A
Presentation
on
"Design Modification and Economic Analysis of Multi-blade Wind Mill for Water Pumping in Morang district."

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Presentation Outline

- Brief Introduction of AEPC
- Wind Activities
- Details of wind pumping pilot project

Introduction of AEPC

- **AEPC** - established in November 3, 1996
- **National Executing Agency –** Renewable energy programmes and projects.
- **Government Institution under Miinistry of Environment-** semi autonomous status.
- **Mandate:** policy and plan formulation, resource mobilization, technical support, M & E, quality assurance and coordination.

Introduction of AEPC

Six Broad Objectives:

- Preparation of short, medium, and long term policies and plans.
- Implementation of programmes for development of RETs and Energy efficiency.
- Standardization, quality assurance, and monitoring.
- Providing technical Service and support to rural people
- Facilitating Subsidy and financial assistance.
- Strengthening of partners' i.e. civil society, local agencies and private sector.

Introduction of AEPC

Promoting Following Energy Technologies throughout the country:

- Mini & Micro Hydro Technology
- Solar Technology
- Biogas Technology
- Energy Efficiency
- Biomass Technology
- Wind Technology
- Biofuel

Wind Activities in AEPC

- Measurement of wind data from 12 different locations
- Conduction of small scale pilot projects of 200 and 400 W in 6 different areas
- Implementation of SWERA Project
- Conduction of pilot projects on wind pumping system
- Development of wind database management system is in final stage

Redesign of Diever 450 wind pumping system: A Pilot project

Existing Wind Pumps in Nepal

S.N.	Locations of installation	Tentative year of installation	Supported by	Status
1	Agriculture Campus Rampur, Chitwan	1986 A.D.	USAID	Non-operational
2	Ramechhap Bazaar	1986 A.D.	GTZ	Non-operational
3	TU, RECAST, Kirtipur	1981 AD	GTZ	Non-operational
4	Local Development Centre Kalbalgudi, Jhapa			Non-operational

(Source: Bhatta, 2004)

5	Nari Bikash Sangha, Kathari, Morang	1984 A.D.	Netherlands Government	Non-operational
6	Fishery firm, Lauki, Sunsari	1995 A.D.	Netherlands Government	Non-operational
7	Private Agriculture Firm, Babita Birta, Morang	1997 A.D.	Private sector Investment	Non-operational
8	BMC-SILT, Biratnagar, Morang	2002 A.D.	KGEW, Biratnagar, &BMC-SILT Private sector investment	Operating as demonstration and study unit Till 2004

(Source: Bhatta, 2004)

Problems Identification

- Blindly adopted technology may be not appropriate.
- Lack of information about the technology.
- The high initial cost for majority of low income group of population.
- People Depends upon rainfall, some canals, diesel-fuelled pumps for deep-bore wells, or hand and foot pumps

Objective

Main objective

- To modify the existing design of wind pumping system and carry out detail economic analysis

Objective

Specific objectives:

- To redesign wind pumping system
- To carryout detail economic analysis of the system
- To recommend suitable design for wind pumping system on the basis of study

Site address

Bhawada VDC, Ward No. 5

Morang District

Owner : BMC Silt (P) Ltd.

Area used for cultivation : 0.75 ha

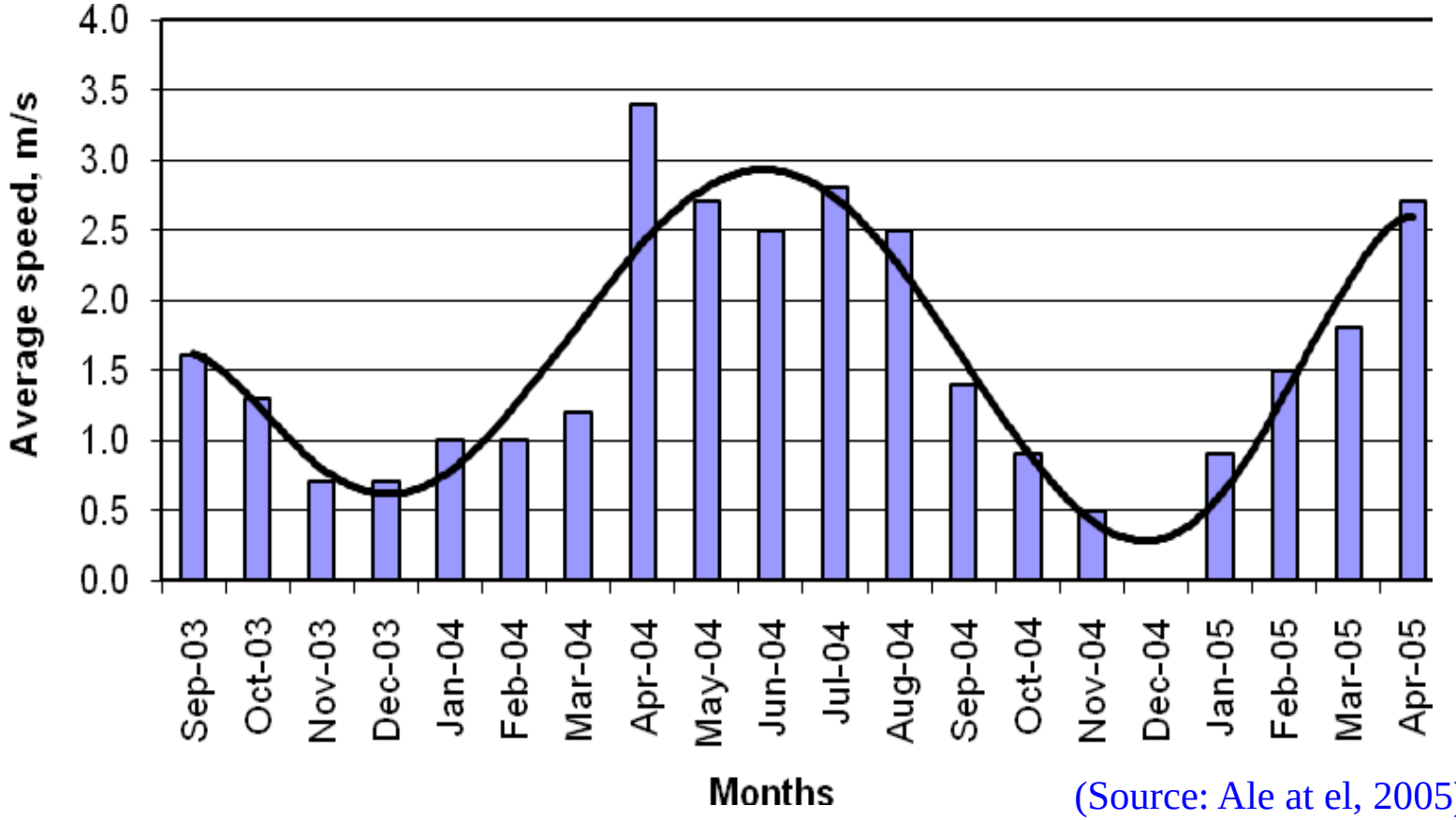
Distance from nearby market : 8 km

Distance from the fabrication workshop: 12 km

Design Parameter

- Annual average wind speed
  - Annual mean wind speed of 20 months for that site was calculated 1.8 m/s and power density at the same case was obtained to be 15 W/m^2 (Ale at el, 2005).

Wind Characteristics in selected region



(Source: Ale at el, 2005)

Design Parameter

- Water lifting head
  - Suction head = 2.5 m
  - Delivery head = 1 m
  - Total friction losses on suction and delivery pipes = (0.3419+0.151) m
  - Drawdown head = 0.7 m
  - Total head (H) = 4.51 m

Design of Wind Water Pumping System

- The rotor
- The safety system
- Transmission mechanism
- Pump and
- Tower

Need of re-Design of system

- As the standard model of Diever 450 developed by WOT (*Working Groups on Development Techniques*) is based on cut-in speed of 3m/s, hence the complete wind pumping system should be designed at the velocity of 2m/s as the annual average velocity at that location is found to be 1.8m/s
- Basically, two options have been found in order to build the complete system as per standard design of 6 inch pump size developed by WOT in this scenario.
  - Either changing the blade profile in effective manner, or
  - Increase the rotor size

Need of re-Design of system

- Hence, it is found to be difficult to apply these alternatives in this proposed system as high technology is required to change the blade profile whereas at the same time cost of the system would increase for increasing blade size which may not be favorable for local adaptive purpose.
- To cope with these circumstances, the pump size has been reduced to 4 inch for design wind speed of 2 m/s so that lifting of water could take place in effective manner.
- Similarly, pump cylinder material has also been changed from steel to locally available PVC due to high friction, wear and tear in steel under pumping mechanism as gained from past experiences.

Design of rotor

- 1 mm thick and 1 m length standard steel sheet is used for rotor, which is available in local market
- Tip speed ratio = 1

Design of rotor

- Blade design

SN	No. of blades on rotor	Projected area of one blade (m^2)	Total projected area (m^2)
1	6	0.97	5.82
2	12	0.501	6.012
3	18	0.34	6.12
4	24	0.26	6.24

(Optimum spokes for 4.5 m rotor is six (WOT,1990) . Hence, the number of blades should be a multiple of six. Hence, no. of blades is chosen as 18 by considering cost and weight analysis.)

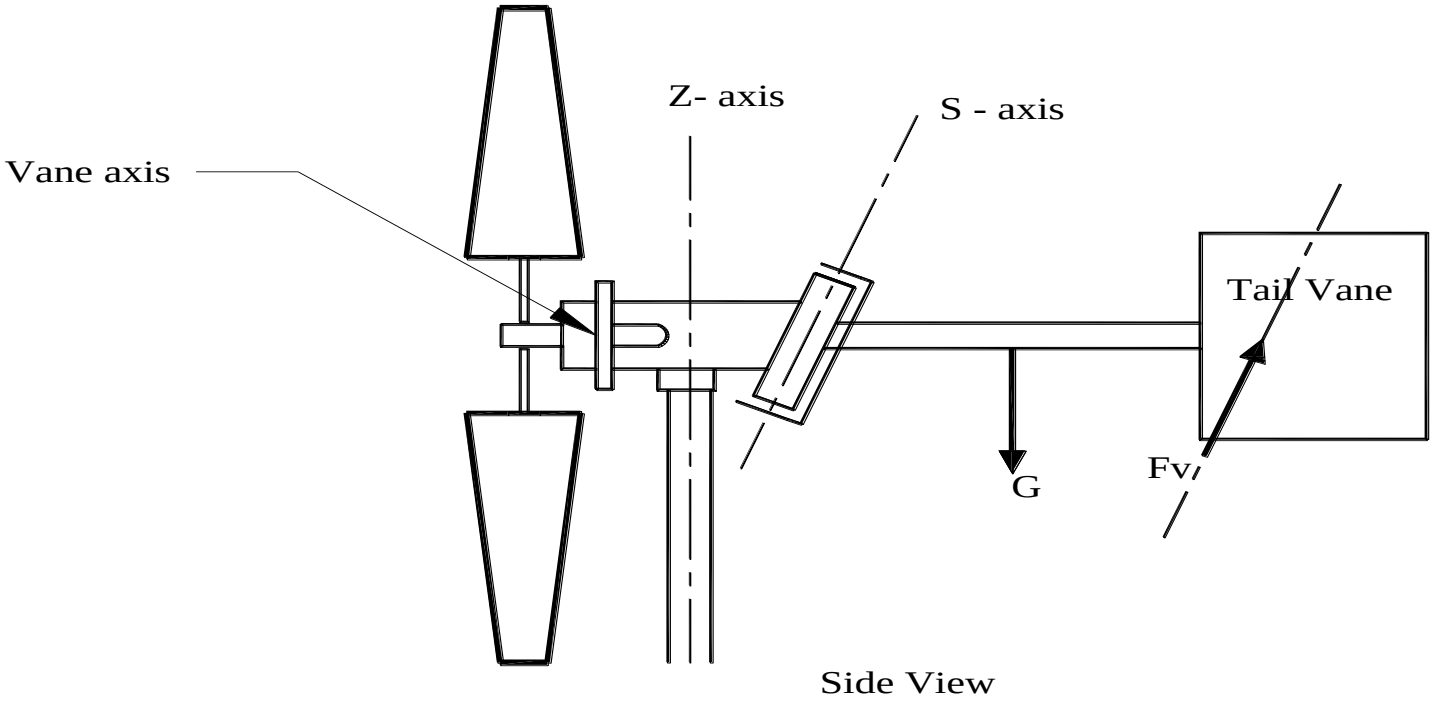
Design of rotor

- Standard design code 18U450 for rotor which implies rotor diameter is 450 cm and no. of blades are 18.

Design of safety system

- Inclined hinge system has been applied due to following reasons:
  - High Sensitivity
  - Low Reacting time
  - Low Manufacturing cost
  - Easy Construction
  - Fully automatic
  - Suitable for constant as well as variable wind speed

Design of safety system



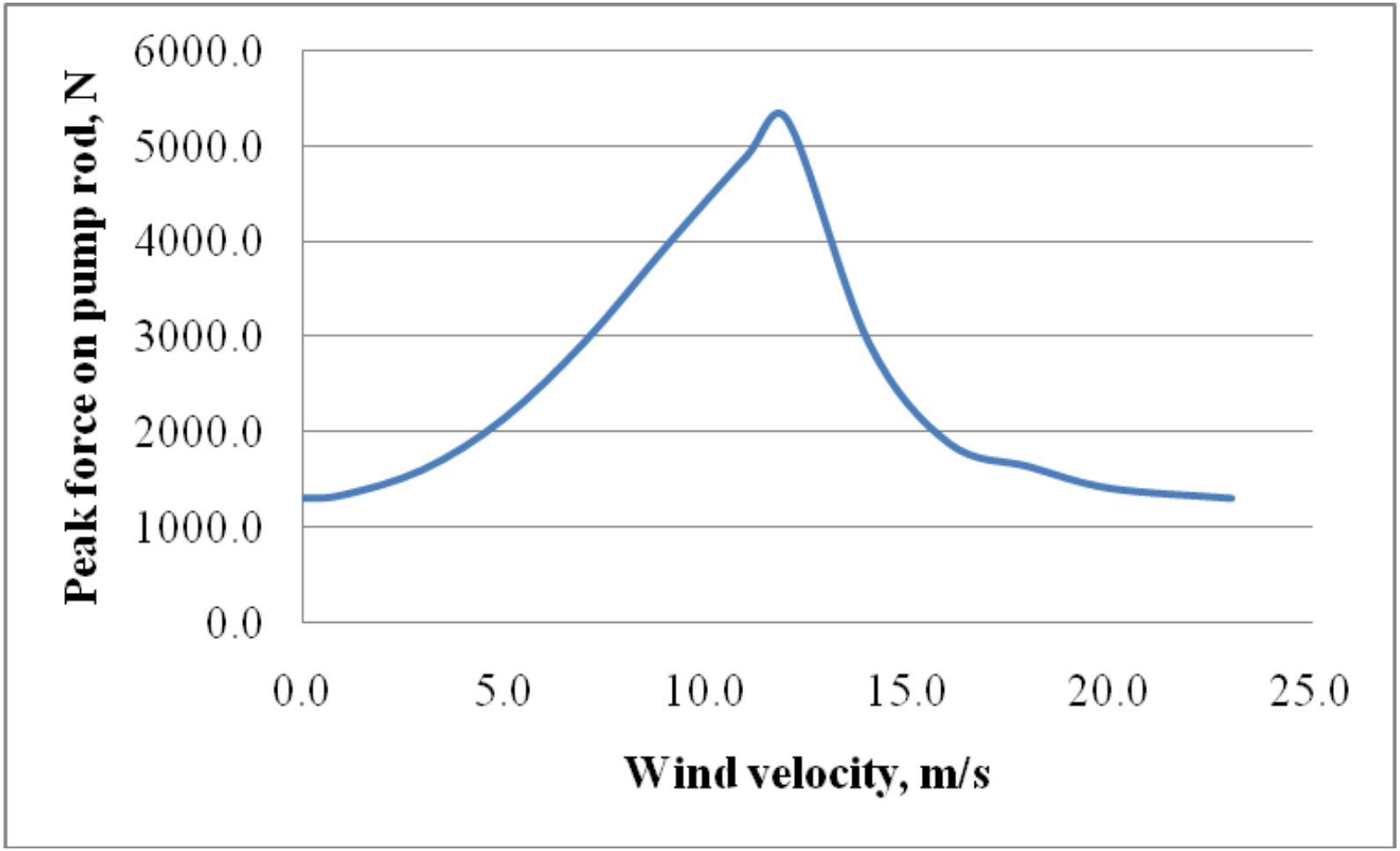
The system works fully automatic with no need of human intervention. The system works on the moments balance of no. of forces developed about z-axis and s-axis (vane axis)

Design of Pump

- The proposed pump is single acting piston pump
- The required water lifting head is 4.51 m.

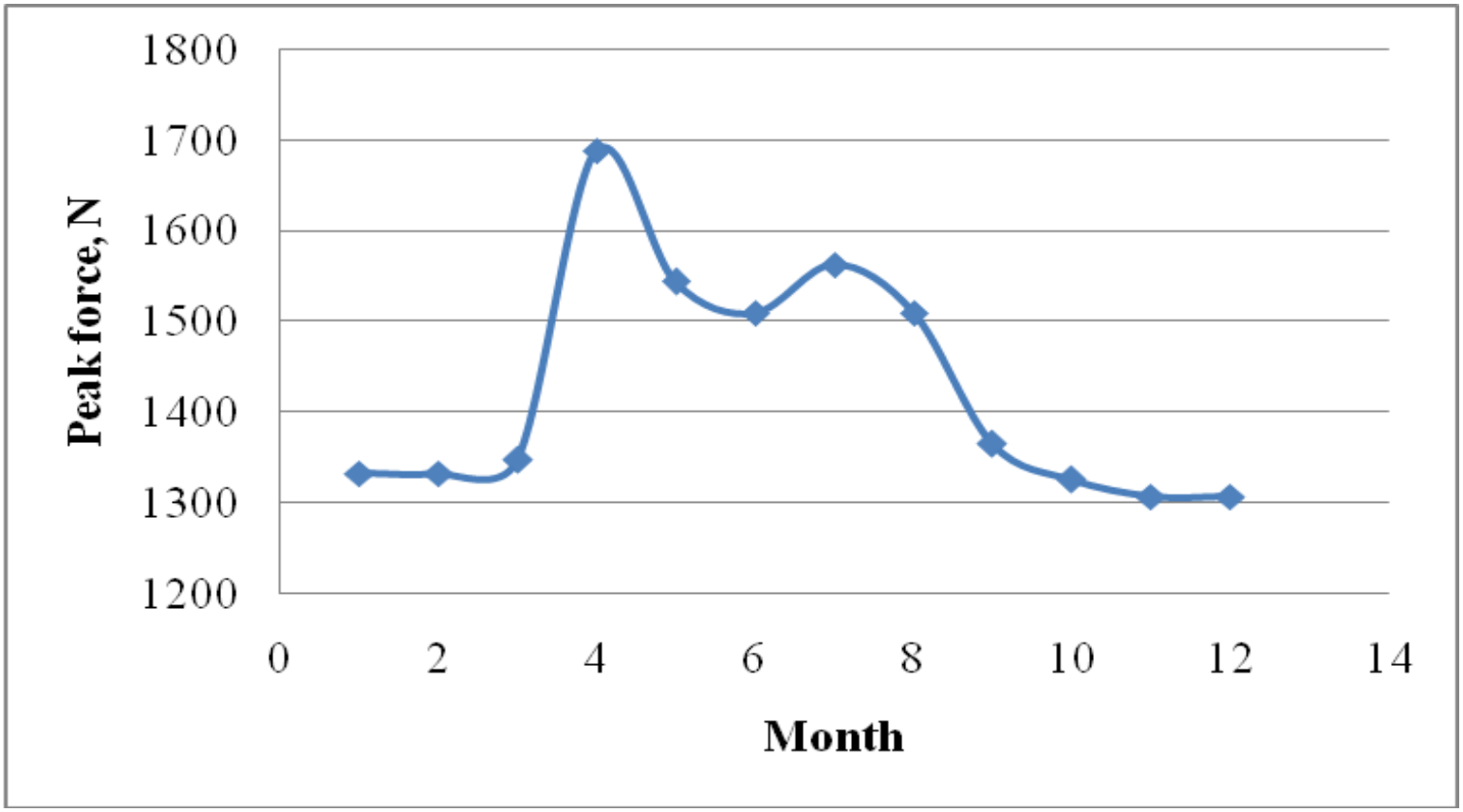
Diameter of Piston (mm)	Stroke (mm)	Water Lifting Head, H (m)	Swept Volume (L)
8" (190.2 mm)	250.00	1.26	8.956/H
6" (150.6 mm)	250.00	2.01	8.956/H
5" (117.6 mm)	250.00	3.50	8.956/H
4" (101.6 mm)	250.00	4.60	8.956/H

Design of Pump



Design of Pump

- Monthly variations of peak forces



Design of Pump

- Material for pump cylinder

Type of material	Design stress, MPa	Actual stress with-without safety system, MPa	Factor of safety with- without safety system
Wood (Pine)	9.6	8.77 - 61.45	1.09 - 0.16
Cast Iron	170	8.77 - 61.45	19.4 - 2.77
PVC	40	8.77 - 61.45	4.56 - 0.65
Bronze	84	8.77 - 61.45	9.58 - 1.4
Steel (0.2% C)	145	8.77 - 61.45	16.53 - 2.36

Design of Pump

- Comparison of materials for piston

Type of material	Peak Force (N)	Young's Modulus of Elasticity (GPa)	Deformation (mm)	Allowable elongation (mm)	Factor of safety
Wood (Pine)	**37154**	**12**	**0.02654**	**2**	**75.4**
Cast Iron	37154	6.9	0.04615	0.25	5.4
PVC	37154	3.1	0.10273	20	194.7
Steel (0.2% C)	37154	200	0.00159	10.5	6603
Nylon	37154	2.8	0.11374	25	219.8
Aluminum	37154	7.5	0.04246	7	164.8

Financial Analysis

- Following assumptions are made during financial analysis
  - Designed volume of water16,079 m^3 yearly
  - In case of diesel set based pumping system construction of pump house structure has been considered.
  - Economic life cycle 20 years
  - MARR = 10 %

Financial Analysis

- Financial comparison between wind based pumping system and diesel based system is best on:-
  - With storage tank of capacity forty cubic metre
  - With storage tank of capacity twenty cubic metre
  - Without storage tank

Financial Analysis

- Case I (wind pumping system with storage tank of 40 m^3)

MARR	**10%**
Initial Investment	**422,100.00**
Payback Period (PB)	**NA**
Net Present Vale (NPV)	**-471,601.04**
Internal Rate of Return (IRR)	**NA**
Annual Equivalent Value (AEV)	**-62,003.17**
Service Life	**20.00**
Annual Discharge (m^3)	**16,079.52**
Cost Per Cu.m (Rs.)	**3.86**

Financial Analysis

- Case II (wind pumping system with storage tank of 20 m^3)

MARR	**10%**
Initial Investment	**2,77,725.00**
Payback Period (PB)	**NA**
Net Present Vale (NPV)	**-313,537.64**
Internal Rate of Return (IRR)	**NA**
Annual Equivalent Value (AEV)	**-41,221.98**
Service Life	**20.00**
Annual Discharge (m^3)	**16,079.52**
Cost Per Cu.m (Rs.)	**2.56**

Financial Analysis

- Case III (wind pumping system without storage tank)

MARR	**10%**
Initial Investment	**133,350.00**
Payback Period (PB)	**NA**
Net Present Vale (NPV)	**-155,474.24**
Internal Rate of Return (IRR)	**NA**
Annual Equivalent Value (AEV)	**-20,440.79**
Service Life	**20.00**
Annual Discharge (m^3)	**16,079.52**
Cost Per Cu.m (Rs.)	**1.27**

Financial Analysis

- Financial Analysis of Diesel system

MARR	**10%**
Initial Investment	**92759.68**
Payback Period (PB)	**N/A**
Net Present Vale (NPV)	**-322,098.93**
Internal Rate of Return (IRR)	**N/A**
Annual Equivalent Value (AEV)	**-52,420.12**
Service Life	**10.00**
Annual Discharge (m^3)	**16,079.52**
Cost Per Cu.m (Rs.)	**3.26**

Financial Analysis

- Incremental analysis between wind and diesel pumping system (Wind – Diesel)

Description	With storage tank capacity of 40^3	With storage tank capacity of 20^3
Incremental Net Present Value (NPV)	Rs - 34,617.52	Rs. 125,982.91
Incremental Internal Rate of Return(IRR)	9%	18%
Incremental Annual Equivalent Value(AEV)	Rs. - 4,066.16	Rs. 14,797.91
MARR	10%	10%

Economic Analysis

Assumptions:

- Only the savings of diesel fuel cost as revenue because the fuel costs in wind pumping system is zero.
- Other costs and benefits such as social cost, environmental costs, carbon revenue etc. have not been considered.

Economic Analysis

- Economic analysis of wind system without storage tank

MARR	**10%**
Initial Investment	**133,350.00**
Payback Period (PB)	**NA**
Net Present Vale (NPV)	**89,853.39**
Internal Rate of Return (IRR)	**20.11**
Annual Equivalent Value (AEV)	**11,813.36**
Service Life	**20.00**
Annual Discharge (m3)	**16,079.52**
Benefit Per Cu.m (Rs.)	**0.73**

CONCLUSION

"WOT Diever 450 " produced on Technical report 1990 may be the viable option for ground water pumping in the context of Terai region of Nepal both for irrigation purpose and drinking water purpose but requires some modifications as per local context "

Some glimpse..

operation irrigation 006.mpg
operation irrigation 008.mpg
Operation top level 001.mpg

Thank You !