

2nd Caribbean Sustainable Energy Forum, 2010
**Hydropower development in the Caribbean - Lessons
learned from projects in St. Vincent and Dominica**

Hydropower Development in the Caribbean – Lessons Learned from Projects in St. Vincent and the Grenadines and The Commonwealth of Dominica

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CREDP-GTZ

June 23rd 2010

2nd CSEF

Montego Bay, Jamaica



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OUTLINE

- 1. Brief introduction to the hydropower projects**
- 2. Why replacing a running system?**
- 3. The roles of government, independent regulator, utility and developer**
- 4. Classic Barrier Project Financing**

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- 1. Brief introduction to the hydropower projects**

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Caribbean Renewable Energy Development Programme

gtz German Technical Cooperation

On behalf of:
Federal Ministry
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SOUTH RIVERS

Hydropower development in the Caribbean - Lessons learned from projects in St. Vincent and Dominica

SOUTH RIVERS

Geographical Information of Powerhouse

Longitude	E	701,414
Latitude	N	1,465,164
Grid		WGS 1984, UTM, 20P
Country		St. Vincent
River name		Colonaire River

Hydropower Data

		Current	Future
Gross head	m	107.12	107.12
Head losses at rated discharge	m	9.8	3.2
Rated net head	m	97.32	103.92
Rated discharge (maximum)	m ³ /s	1.100	1.300
Ecological min flow in river	m ³ /s	0.000	0.280
Installed capacity	kW	870	1,110
Annual energy output	MWh	3,950	4,480
Current plant load factor		0.52	0.64

Technical Data

		Current	Future
Turbine type		Turgo	Turgo
No. of units		3	1
Year of installation		1952; 1952; 1959	2010?
Unit capacity	kW	275; 275; 320	1,110
Rotation speed	rpm	750	750
Grid frequency	Hz	50	50
Grid voltage level	kV	11	11



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RICHMOND

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RICHMOND

Geographical Information of Powerhouse

Longitude	E	691,519
Latitude	N	1,470,441
Grid		WGS 1984, UTM, 20P
Country		St. Vincent
River name		Richmond River

Hydropower Data

		Current	Future
Gross head	m	104.3	104.3
Head losses at rated discharge	m	8.8	3.87
Rated net head	m	95.5	100.43
Rated discharge (maximum)	m ³ /s	1.500	2.000
Ecological min flow in river	m ³ /s	0.000	0.330
Installed capacity	kW	1,100	1,630
Annual energy output	MWh	5,576	7,062
Current plant load factor		0.58	0.47

Technical Data

		Current	Future
Turbine type		Turgo	Turgo
No. of units		2	1
Year of installation		1962	2010 ?
Unit capacity	kW	2 x 550	1,630
Rotation speed	rpm	600	500
Grid frequency	Hz	50	50
Grid voltage level	kV	11	11



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NEWTOWN

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NEWTOWN

Geographical Information of Powerhouse

Longitude	E	465,165
Latitude	N	1,690,196
Grid		WGS 1984, UTM, 20P
Country		Dominica
River name		Roseau River

Hydropower Data

Gross head	m	107.55
Head losses at rated discharge	m	34.06
Rated net head	m	73.49
Length of pipeline	m	5,153
Diameter of pipeline	m	0.58 / 0.51
Rated discharge (maximum)	m ³ /s	0.350
Ecological min flow in river	m ³ /s	1.217
Installed capacity (@transformer)	kW	214
Annual energy output	MWh	1,800
Plant load factor		close to 1

Technical Data

Turbine type		Pelton
No. of units		1
Unit capacity	kW	227
Rotation speed	rpm	750
Grid frequency	Hz	50
Grid voltage level	kV	11



Hydropower development in the Caribbean - Lessons learned from projects in St. Vincent and Dominica

OUTLINE

1. Brief introduction to the hydropower projects
2. Why replacing a running system?

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Pertinent Question:

**Why replacing a running system
that is already depreciated and generates
electricity at very low cost?**

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Why Replacing existing Equipment with new Equipment?

- Existing equipment has reached it's life expectancy
 - South Rivers: 57 and 50 years since installation
 - Richmond: 47 years since installation
- Equipment efficiency decreases
- Maintenance cost increases
- Reliability of equipment decreasing

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Why Replacing existing Equipment with new Equipment?

- Existing equipment has reached it's life expectancy
 - South Rivers: 57 and 50 years since installation
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- Equipment efficiency decreases
- Maintenance cost increases
- Reliability of equipment decreasing

→ **Conclusion: New equipment required**

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Hydropower Plant Parameters as obtained from the Feasibility Study

South Rivers Small Hydropower Plant



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From pond to steel penstock		Current	Future
Penstock material		Wood stave	GFP Pipe, PN16
Penstock length	m	720	720
Penstock diameter	m	0.686	0.900
Wall thickness	mm		16

Steel penstock to powerhouse		Current	Future
Penstock material		Steel	GFP Pipe, PN16
Penstock length	m	426	426
Penstock diameter	m	0.660	0.900
Wall thickness	mm		16

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Richmond Small Hydropower Plant



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Penstock, Section 2

Penstock material		Wood stave	GRP pipe, PN10
Penstock length	m	973	973
Penstock diameter	m	0.980	1.1
Wall thickness	mm		18

Penstock, Section 3

Penstock material		Steel	GRP pipe, PN16
Penstock length	m	580	580
Penstock diameter	m	0.930	1.1
Wall thickness	mm		18.5

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Why replacing a running system?

- A) Increasing the energy output of the machines through:**
- Increasing the discharge capacity of the pipelines
 - Increasing the electrical capacity of the generating equipment
- B) Increasing the security of the generation facility**
- South Rivers is 58 years old, Richmond 48 years
 - The probability of mechanical failure of equipment increases significantly with every additional year

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Why replacing a running system?

B) Increasing the security of the generation facility (Cont'd)

17 Month of loss of revenue means ...

		Richmond	South Rivers
Laydown time	months	17	17
Lost electricity generation ^{*)}	kWh	9,633,333	3,960,000
Generation cost of existing HPPs	EC\$/kWh	0.130	0.195
Marginal cost of diesel stations @ crude oil price of 80 US\$/bbl	EC\$/kWh	0.33	0.33
Loss due to unplanned laydown	EC\$	1,926,666.67	534,600.00

***) Calculated with long term average production data. Recent data shows higher production → loss in electricity production is likely to be up to 40% higher!**

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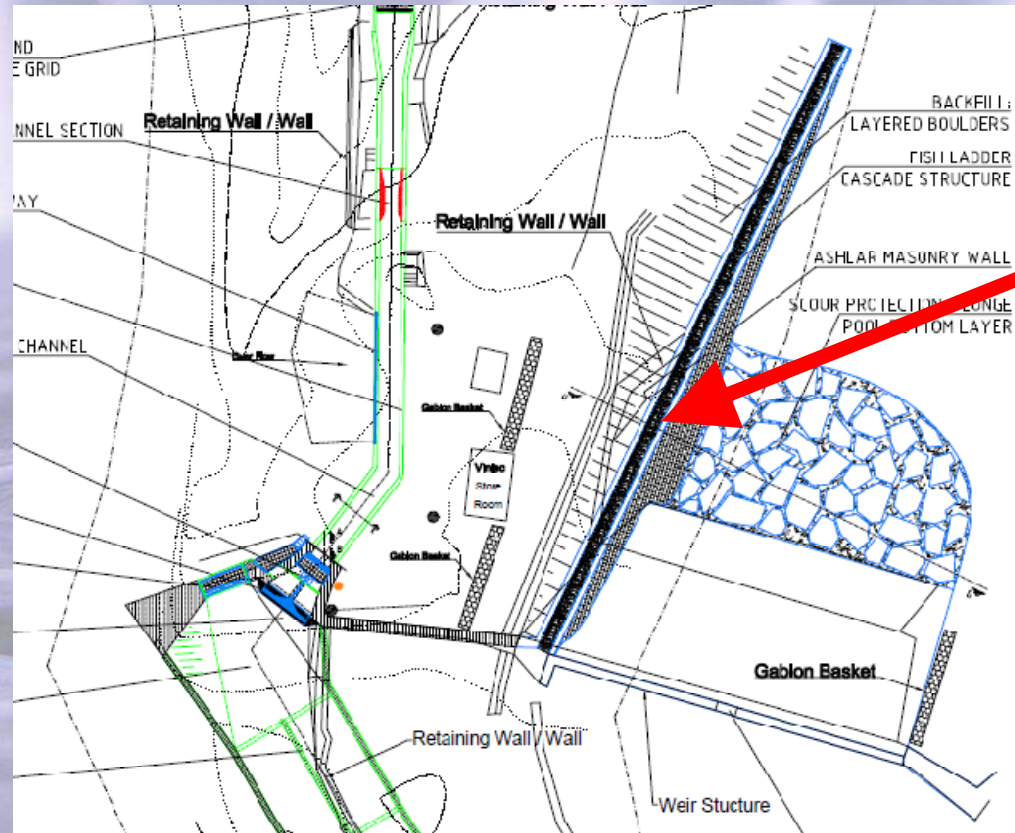
Other effect of refurbishments:

Consideration to be given to environmental issues.

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**During feasibility study:
Rapid Environmental and Social Impact Survey (RESIS)**

→ Fish mitigation help is recommended (Fish Ladder)



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During feasibility study: Rapid Environmental and Social Impact Survey (RESIS)

→ Recommended minimum flow to remain in the river:

- | | | |
|-----------|------------------------------|--|
| 1. | Richmond: | 0.330 m³/s (5,530 gal/min) |
| 2. | South Rivers: | 0.280 m³/s (4,440 gal/min) |
| 3. | South Rivers Stage 2: | 0.325 m³/s (5,150 gal/min) |

- To enable aquatic life in the river at all times**
- To protect riparian flora from drying out**
- To enable current usage of the water for bathing, washing etc**
- Minimum flow: international standard requirement**
- Values derived by an analysis done by CEHI**

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Currently: no minimum flow requirements

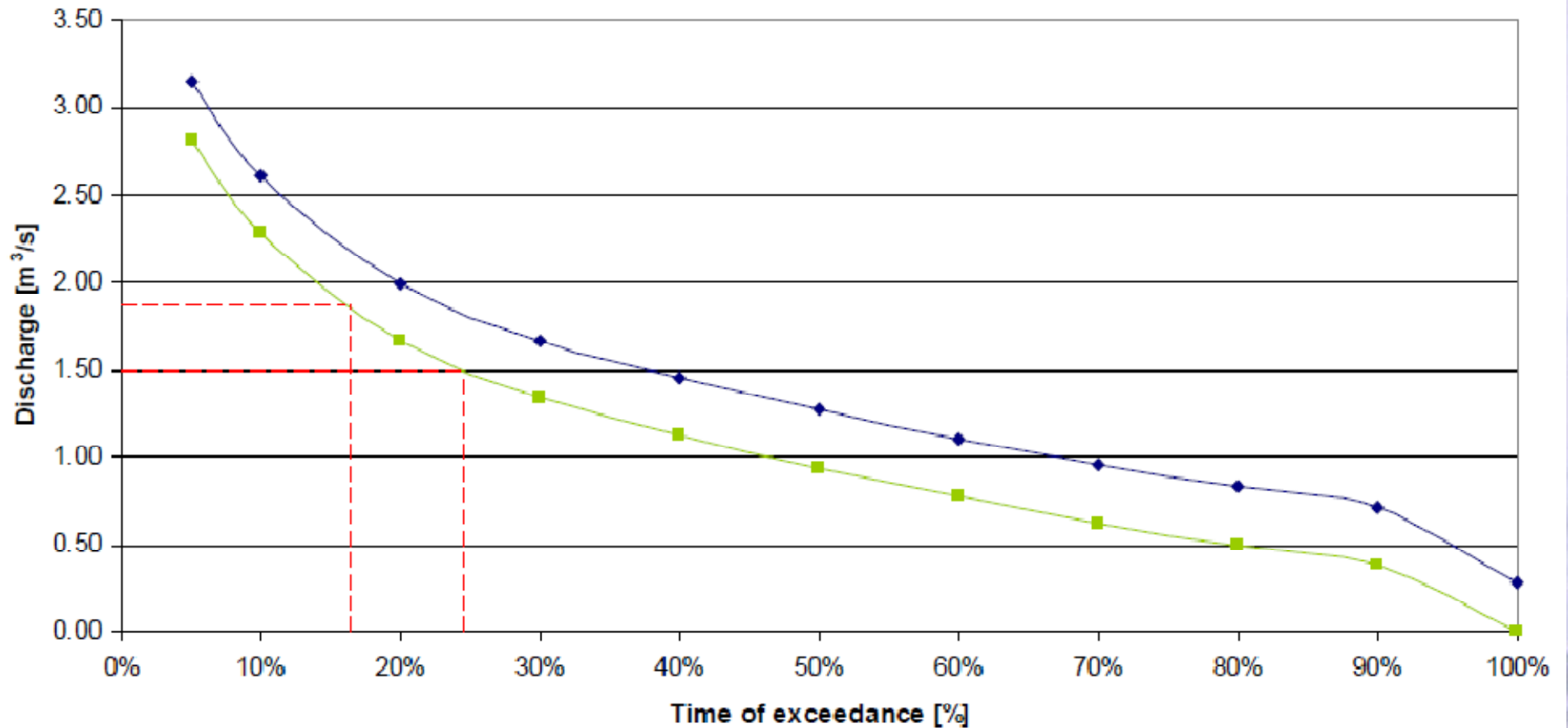
→ **At times in the dry season the rivers fall dry and all the water is used for hydropower generation**

Residual flow in the river → less water for hydropower → less electricity generation

How much less?

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FDC Richmond



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Loss in electricity generation:

Richmond projected annual electricity generation

Without minimum flow donation	9,630 MWh
With minimum flow donation	7,690 MWh
Difference	1,940 MWh (-20%)
Lost annual income due to min. flow	640,200 EC\$

South Rivers projected annual electricity generation

Without minimum flow donation	5,450 MWh
With minimum flow donation	4,480 MWh
Difference	967 MWh (-22%)
Lost annual income due to min. flow	319,110 EC\$

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Burning question:

Will the new hydropower plant still be financially viable?

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Generation cost obtained from the feasibility study:

		Richmond	South Rivers
Generation cost of existing HPPs	EC\$/kWh	0.130	0.195
Generation cost for new HPPs	EC\$/kWh	0.134	0.204
Marginal cost of diesel stations @ crude oil price of 80 US\$/bbl	EC\$/kWh	0.33	0.33

**These figures do not include possible income from Clean
Development Mechanism (CDM)!**

→ CDM only for newly established capacity

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Example: Newtown Hydropower Project Dominica Project Development

**CREDP-GTZ &
DOWASCO**

Project Identification Study

Analysis of existing pipeline

**External Consultant &
CEHI**

Feasibility Study

Environmental and Social Survey

Tender Design and Tender Documents

**DOWASCO &
???**

Negotiation of PPA

Project Financing

Project Implementation

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**DOWASCO &
???**

What happened?

After finishing the feasibility study and the tender documents:
**Find out feed-in tariff to consolidate financial figures and
negotiate financing conditions with banks.**

1. Step



DOMLEC: “You go to IRC and what ever tariff they tell us we will pay.”

2. Step



IRC: “You negotiate with DOMLEC and we decide if tariff is acceptable.”

Who plays which role?

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Classical Roles in IPP Hydropower Project Development

- | | | |
|-------------------|---|--|
| Developer | → | Project Identification |
| | → | Studies of Project (sometimes: Consultant) |
| | → | Owner of Project |
| | → | Put forward applications (construction, electricity generation etc) |
| Government | → | Outlines the Rules for Regulation (to IRC) |
| | → | Checks applications and decides: yes/no |
| | → | Requires obligations (e.g. environment) |
| IRC | → | Outlines conditions for PPA (economical) |
| | → | Control if conditions are met |
| Utility | → | Outlines technical requirements |
| | → | Negotiates PPA with Developer |
| | → | Buys electricity from IPP and re-sells it |

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Differentiation

	Private Investor	Public Investor	PPP
Possible Financing	<ul style="list-style-type: none"> Commercial Banks Development Banks Private Equity Donor Grant 	<ul style="list-style-type: none"> Commercial Banks Development Banks Government Budget Donor Grant 	<ul style="list-style-type: none"> Commercial Banks Development Banks Private Equity Government Budget Donor Grant
Interest Rate (e.g. CDB)	$i = 6.5 \%$	$i = 4.5 \%$	$6.5 \% > i > 4.5 \%$
Security for Loan	<ul style="list-style-type: none"> PPA Equity 	<ul style="list-style-type: none"> PPA Government Guarantee 	<ul style="list-style-type: none"> PPA Equity Government Guarantee
Risk Bearing	Private Investor	Government	Government and Private Investor

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Conclusions

To identify the best financing mechanism several opportunities should be checked:

- **Utility Project, IPP or PPP**
- **Equity supplemented by loans from Commercial Bank, Development Bank or both**
 - Possible Development Banks:
 - European Investment Bank (EIB)
 - Caribbean Development Bank (CDB)
 - Inter American Development Bank (IDB)
 - German Development Bank (KfW)
 - Austrian Development Bank (OeEB)
 - International Finance Corporation (IFC)
- **Development Banks usually give loan financing**
- **Donors sometimes provide grant financing for particular projects for Technical Assistance, e.g. pilot projects**
- **Essential: Initiative of the Developer!!**

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Questions?