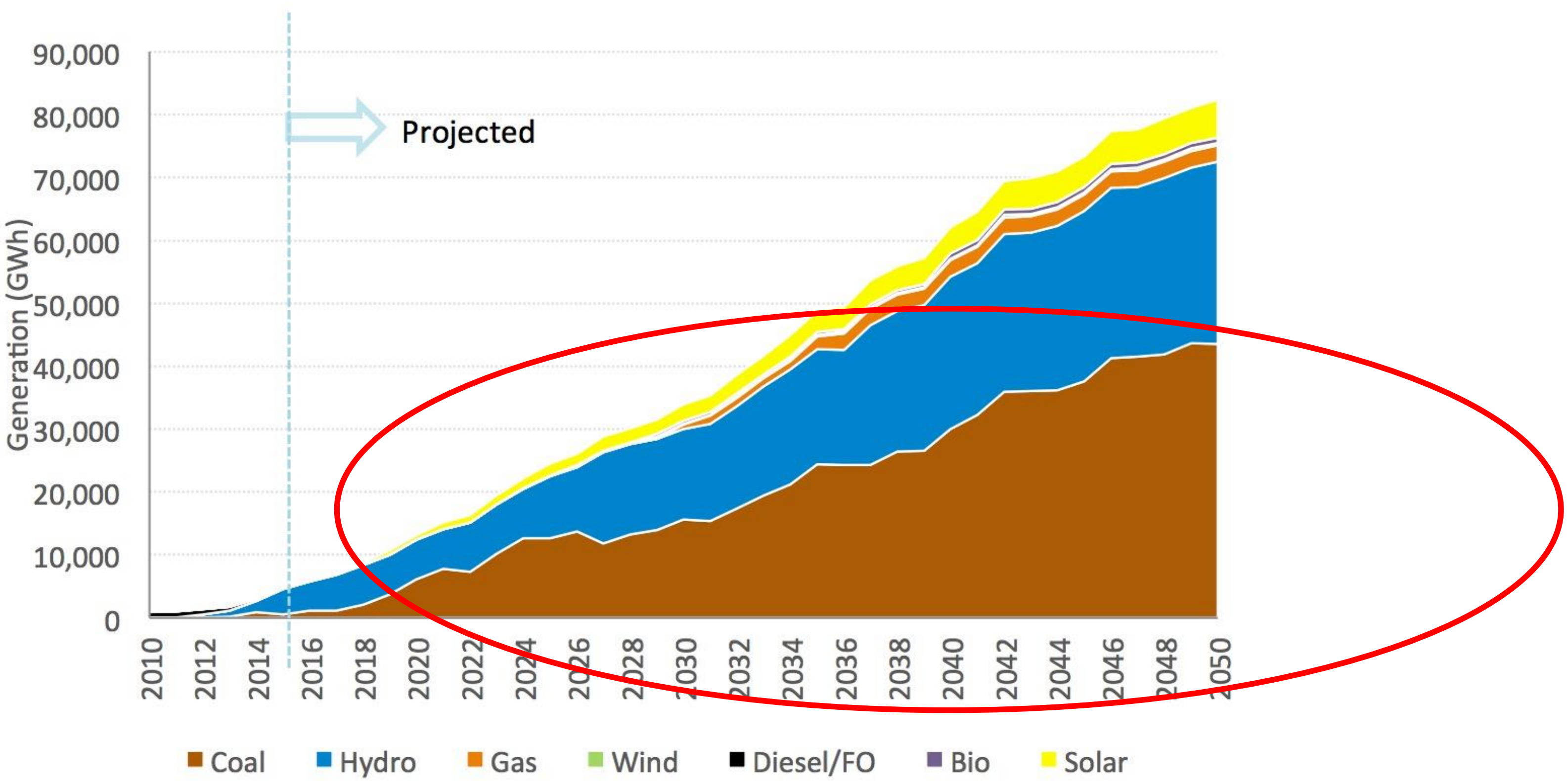
Figure 34 Cambodia Generation Mix (BAU, GWh)



Source: IES and MKE 2017

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A mix of solar, wind, biomass and hydropower can supply 100% RE (ASES) (coal not necessary)

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Figure 62 **Cambodia Generation Mix (ASES, GWh)**

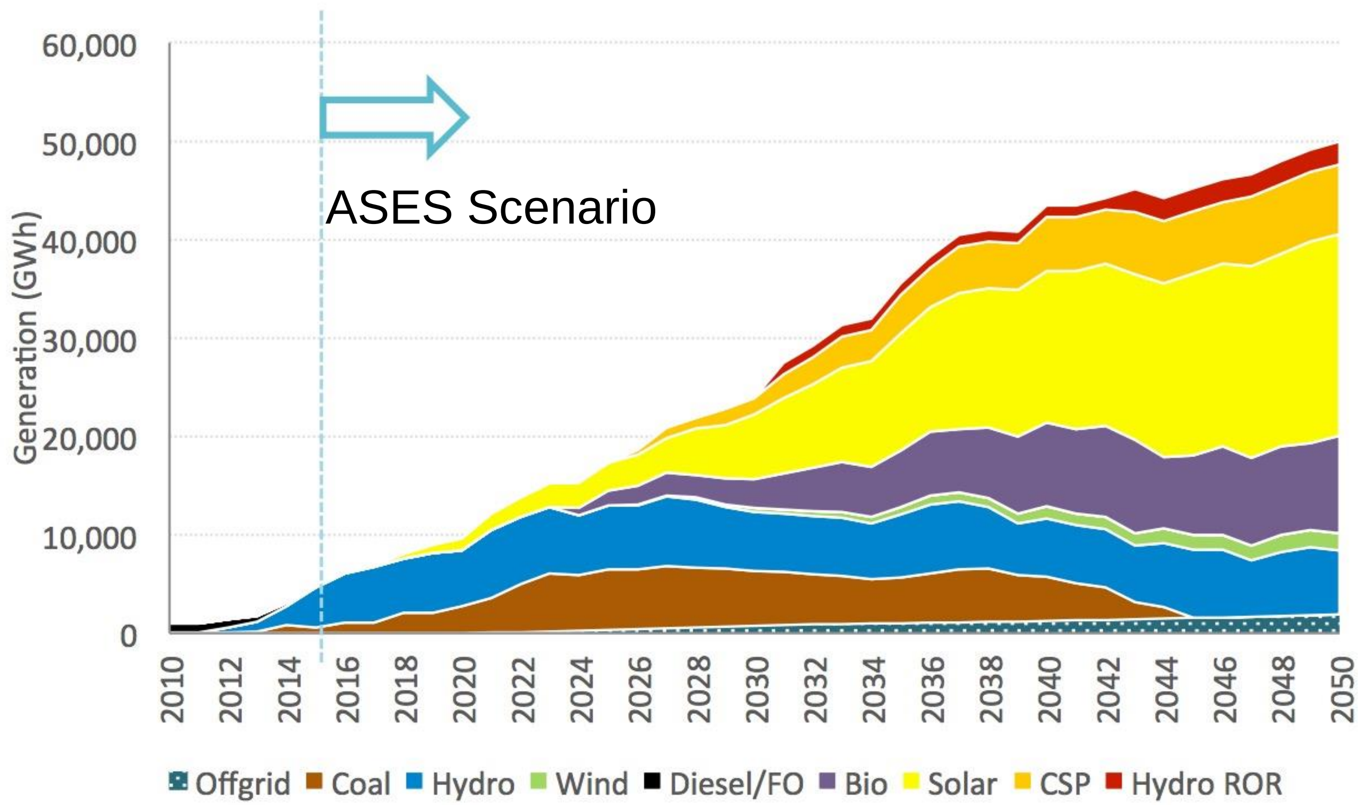
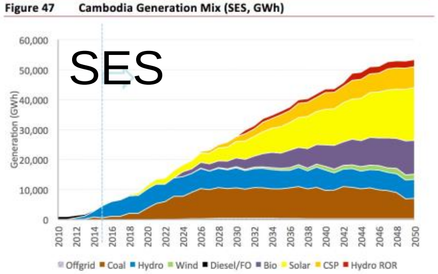


Figure 47 **Cambodia Generation Mix (SES, GWh)**



Source: IES and MKE 2017

Coal is only in the SES scenario in 2050 because the existing plant is still allowed to operate, but it is not needed!

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A mix of solar, wind, biomass and hydropower can supply 100% RE (ASES scenario)

Table 18 Cambodia Generation by Type (ASES, GWh)

Resource	2010	2015	2020	2030	2040	2050
Coal	32	587	2,722	5,522	4,459	0
CCS	0	0	0	0	0	0
Diesel	898	0	0	0	0	0
Fuel Oil	0	0	0	0	0	0
Gas	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Hydro	31	4,038	5,632	6,018	5,925	6,485
Onshore Wind	0	0	0	412	1,242	1,780
Offshore Wind	0	0	0	0	0	0
Biomass	0	0	0	2,961	8,532	9,954
Biogas	0	0	0	0	0	0
Solar	0	0	1,250	6,568	15,363	20,440
CSP	0	0	0	1,634	5,544	7,067
Battery	0	0	0	0	0	0
Hydro ROR	0	0	0	0	1,163	2,312
Geothermal	0	0	0	0	0	0
Pump Storage	0	0	0	0	0	0
Ocean	0	0	0	0	0	0
Off grid	0	0	30	765	1,246	1,887

Source: IES and MKE 2017

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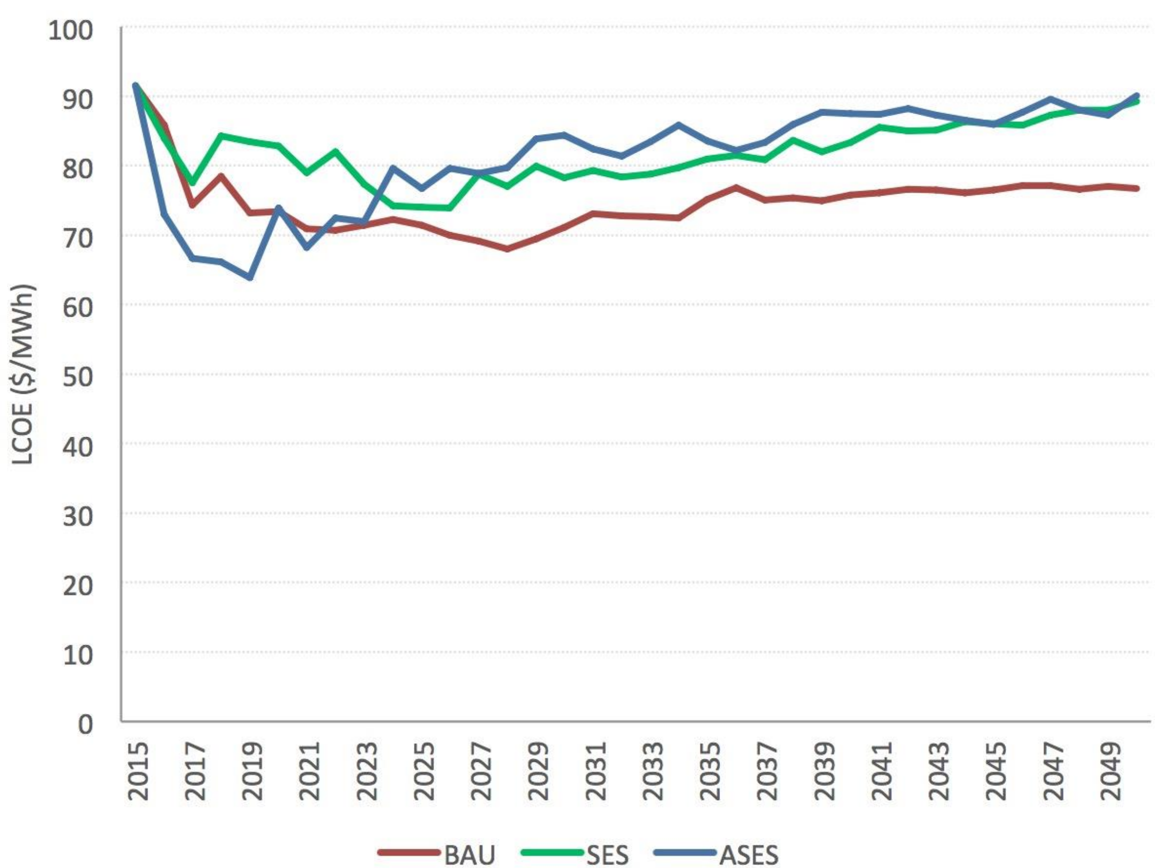
The levelized cost of electricity remains at a similar level

Figure 89 Cambodia LCOE for Generation



Source: IES and MKE 2017

Pump storage can be done by combining normal reservoirs (example from Laos PDR)

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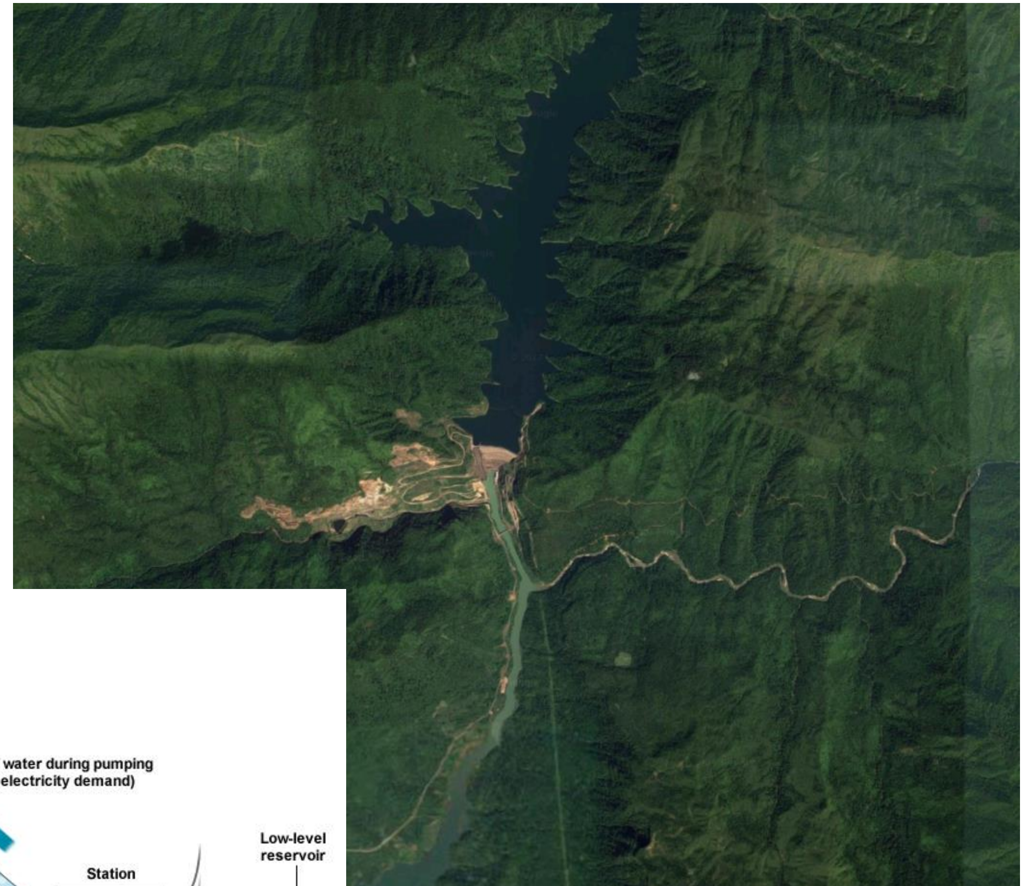

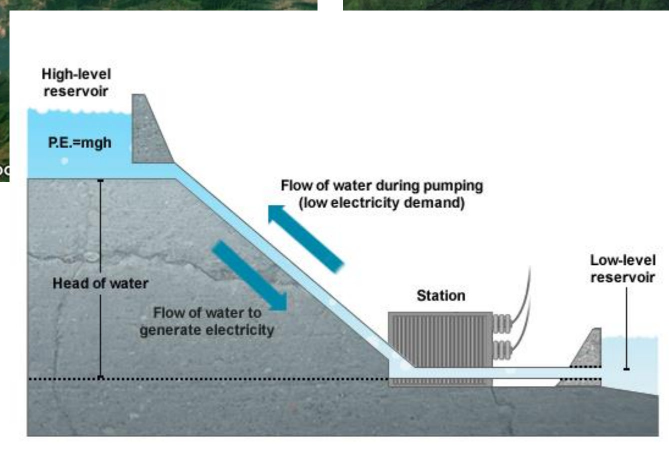

A 100% renewable energy supply
A chance for Cambodia?

Prof. Dr. Olav Hohmeyer
Europa-Universität Flensburg

Phnom Penh, Cambodia, October 27th, 2017

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Conclusions

- Cambodia can gain far higher energy independence
- Cambodia can shift to 100% RE without substantially higher costs
- Cambodia will benefit by higher jobs and less pollution
- International climate money can pave the way
- A 100% RE strategy can avoid substantial future payments for CO_2 emission charges
- We know how to do it and how to get the NAMA funding and financing (fits well with the existing energy NAMA)
- 100% RE power supply may be an interesting option for Cambodia

Thank you very much for your attention