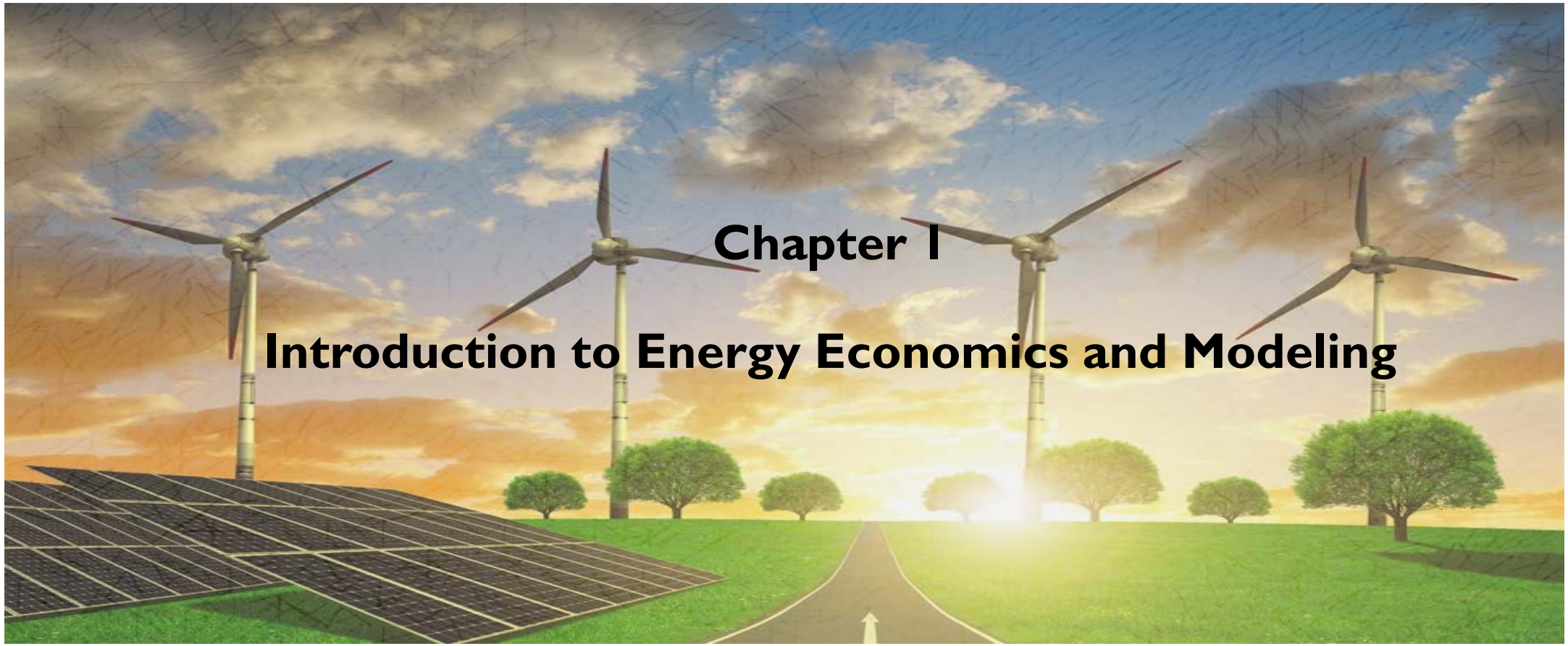
ENERGY PLANNING : MODELLING AND DECISION SUPPORT



Chapter I

Introduction to Energy Economics and Modeling

-CONTENT-

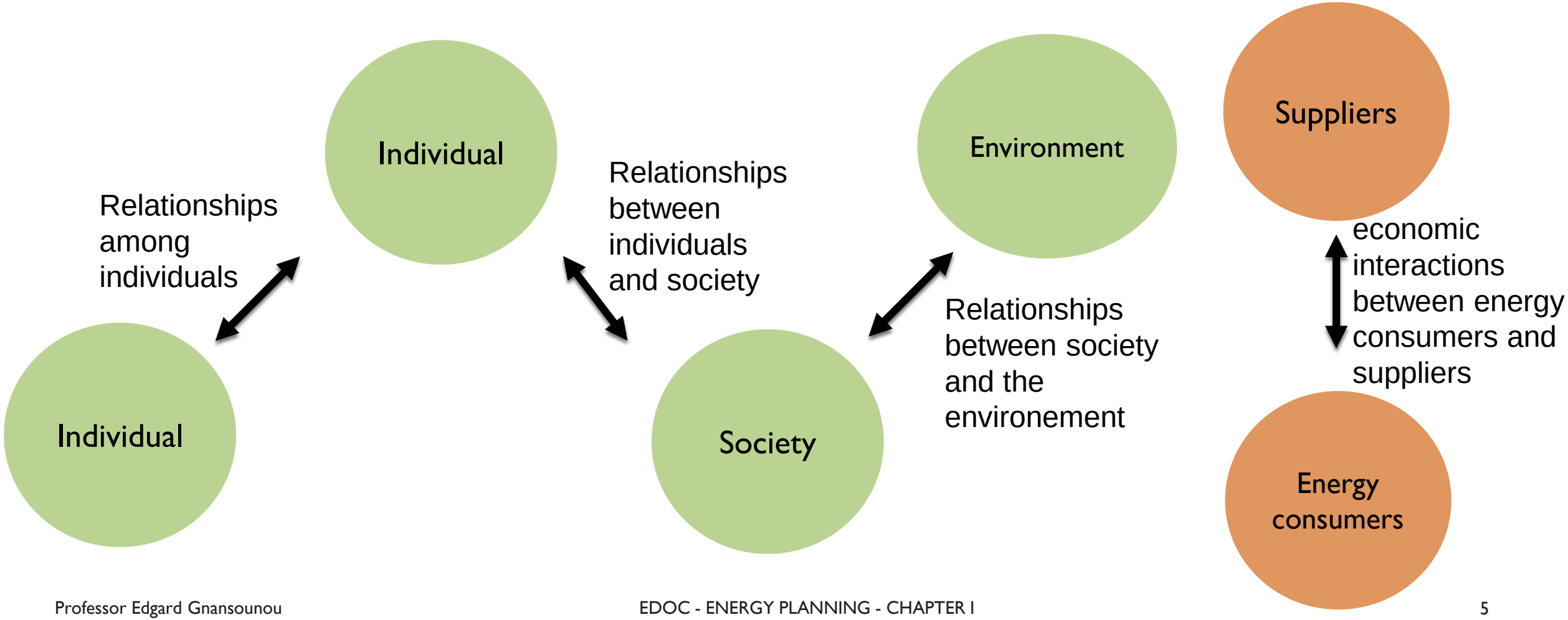
1.1 FEW ISSUES OF ENERGY ECONOMICS

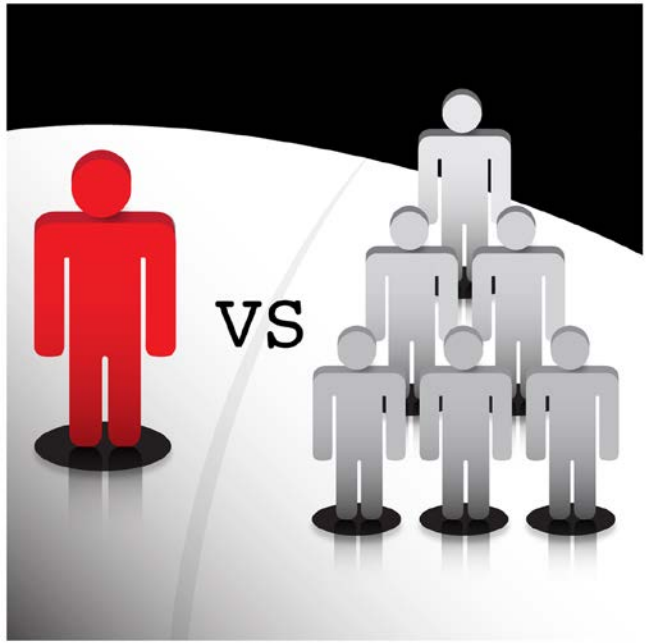
- Relation between energy demand and economic growth
- Optimal allocation of the resources and its application to energy
- Optimal pricing of energy in the case of monopoly
- Investment choices in the energy sector
- Efficiency of energy markets

1.2 OBJECTIVE OF ENERGY ECONOMICS

- Understanding how energy demand emerges
- Study the economic dimensions of energy provision to consumers
- Study the economic interactions between energy consumers and suppliers
- Study the economic interactions between the energy suppliers
- Study optimal allocation of energy resources as scarce natural resources
- Management of collective goods (i.e. the environment)

1.3. ECONOMICS AS A STUDY OF PROVISION OF GOODS TO CONSUMERS





Individual vs. society

As a social science Economics is concerned with the balance between the autonomy of an individual and the social welfare

How can one's individual freedom be compatible with the social welfare ?

- Cooperation, competition and conscription are few modalities of the coordination between the individuals' values and preferences

Social interactions

Through social interactions, individuals interact in ways that are compatible with the legal system. Contracting is the concrete mode of interaction between two individuals (agents). Based on bilateral contracts or organized markets, agents perform transactions

Technology

- Used by agents and society for cumulative knowledge and artefacts to solve the problem of provision.
- Not neutral from a social point of view.
- Technological change and innovation are important factors in Economics.

Decision

Based on rules and other factors, agents decide wether to buy or sell a certain quantity of goods at a certain price, and accept or not a certain level of risk.

Information and decision support

The distribution of information amongst agents is a determinant factor of the nature of the decision.

The tools for managing, analyzing data and evaluating variants of decision are more and more important.

Rationality

Ideally an agent makes a rational decision to optimize his choices in regards to his own preferences, which is a fundamental assumption in Economics, based on perfect information on the alternatives and other conditions.

Bounded rationality

Due to imperfect information and complexity in the process of choice, many decisions especially in market oriented framework are taken with a bounded rationality (Herbert Simon, 1972)

Imperfect knowledge

Knowledge is neither centralized nor certain, but is dispersed.

Knowledge on the behaviors of agents is imperfect.

Process of improvement of knowledge

Cumulative process based on the historical knowledge development, theories to explain a class of phenomena, laws, experiments for developing empirical models.

Objectives:

The goals that an agent (or a group of agents) hopes to achieve as the outcome of his decisions.

Economic objective

Derived from utilitarianism phylosophy: maximize the utility of agents and the social welfare. In economics, an individual utility is connected with the quantity of goods and their prices.

Ethical value of modern Economics

Hedonism is the ethical value of the orthodox economics: maximization of the utility of an agent and the social welfare.

Criteria of evaluation

- Evalutate alternatives in regards to various criteria to estimate their achievements
- Choose an ethical value that makes it possible to judge an action as good or wrong and estimate its degree of goodness (consequentialist ethics)

Result of the evaluation

Each alternative is rated with respect to each criterion in order to get partial performance

Global achievement or performance

In order to evaluate the global achievement of an alternative, a certain aggregation of the partial performances is necessary.

1.4 ECONOMICS AS A STUDY OF ALLOCATION OF SCARCE RESOURCES

Technical efficiency

Let us assume that a certain quantity of inputs , e.g. Capital (K), Labor (L), and Land (R) are used to produce two goods, X in an amount Qx and Y in an amount Qy through a given technology (Reynolds, 2011), the technical efficiency is defined as follows:

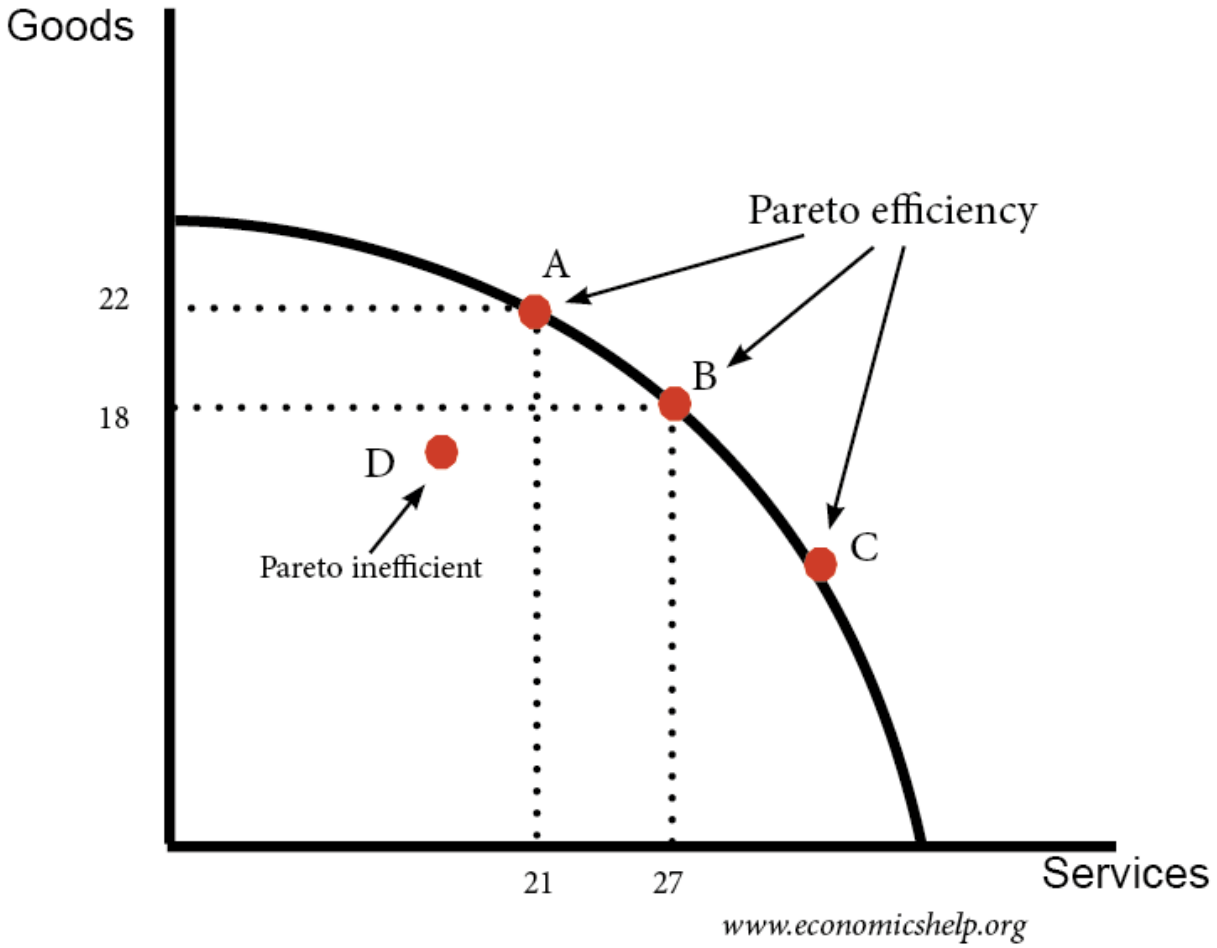
$$Technical\ \ efficiency = \frac{Q_x + Q_y}{R + L + K} = \frac{output}{input}$$

Allocative efficiency

This occurs when there is an optimal distribution of goods and services, taking into account consumer's preferences.

$$Allocative\ efficiency = \frac{p_x Q_x + p_y Q_y}{p_L L + p_K K} = \frac{Value\ of\ output}{Value\ of\ input}$$

Pareto



Pareto efficiency

Pareto efficiency frontier is a curve where it is not possible to increase the gain in Qx (resp. Qy) without decreasing the gain in Qy (resp. Qx).

Pareto potential

If a choice makes an agent or a group of agents better off and others worse off and if the winners reimburse the losers but stay better off, then the choice will increase the social welfare.

Marginal value

The marginal value of a function (e.g. F(Q1, Q2)) with respect to a variable (e.g. Q1) is the variation of that function caused by a variation of the variable (e.g. Q1).

- Marginal cost
- Marginal benefit
- Marginal utility
- Marginal revenue

$$MF = \frac{\Delta F}{\Delta Q}$$

Marginal analysis

The problem of the consumer

A consumer who has a budget R wants to consume N goods. Each good i provides to him a utility Ui, the marginal analysis assumes that the consumer agent will maximize his total utility. He will start with the good i that provides the highest utility and then each additional unit that will be consumed will be of the good j that will have the next highest utility, the maximal total utility will be such as the equimarginal principle will be complied with:

$$\frac{MU_1}{p_1} = \frac{MU_2}{p_2} = \ldots\ldots = \frac{MU_n}{p_n}$$

Suject to :

$$R \geq (p_1 Q_1 + p_2 Q_2 + \ldots\ldots + p_n Q_n)$$

Marginal analysis

Demand function of the consumer subject to revenue constraint

Let U (Q1, Q2, ……., Qn) be the utility function of the consumer :

- The Problem of the consumer: Max U (Q1, Q2, ……., Qn)
- Suject to : $R \geq (p_1 Q_1 + p_2 Q_2 + \ldots\ldots + p_n Q_n)$

Marginal analysis

Demand function of the consumer subject to revenue constraint

- Using the Lagrangian, the problem can be formalized as:

$$\text{Max } [Z = U(Q1, Q2, \ldots\ldots\ldots\ldots, Qn) + \lambda(R - p_1 Q_1 - p_2 Q_2 - \ldots\ldots\ldots - p_n Q_n)]$$

Marginal analysis

Demand function of the consumer subject to revenue constraint

- First order conditions:

$$\frac{\partial Z}{\partial Q_i} = \frac{\partial U}{\partial Q_i} - \lambda p_i = 0 \quad , \; i = 1, \ldots\ldots\ldots, n$$

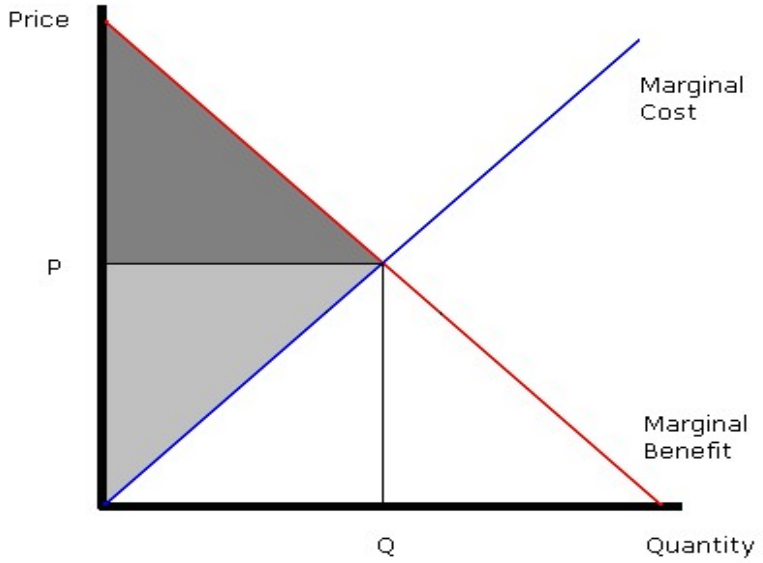
$$\frac{\partial Z}{\partial \lambda} = R - \sum_i (p_i Q_i) = 0$$

Marginal analysis

The producer rule

As long as the marginal value (or marginal benefit) of the good (MV) is higher to its marginal cost (MC) an additional unit can be produced. At the equilibrium production, marginal value equals to marginal cost:

$$MV_{eq} = MC_{eq}$$



Marginal analysis

Social welfare

- A consumer agent will consume an additional unit as long as:

  MU ≥ p (where MU is the marginal utility)

- A producer will produce an additional unit as long as:

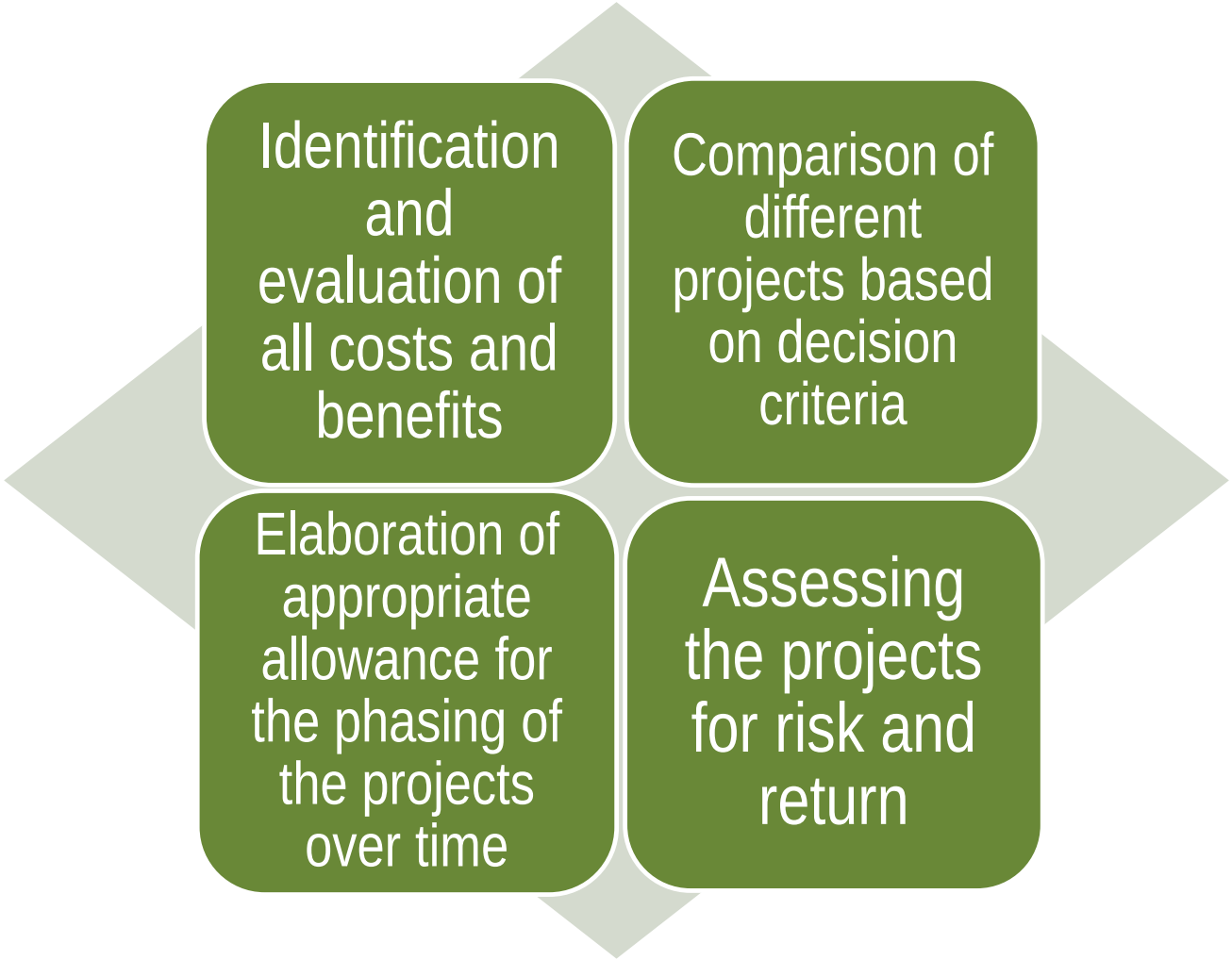
  p ≥ MC (where MC is the marginal cost)

- At the maximum social welfare the following condition will be complied with:

  MU = MC = p

1.5 INTRODUCTION TO PROJECT APPRAISAL

-Main principles-



VALUATION

Economic versus Financial appraisal

- Economic appraisal:

  Cost and benefits are valued at opportunity cost

- Financial appraisal:

  Inputs and outputs are valued at market price

TIME AND DISCOUNTING

Time

- The value of the project changes with time
- A project generally implies net cost at the beginning for further net revenues
- Risks involved in the project and in its environment may increase with time

Discounting

- Assuming that you have to choose between two options:

- Receive 10’000 CHF in 2015 or 10’300 CHF in 2016. Suppose that the return you will get from the bank is 3% per year.

What would you choose?

- Same question but supposing that the return you will get from the bank is less than 3%, say 2% per year.

https://youtu.be/Mol1yT7tczY

Discounting

As the Homo economicus would prefer an immediate consumption to a future one, future amount is converted to its present equivalent by discounting:

V_0: present value

V_n: future value at year «n»

d: discount rate

$$V_0 = \frac{V_n}{(1+d)^n}$$

Note : At a country level, the discount rate is the rate that clears the market for public investment funds. High discount rates will disadvantage capitalistic projects.

INFLATION, VALUE OF THE MONEY, NOMINAL AND REAL VALUE

Inflation

- Inflation measures the loss in purchase power of the money.
- Assume that with the same amount M of money I can purchase only 95% of goods in 2015 compared to 2014, then the inflation rate is 5%.
- An inflation of 5% means that the basket of the reference goods is 5% more expensive compared to the previous year.

INFLATION, VALUE OF THE MONEY, NOMINAL AND REAL VALUE

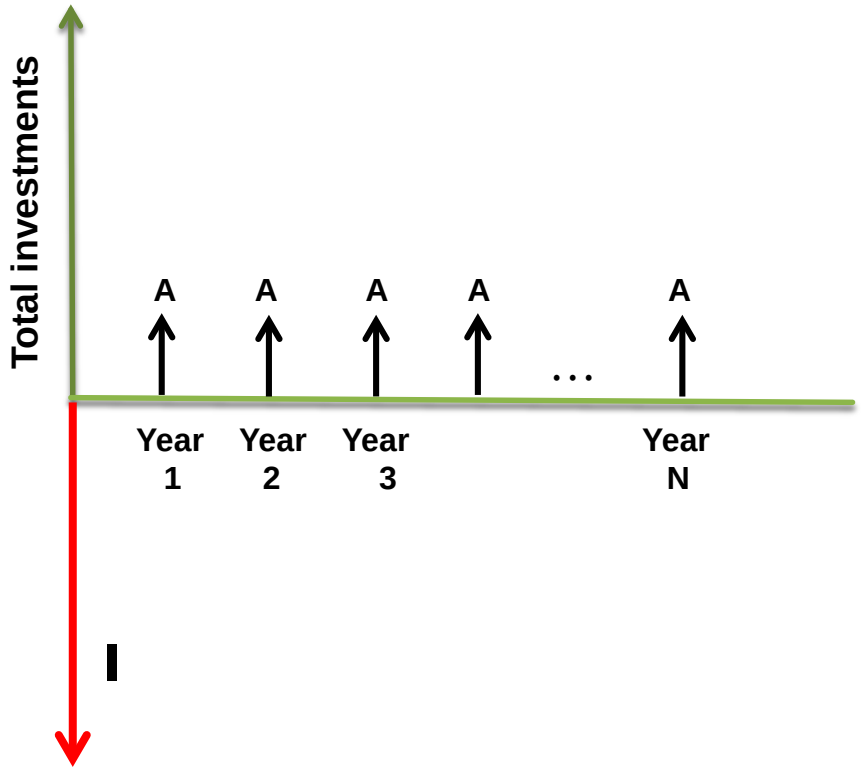
Nominal value

- The value of something today, in current money (what you see in shops and pay slips)

Real value

- The value of something after accounting for inflation (varies with the rate of inflation)
- Variations estimated in real value measure physical variations of goods
- Used in planning

AMORTIZATION WITH A CONSTANT ANNUITY



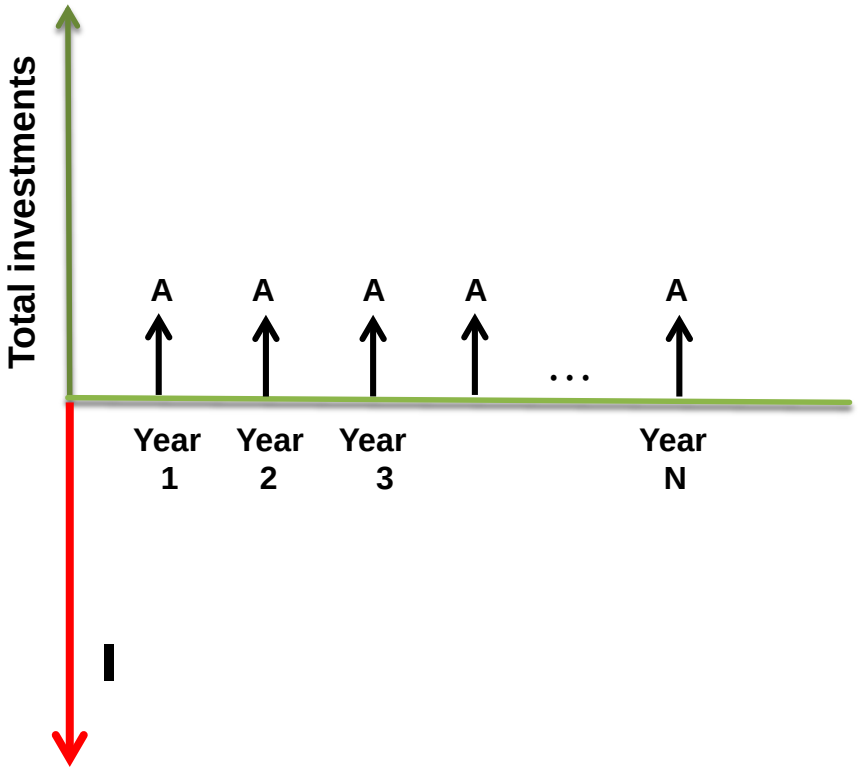
Debt at the end of the first year:

$$D_1 = I\,(1+i) - A$$

Debt at the end of the second year:

$$D_2 = D_1\,(1+i) - A$$
$$= (I\,(1+i) - A)\,(1+i) - A$$
$$= I\,(1+i)^2 - A(1+i) - A$$

i: interest rate; I : investment



Debt at the end of the last year:

$$D_N = I(1+i)^N - A\left(\sum_{j=0}^{N-1}(1+i)^j\right.$$

$$D_N = 0 \Rightarrow A = I\frac{(1+i)^N}{\sum_{j=0}^{N-1}(1+i)^j}$$

$$or \quad \sum_{j=0}^{N-1}(1+i)^j = \frac{(1+i)^N - 1}{i}$$

$$A = I\frac{i}{1-\frac{1}{(1+i)^N}}$$

INDICATOR OF ECONOMIC PERFORMANCE

a) Sum of discounted cost or Net Present Value

b) Levelized cost of Energy (LCOE)

$$\sum_{t=0}^{T} \frac{c.E_t}{(1+d)^t} = \sum_{t=0}^{T} \frac{D_t}{(1+d)^t}$$

$$c = \frac{\sum_{t=0}^{T} \frac{D_t}{(1+d)^t}}{\sum_{t=0}^{T} \frac{E_t}{(1+d)^t}}$$

Et: Energy Production in year t
Dt: Total expenditure in year t
c: LCOE
d: annual discount rate
t: year
T: Horizon of the project

Reference book in Microeconomics:

Edgar K. Browning and Mark Zupan
Microeconomics
Theory and Application
Wiley, 2012

Readings

1) *Claudia Kemfert. Applied Economic-Environment-Energy Modeling for quantitative impact assessment*
2) *Thomas Weyman-Jones. The theory of energy economics: an overview*