Financial analysis of clean energy technologies. Barriers. Micro-financing, subsidy.

Lecture – 4

OUTLINE OF COURSE

MANAGEMENT OF MICRO LEVEL CLEAN ENERGY PROJECTS

- Introduction to project management for clean energy system at micro level.
- Functions of project based management: scope of work, project organization, quality, cost and duration
- Tools and techniques of project-based management
- Project life cycle. Processes of project management. Types of management
- Methods of selecting sustainable clean energy technologies for the household, community.
- Social, economical and technical impact of selected clean energy technologies
- Financial analysis of clean energy technologies. Barriers. Micro-financing, subsidy.
- Capacity building of local operators, managers regarding the maintenance of clean energy technologies.
- Project management of micro level clean energy projects (such as MHP, SHS, wind energy for electricity generation and irrigation, biomass gasifiers etc.).

Basic terms

- Net Present Value (NPV)
- Present Value
- Future Value
- Discount Rate
- Internal Rate of Return (IRR)
- Sensitivity Analysis

Financial analysis

- Time value of money
  - Principle
  - Interest: simple, compound

$$PV = \frac{FV}{(1+r)^n}$$

- Cash flows
  - Net cash flow =Revenue or saving – production cost –taxes-capital

The time value of money looks at the timing of investments and income; money received sooner is more important than equal money received in the future. The cash flow is a series of negative and positive values reflecting how money flows from and to an investor. Investors must look at incremental cash flows.

Example 1

- The estimated salvage value of a flat plate solar collector at the end of its useful lifetime of 20 years is Rs 5,000 determine it present worth for a discount rate of 10 percent.

$$PV = \frac{FV}{(1 + r)^n}$$

- PV = 5,000/(1+ 0.1)^20 =Rs 743.22

Example 2

- It is estimated that about 4.5 million households in the country can benefit fro the use of improved biomass cook stoves. What is the required growth rate to achieve the potential in the next 20 years if the number of improved biomass cook stoves disseminated so far is 0.3 million? [Ans. r=14.5%]
- A 2 m3 biogas plant cost Rs. 10,000 and has a useful life of 20 years. Calculate the unit cost (Rs/m3) of biogas produced if the annual average biogas production efficiency is 90%, average maintenance cost is 5%of the capital cost and the discount rate is 12%.] [Ans. Rs 2.80/m3.
- Hint: Annualized capital cost = Principal*[r*(1+r)^n/((1+r)^n-1)]

Financial tools: NPV, IRR

- **Net present value**

  The net present value is the revenue or savings derived from an investment, less its cost. Future values are brought back to the present at a compound interest rate called the discount rate.

- This **discount rate (discount factor)** is also called the
  - Cost of capital
  - Opportunity cost of capital
  - Hurdle rate
  - Minimum rate of return
  - Minimum acceptable rate of return

$$\boxed{\text{Discount rate} = \frac{1}{(1+r)^n}}$$

- Discounted cash flow = cash flow x discount factor
- NPV = sum of discounted cash flow = cum discounted cash flow at the end of project

Net present value

$$NPV = \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \ldots + \frac{C_2 \ldots I_o}{(1+r)^n} \qquad NPV = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - I_o$$

- where:
- C_t = the net cash receipt at the end of year t
  I_o = the initial investment outlay
  r = the discount rate/the required minimum rate of return on investment
  n = the project/investment's duration in years.
- Decision:
  - If NPV is positive (+): *accept the project*
  - If NPV is negative(-): *reject the project*

Example 3-A

- A small windmill for water pumping costs Rs 10,000 to purchase and install on the field of a farmer. It is expected to save Rs 800 worth of diesel annually to the farmer and its annual maintenance cost is estimated at Rs 200. calculate the NPV of the investment on the windmill if the useful life of the windmill is 10 years and the interest rate is 12%.

- $$NPV = -I_0 + (B - C)\left[\frac{(1 + i)^N - 1}{i(1 + i)^N}\right]$$ (For even cash flow)

$$NPV = -10{,}000 + (800 - 200)\left[\frac{(1 + 0.12)^{10} - 1}{0.12(1 + 0.12)^{10}}\right]$$

$$NPV = -10{,}000 + 3{,}390 = -6{,}610$$

- The investment in the windmill is not a financially viable investment for the farmer. NPV should be positive for a financially viable investment.

Example 3-B

- **Uneven Cash Inflows**: An initial investment of $8,320 thousand on plant and machinery is expected to generate cash inflows of $3,411 thousand, $4,070 thousand, $5,824 thousand and $2,065 thousand at the end of first, second, third and fourth year respectively. At the end of the fourth year, the machinery will be sold for $900 thousand. Calculate the net present value of the investment if the discount rate is 18%. Round your answer to nearest thousand dollars.

Discount rate 18%

Year	0	1	2	3	4	Total
Income	0	3411	4070	5824	2065	15370
Salvage					900	900
Capital	-8320					-8320
Cash flow	-8320	3411	4070	5824	2965	7950
Discount factor	1.000	0.847	0.718	0.609	0.516	
Discounted cash flow	-8320	2891	2923	3545	1529	2568
Cum discounted cash flow	-8320	-5429	-2506	1038	2568	
NPV	2568					
IRR	32.8%					

Financial tools: NPC, IRR

- Internal rate of return

  The internal rate of return measures an investment's ability to repay capital. It tells you the rate at which a project generates money. This rate is the compounded return rate, also called investment yield.

- The IRR is the discount rate at which the NPV for a project equals zero. This rate means that the present value of the cash inflows for the project would equal the present value of its outflows.

$$\sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - I_o = 0$$

Example 4

- Calculate the internal rate of return for the investment in a heat exchanger which will cost Rs 5,00,000 to purchase and install, will last 10 years and will result in fuel savings of Rs 1,45,000 per year. Also assume that the salvage value of the heat exchanger at the end of 10 year is negligible.

$$NPV = -I_0 + (B - C)\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right] = 0 \quad \text{(For even cash flow)}$$

Year	0	1	2	3	4	5	6	7	8	9	10	Total
Income	0	145000	145000	145000	145000	145000	145000	145000	145000	145000	145000	1450000
Capital	-500000											-500000
Cash flow	-500000	145000	145000	145000	145000	145000	145000	145000	145000	145000	145000	950000
Discount factor	1.000	0.793	0.628	0.498	0.395	0.313	0.248	0.197	0.156	0.124	0.098	
Discounted cash flow	-500000	114932	91100	72209	57235	45367	35960	28503	22592	17908	14194	0
Cum discounted cash flow	-500000	-385068	-293968	-221759	-164524	-119157	-83197	-54694	-32102	-14194	0	
NPV	0											
IRR	26.1612%		Compare this IRR with MARR (min attractive rate of return.									

Example 5

- Installation of a Rs 50,00,000 energy management system in an industry is expected to result in a 25% reduction in electricity use and a 40% saving in process heating costs. This translates to net yearly savings of Rs 6,00,000 and Rs 7,50,000 respectively. If the energy management system has an expected useful life of 20 years, determine the internal rate of return on the investment. Salvage value need not be considered in the analysis.

[Ans. IRR=27%]

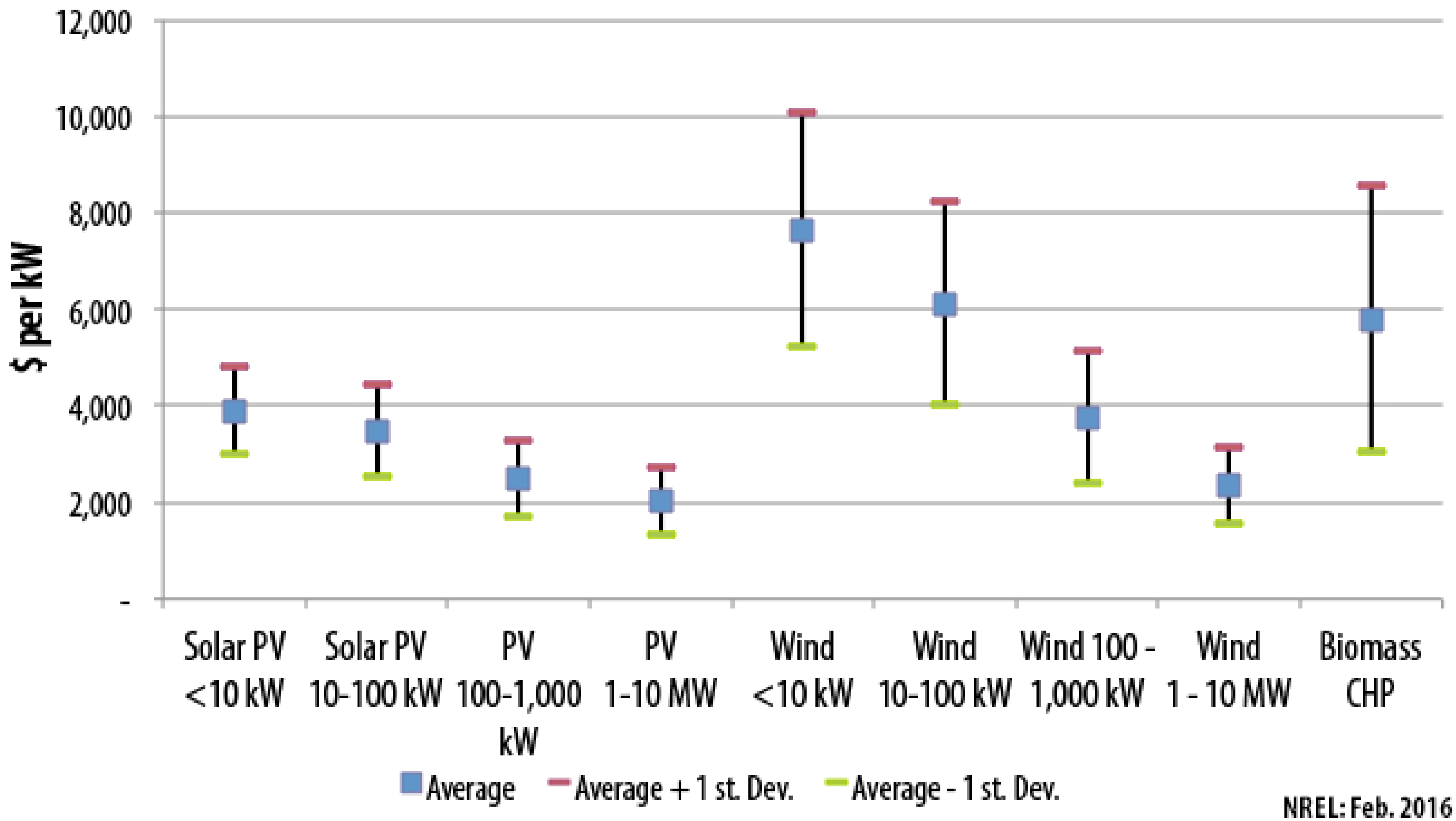
Note:

- The IRR is a good way of judging different investments.
- First of all, the IRR should be higher than the cost of funds. If it costs you 8% to borrow money, then an IRR of only 6% is not good enough!

Annualized life cycle cost of fuel cook stoves

Interest rate, i	10%	10%	10%	10%	10%	10%	10%	10%	10%
Loan period, n years	5	3	5	5	5	5	25	10	15
Capital recovery factor	0.264	0.402	0.264	0.264	0.264	0.264	0.110	0.163	0.131
$CR = \frac{i(1+i)^n}{(1+i)^n - 1}$	Capial recovery is the earning back of the initial funds put into an investment.								
	Capital recovery must occur before a company can earn a profit on its investment.								
Inter-fuel cost of cooking stoves at the current prices of fuel and at their economic costs/ household					7/7/2016				
Description	Fuelwood			Briquette	Rice husk	Kerosene	Biogas	Electricity	LPG
	TCS (tripod)	ICS (fixed)	ICS (portable)	ICS (portable)	Domestic GS	Kerosene S	market price		
Stove/plant price	100.00	250.00	1,200.00	800.00	1,200.00	1,500.00	50,000.00	5,000.00	5,000.00
Useful life	5	3	5	5	5	5	25	10	15
Collection time hours/bhari	5.00	5.00	5.00	-	-	-	1.00	-	-
Shadow cost of collection/hr	50.00	50.00	50.00	-	-	-	50.00	-	-
Capital recovery factor	0.26	0.40	0.26	0.26	0.26	0.26	0.11	0.16	0.131
Annualized capital cost	26.38	100.53	316.56	211.04	316.56	395.70	5,508.40	813.73	657.37
Energy content (MJ/kg or MJ/L)	15.00	15.00	15.00	18.00	13.00	35.00	20.00	3.60	45.00
Efficiency of stove	7%	15%	15%	20%	25%	50%	60%	77%	60%
Energy produced, MJ	41,063	27,375	27,375	19,710	28,470	7,665	8,030	4,403	6,615
Useful energy, MJ	2,874	4,106	4,106	3,942	7,118	3,833	4,818	3,390	3,969
Price of fuel per kg (or liter or unit)	10.00	10.00	10.00	20.00	6.00	75.00	50.00	8.00	102.00
Annual fuel usage kg or L, m3 or unit	2,738	1,825	1,825	1,095	2,190	219	402	1,223	147
Annual fuel cost, NRs	27,375.00	18,250.00	18,250.00	21,900.00	13,140.00	16,425.00	18,250.00	9,784.00	14,994.00
Energy consumption per family/year,MJ	2,874.38	4,106.25	4,106.25	3,942.00	7,117.50	3,832.50	4,818.00	3,390.16	3,969.00
Energy cost per MJ, NRs	9.52	4.44	4.44	5.56	1.85	4.29	3.79	2.89	3.78
Annualized life cycle cost (ALCC)	27,401.38	18,350.53	18,566.56	22,111.04	13,456.56	16,820.70	23,758.40	10,597.73	15,651.37
ALCC with stove efficiency									
Fuelwood saved in comparison to TCS	0	913	913	2,738	2,738	2,738	2,738	2,738	2,738
Fuelwood saved, %	-	33%	33%	100%	100%	100%	100%	100%	100%
Environmental aspects	Smoky kitchen	Min. smoke	min. smoke	min. smoke	min. smoke	clean burning	clean burning	no smoke	
Cost per month, NRs	2,283.45	1,529.21	1,547.21	1,842.59	1,121.38	1,401.72	1,979.87	883.14	1,304.28

Installed Costs for Electric Generating Technologies



http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html

Barriers to CET

- Commercialization barriers
  - Undeveloped infrastructure
  - Lack of economies of scale
- Unequal government subsides and taxes
- Market failure to value public benefits of renewable energy
- Market barriers
- Lack of information
- Institutional barriers
- Small size
- High transaction costs
- High financing costs
- Split incentives
- Transmission costs
- Green market limits
- xxxx

http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/barriers-to-renewable-energy.html#.V2R7QKJZhvI

Nontechnical Barriers to Solar Energy Use: Review of Recent Literature

- Lack of government policy supporting EE/RE
- Lack of information dissemination and consumer awareness about energy and EE/RE
- High cost of solar and other EE/RE technologies compared with conventional energy
- Difficulty overcoming established energy systems
- Inadequate financing options for EE/RE projects
- Failure to account for all costs and benefits of energy choices
- Inadequate workforce skills and training
- Lack of adequate codes, standards, and interconnection and net-metering guidelines
- Poor perception by public of renewable energy system aesthetics
  Lack of stakeholder/community participation in energy choices and EE/RE projects.

http://www.nrel.gov/docs/fy07osti/40116.pdf

Table 3.1: Barriers analysed

Barrier type	Example
Institutional	Institutional capacity limitations (R & D, demonstration and implementation)
Market	Small size of the market, limited access to international markets for modern RETs, limited involvement of the private sector
Awareness / Information	Lack of awareness / access to information on RETs
Financial	Inadequate financing arrangements (local, national, international) for RET projects
Economic	Unfavourable costs, taxes (local and import), subsidies and energy prices
Technical	Lack of access to the technology, inadequate maintenance facilities, bad quality of product
Capacity	Lack of skilled manpower and training facilities
Social	Lack of social acceptance and local participation
Environmental	Visual pollution, lack of valuation of social and environmental benefits
Policy	Unfavourable energy sector policies and unwieldy regulatory mechanisms

http://orbit.dtu.dk/ws/files/7968924/Implementation_of_renewable_energy.pdf

Micro-financing

- Micro-financing of renewable energy systems is a possible answer to provide financial services and support productive activities in a sustainable manner for **low-income people**.
- There are various types of microfinance institutions (MFIs), ranging from local cooperatives, NGOs, credit unions, private commercial banks and non-bank financial institutions as well as parts of state-owned banks.
- The two different approaches of the project support:
  - ✓ SEPS – Sustainable Energy Project Support and
  - ✓ PREP – Promotion of Resource Efficiency Projects
- Creation of revolving fund for renewable energy technologies

http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_3/3.186/paper

Objectives of microfinance

- Access to capital
  - By lending money to those people who rely on “informal” expensive sources, microfinance institutions provide access to capital to start new business.
- Entrepreneurship and self-sufficient
  - "Microcredit" loans give clients just enough money to get their idea off the ground so they can begin turning a profit. They can then pay off their micro loan and continue to gain income from their venture indefinitely.
- Improved standards of living
  - Microcredit ultimately aims to give impoverished people enough financial stability to move from simply surviving to accruing savings. This gives them a certain amount of protection from sudden financial problems. Savings also allow for educational investment, improved nutrition, better living conditions and reduced illness.
- Women’s economic advancement
  - Microfinance provides women with the financial backing they need to start business ventures and actively participate in the economy. The aim is to improve their status and make them more active in decision-making, thus encouraging gender equality.
- Trickle-down benefits
  - Microfinance lenders hope to improve not just the lives of their direct clients, but also the health of their clients' communities. New business ventures can provide jobs, thereby increasing income among community members and improving their overall well-being.

http://www.ehow.com/list_6654232_objectives-micro-finance.html

Subsidy

- Nepal government has subsidy scheme for the promotion of renewable energy technologies.
- Refer to "Renewable Energy Subsidy Policy, 2073 BS". That is;

http://www.aepc.gov.np/docs/resource/rescenter/20160606165013_RE%20Subsidy%20Policy%202016%20(2073%20BS)_Unofficial%20Translation_English.pdf

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- http://www.toweringskills.com/
- https://www.youtube.com/watch?v=VfjiWmVK2Z4
- https://www.youtube.com/watch?v=fM63moi1Qjo
- http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html

Problems

- A domestic solar water heater installed in ABC has a capital cost of Rs 25,000 and annual operation and maintenance cost or Rs 500. Calculate the simple payback period for the investment in the domestic solar water heating system if it saves 1,500 units of electricity in a year. Also estimate the discounted payback period if the discount rate is 10%.
- A wind turbine of 1 kW rated capacity costs Rs 60,000 to purchase and install. For an annual turbine output of 4,000 kWh, calculate the unit cost of electricity of electricity if the salvage value at the end of the 20 years of useful life of the turbine is negligible, the interest rate is 12% and the annual operation and maintenance costs are about 3% of the initial cost.