INTERNATIONAL SYMPOSIUM ON RENEWABLE ENERGY DEVELOPMENT

LARGE-SCALE RENEWABLE ENERGY PROJECTS AND FUTURE PLANS BY FIJI ELECTRICITY AUTHORITY
Outline

- FEA Vision & Mission
- Why Renewable Energy
- Renewable Energy Projects Developed
  - Monasavu Hydro Scheme
  - Wainikasou Hydro
  - Nagado Hydro
  - Butoni Wind Farm
- Current Renewable Energy Project
  - Nadarivatu Hydro
- Proposed Renewable Energy Projects
  - Wailoa Downstream Hydro
  - Wainisavulevu Weir Raising
- Independent Power Producers (IPP)
- Government Incentives

energizing our nation
Butoni Wind Farm
The Fiji Electricity Authority (FEA) was established under the provisions of the Electricity Act of 1966.

It began operation on 1st August 1966

Studies on Fiji’s potential to generate hydroelectricity dated back to 1930.

However, it was not until the sudden increase in oil prices and the predicted increase in demand for electricity in the 1970’s that major investigations were made into the viability of hydro power projects.
• In 1972, EXEX of New Zealand, consulting engineers, prepared a detailed report.

• In 1976, Sir Alexander Gibb and Partners of Australia were engaged to prepare a long term power development plan for Fiji. The report highlighted the feasibility of Hydro power generation on Viti Levu and Nadrau area and surrounding plateau were identified as the location to produce the most economical return on investment.
FEA’s Mission and Vision

VISION

“Energising our people and our nation”

MISSION

“We will provide clean and affordable energy solutions to Fiji and the Pacific. We aim to provide all energy through renewable resources by 2011”
Why Renewable Energy?

• Unlimited Supplies
  • Fossil fuels are limited in supply and price will increase as they become scarcer
  • Renewable energy supplies will never run out

• High Fossil Fuel Price and Energy Price Stability
  – We are experiencing large fluctuations in the cost of fossil fuels due to global economics, market deregulations & political events
  – Renewable energy is not subject to sharp price changes because it comes from sources which are free (e.g. sunlight, wind, water)

• Clean Air
  – Renewable Energy adds few pollutants to the environment so considered “clean” and “green”

• Protecting Global Climate
FEA’S RENEWABLE ENERGY DEVELOPMENT PROGRAMME

• In 2002, FEA adopted a renewable energy development strategy, in order to reduce Fiji’s dependency on imported thermal fuel. The strategy is to produce at least 90% of the required generation by renewable sources. It is estimated that in excess of F$120 million per year at current diesel price of $2,100 per tonne could be saved in foreign exchange leakage if the renewable energy development program is successfully implemented by 2011.

• FEA’s renewable energy development programme up to 2015 is shown graphically below.
POWER DEVELOPMENT PLAN TO 2015

- Diesel generation (FEA)
- Lower Wailoa Additions (FEA)
- Wailoa improvements (FEA)
- Tropik Nadi (IPP)
- Nadarivatu (FEA)
- Iviti Bio Mass (IPP)
- Deuba Bio Mass (IPP)
- Tropik Drasa (IPP)
- FSC Lautoka (IPP)
- Butoni (FEA)
- FSC Labasa (IPP)
- Wainikasou/Nagado (IPP)
- Monasavu (FEA)
Renewable Energy Developed
Monasavu Hydro Scheme

Monasavu Hydro Scheme was in three parts:

• Power Project I (PPI):
  – Building of the Monasavu Dam and Lake
  – Wailoa Power Station with two 20 MW turbine generators
  – 132 kV transmission line to Suva & Vuda (Lautoka)

• Power Project II (PPII):
  – Raising of the Monasavu Dam by 15 metres
  – Installing two more 20 MW turbine generators at Wailoa
  – Diverting three additional creeks into Monasavu lake

• Power Project III (PPIII):
  – Diversion of four more creeks to Monasavu lake. Through a combination of weirs to collect the water, and shafts and tunnels. PPII & PPIII have enlarged the original 62 km² catchment area of PPI to 110 km² and increased the electrical capacity of Monasavu scheme to 80 MW.
Successful completion of FEA’s renewable energy development programme including IPP projects will reduce diesel generation for electricity production to less than 10% by 2011, compared to 51% in 2006 and 33% in 2007, and also result in a more balanced and diversified generation mix.
Renewable Energy Developed
Monasavu Hydro Scheme

energizing our nation
energizing our nation

2006

Diesel 51%
Monasavu, 45%
IPP 4%

FUTURE

Monasavu, 31%
IPP, 30%
Nadarivatu, 11%
Wind, 5%
Biomass, 15%
Diesel, 8%
Renewable Energy Developed
Monasavu Hydro Scheme

Chronology

- **1978**
  - Construction on PPI began in April.

- **1979**
  - Initial planning to raise the height of Monasavu dam by 15 metres started - to increase generating capacity at Wailoa from 40 to 80 MW. This was PPII project.

- **1980**
  - Tenders for PPII were called
  - 132kV transmission line across Viti Levu completed

- **1981**
  - Construction of PPII started
  - Two turbines installed at Wailoa power station
  - PPIII contract was also awarded.
Renewable Energy Developed
Monasavu Hydro Scheme

• 1982
  – Monasavu dam completed ahead of schedule and controlled filling of
dam started (16 April).
  – More emphasis on training of employees

• 1983
  – Power from Monasavu Hydro Scheme finally flowed to the Viti Levu
  interconnected system
  – Cyclone Oscar had a devastating impact on FEA’s distribution system
    ($2.1 million)

• 1984
  – Hydropower accounted for 99.2% for total Viti Levu.
  – 94.7% of total FEA electricity generated

• 1985
  – PPIII project completed and opened
The Costs

• In the region of $230 million
• Balanced against the estimated 1983 savings of $22 million annually for diesel fuel

• Cost was met through:
  – International loan (ADB, CDC, EIB, World Bank & Tokai Bank, Japan)
  – Local loan (FNPF)
  – Government grants
  – Australian grant assistance
Renewable Energy Developed
Monasavu Hydro Scheme

Monasavu Dam
Renewable Energy Developed
Wailoa Power Station
Renewable Energy Developed
Monasavu Hydro Scheme

LONGITUDINAL SECTION THROUGH MONASAVU HYDRO ELECTRIC SCHEME

<table>
<thead>
<tr>
<th>PROJECT DETAILS</th>
<th>WAILOA POWER STATION</th>
<th>WAINIKASOU POWER STATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>YEAR COMMISSIONED</td>
<td>1983</td>
<td>2004</td>
</tr>
<tr>
<td>POWER STATION CAPACITY</td>
<td>80 MW</td>
<td>6.4 MW</td>
</tr>
<tr>
<td>ANNUAL ELECTRICITY PRODUCTION</td>
<td>400 GWh</td>
<td>19 GWh</td>
</tr>
<tr>
<td>WATER YEARLY FLOW TO POWER STATION</td>
<td>200,000,000 m³</td>
<td>70,000,000 m³</td>
</tr>
<tr>
<td>TOTAL LENGTH OF TUNNELS &amp; SHAFT</td>
<td>17,200 m</td>
<td>1,564 m</td>
</tr>
<tr>
<td>RESERVOIR CAPACITY</td>
<td>133,000,000 m³</td>
<td>37,000 m³</td>
</tr>
<tr>
<td>GROSS HEAD</td>
<td>623 m</td>
<td>116.8 m</td>
</tr>
<tr>
<td>TAILRACE TUNNEL TO MONASAVU</td>
<td></td>
<td>11000 m</td>
</tr>
</tbody>
</table>
Renewable Energy Developed
Wainikasou Power Station

• Wainikasou Power Station is owned by Sustainable Energy Limited - a joint venture company between Pacific Hydro Limited (PHL) Australia and Fiji Electricity (fea) Fiji.

• Run-Off River Hydro

• Estimated annual energy production at 18 GWh

• Started operation in May 2004
Renewable Energy Developed
Wainikasou Power Station

• The Wainikasou Hydro Power Scheme uses the energy potential of an existing discharge valve in the very upstream of the Monasavu Hydro Scheme - Power Project III (PPIII).

• The existing valve structure has been designed to accommodate the later addition of generating plant with a bifurcation already existing in the tunnel outlet pipe work, and a removable wall in the stilling basin.

• Water after used in the power station is diverted by tunnel down to Monasavu dam
Renewable Energy Developed
Wainikasou Power Station

The work done to complete the scheme were:

- Raise the existing Wainisavulevu weir to increase the scheme head and available storage without inundating land beyond the FEA land boundaries.
- Construct a powerhouse and control building adjacent to the existing valve house.
- Installation of a turbine generator plant and ancillaries
- Construction of 38km of 33kV transmission line to Wailoa power station – done by FEA.
- Integration of a diesel generator set into the Local Service Supply with fully automatic operation.
- Construction of 1.5 km of 6.6kV power line and catenary cable to weir site.
Renewable Energy Developed
Wainikasou Power Station

Wainisavulevu Weir (without the Rubber Gate)
Wainisavulevu Weir

- Type: Adjustable height (Obermeyer Gate)
- Operating Mechanism: Inflatable Bladder
- Weir Crest Level: RL 913.58 m
- Maximum Gate Height: 1.5 m

Renewable Energy Developed
Wainikasou Power Station
Renewable Energy Developed
Wainikasou Power Station

Wainisavulevu Weir with the Rubber Gate
Renewable Energy Developed
Wainikasou Power Station
Renewable Energy Developed  
Wainikasou Power Station

- **Turbine**
  - Manufacturer: Voith ESAC Hydro
  - Type: Horizontal Francis
  - Net Head: 115.4 m
  - Maximum Output: 3.4 MW
  - No. of Units: 2
  - Operating Speed: 1000 rpm
  - Runaway Speed: 1850 rpm

- **Generator**
  - Manufacturer: Leroy Somer
  - Rated Output: 3664 kVA
  - Rated Voltage: 6.6 kV
Renewable Energy Developed
Wainikasou Hydro Power Station
Renewable Energy Developed
Nagado Hydro Power Station

- Exploits the energy potential of an existing water supply pipeline from Vaturu Dam to Nagado Water Treatment Plant (WTP).

- The potential is being realised as Public Works Department (PWD) had to do away with a number of “break pressure” tanks in a new pipeline to the WTP.
Renewable Energy Developed
Nagdo Hydro Power Station

The work required to complete the scheme were:

- Construct a powerhouse and control building adjacent to the existing WTP inlet chamber.

- Installation of a turbine generator plant and ancillaries.

- Construction of 33kV transmission line to the existing FEA system.
Nagado Power Station is also owned by Sustainable Energy Limited - a joint venture company between Pacific Hydro Limited (PHL) Australia and Fiji Electricity (fea) Fiji.

- Water Storage at Vaturu Dam
- Estimated annual energy production at 19 GWh
- Started operation in April 2006
Renewable Energy Developed
Nagado Hydro Power Station
Renewable Energy Developed
Nagado Hydro Power Station
Renewable Energy Developed
Nagado Hydro Power Station
Renewable Energy Developed
Nagado Hydro Power Station

Main Inlet Valve (Open position)
Renewable Energy Developed
Nagado Hydro Power Station
**Renewable Energy Developed**

**Nagado Hydro Power Station**

---

**Turbines**

- **Manufacturer**: Voith ESAC Hydro
- **Type**: 2 Nozzle Horizontal Pelton
- **Nett Head**: 268.2 m
- **Rated Flow**: 1.27 m³/s
- **Maximum Output**: 3.0 MW
- **No. of Units**: 1
- **Operating/Runaway Speeds**: 600/1080 rpm

**Generators**

- **Manufacturer**: Leroy Somer
- **Rated Output**: 3333 kVA
- **Rated Voltage**: 6.6 kV

---

*energizing our nation*
Renewable Energy Developed
Butoni Wind Farm

- FEA’s first wind farm feeding into the national grid from Sigatoka region

- The Butoni Wind Farm Site is located in the south-western part of the Viti Levu Island of Fiji near Sigatoka township.

- The average elevation of the main ridge is about 220 mASL.

- The wind regime is dominated by south-easterly trade winds with small occurrences of sea breezes.
Renewable Energy Developed
Butoni Wind Farm – Project History

• 2003
  – The FEA in line with its mission to produce all energy by renewable sources by the year 2011 decided to embark on a wind farm project.
  – FEA and Pacific Hydro Ltd (PHL) met with Department of Energy (DOE) and made site visits to all the sites where DOE had already taken wind measurements.

• 2004
  – Butoni, one of the sites close to where wind data was collected by DOE was chosen due to:
    • easy accessibility,
    • proximity of the Butoni ridge to the FEA grid
    • and Sigatoka being an area of increasing development,
  SEL decided to install a wind monitoring tower on the Butoni ridge to get more accurate wind data.
• 2004 (cont.)
  – Initial data collected put Butoni in the low wind speed category with average wind speeds recorded at 4 - 6m/s. Project deemed financially uneconomical by PHL based on the development cost and the expected energy generation.
  – FEA decides to pursue project on own accord as JV partner (PHL) pulls out of the project.
  – PB Power (Australia) taken onboard by FEA as principal consultants to prepare documentation for tender.
  – International tender called by FEA in Q4 2004
Renewable Energy Developed
Butoni Wind Farm – Project History

• 2005

– March 2005 – memorandum of understanding and confidentiality agreement signed between Vergnet and FEA
– July 2005 – design, supply and installation contract was signed between Vergnet Pacific and FEA for a 10MW Turnkey Wind Farm Project.
– Civil tender specification prepared by Vergnet. Civil scope included road works, platforms works, drilling and concrete works.
Renewable Energy Developed
Butoni Wind Farm – Project History

• 2005 (cont.)
  – Environmental Impact assessment concluded with final approval from Department of Environment
  – Landowners sent on an excursion in New Caledonia in October to visualise what a wind farm looks like and the impact on their land.
  – Full landowner and NLTB consensus to lease FEA land for the wind farm granted in November 2005
  – Official start date of the contract was agreed to be **23 November, 2005** by both parties. Vergnet’s 14 months period from ground works to commissioning commenced on the 23\(^{rd}\).
Renewable Energy Developed
Butoni Wind Farm – Project History

• 2006
  • Commissioning start April 2006 and last turbine commissioned in August 2007
Renewable Energy Developed
Butoni Wind Farm – Data

The wind farm is made of:

- 37 wind turbines (GEV-MP 275)
  - Horizontal axis, 2 blades
  - Tower Height of 55m & Rotor Dia of 32m
  - Collapsible tower
- Each having a rated power output of 275KW
- Total rated capacity 10MW

The Performance Warranty under this Turnkey Contract is 11.3GWH for a period of one year at an average wind speed of 5.47m/s.
Renewable Energy Developed
Butoni Wind Farm - Performance

Power Curve for a Vergnet GEV-MP275 turbine (manufacturer's data)

energizing our nation
Renewable Energy Developed
Butoni Wind Farm - Performance

Butoni Wind Farm Generation (MWh)

energizing our nation
Renewable Energy Developed
Butoni Wind Farm - Performance

- Annual Average Wind speed recorded at the windfarm during the first year was $\approx 4.96 \text{ m/s}$

- Capacity Factor for first year of operation at 5.2% compared to 12% as manufacturer performance contract

- O&M specific cost at $0.12/\text{kWh}$ compared to approx. $0.27/\text{kWh}$ for diesel power generation

- O&M Cost expected to increase after few years of operation – due to wear & tear and component life
Renewable Energy Developed
Butoni Wind Farm
Renewable Energy Developed
Butoni Wind Farm
Current Renewable Energy Projects
Nadarivatu Hydro

- Detail study for Nadarivatu Hydro project started in 2003
- International tender out in 2006
- Tender awarded to Sino-Hydro from China on a turnkey project in 2008
- MWH engaged as Owners Engineer
- Construction started 2009
- Expected to commission by 2011
- Power station capacity of 40MW (2x20 MW units)
Current Renewable Energy Projects
Nadarivatu Hydro

• Detail study for Nadarivatu Hydro project started in 2003
• International tender out in 2006
• Tender awarded to Sino-Hydro from China on a turnkey project in 2008
• MWH engaged as Owners Engineer
• Construction started 2009
• Expected to commission by 2011
• Power station capacity of 40MW (2x20 MW units)

- It was confirmed that potential exists for a 10 MW scale run-off-river plant immediately downstream of the existing Wailoa hydro power station

- 2008 – 2009 detail study (Tokyo Electric Power Company:
  - Run-off-river scheme
  - 7.3 MW
  - Annual generated energy of 44.9 GWh
Proposed Renewable Energy Projects
Wailoa Downstream Hydro Project
Proposed Renewable Energy Projects
Wanisavulevu Weir Raising Hydro Project

- Study completed for raising the Wainisavulevu weir (storage pond for Wainikasou Hydro station)
  - Potential:
    - Raise the existing weir by 6m
    - Energy yield average 7.3GWh/year
Proposed Renewable Energy Projects
Wanisavulevu Weir Raising Hydro Project

Raise weir height by 6 metres
Proposed Renewable Energy Projects
Independent Power Producers (IPP)

• Currently the following IPP’s are selling electricity to FEA
  – Fiji Sugar Corporation (Lautoka & Labasa mills during crushing season)
  – Tropik Wood (Drasa, Lautoka)
GOVERNMENT INCENTIVES FOR RENEWABLE ENERGY
POWER GENERATION

- Duty Free for all materials purchased off-shore
THANK YOU