UNIVERSITÀ DEGLI STUDI DI GENOVA

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Economic Analysis of Energy Efficiency

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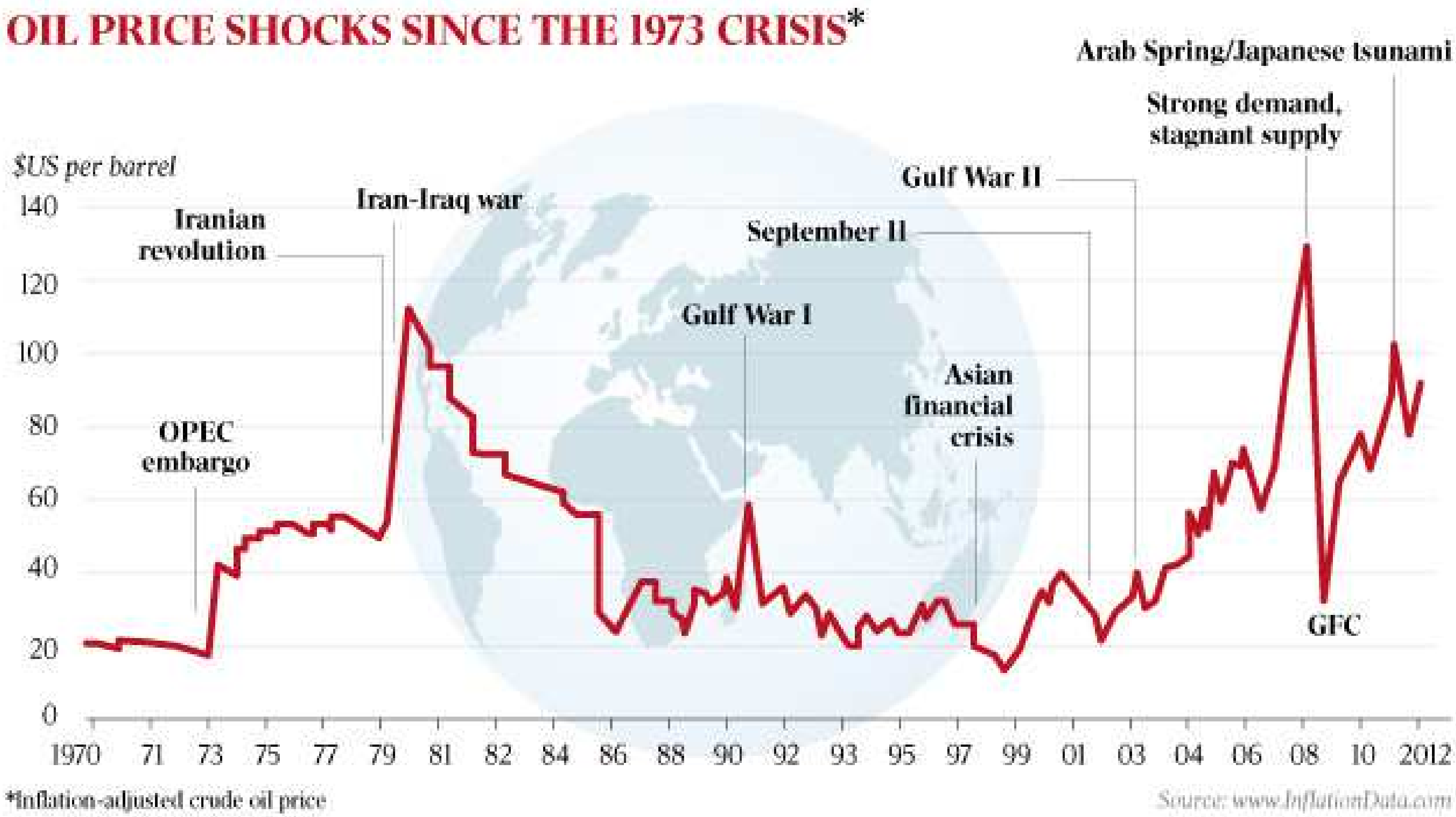
- Please consider that the present document is a presentation and it cannot be utilized without taking into account oral comments of the speaker
- The present document is a presentation and cannot be considered as a reference paper to study the subject contained in it
- Some of the topics reported in the following charts are treated in a simplified and not always rigorous way for the sake of the simplicity
- For an accurate discussion about the topics of the present document, you are warmly invited to consult the suggested bibliography.

Index

Energy Efficiency: economic motivations

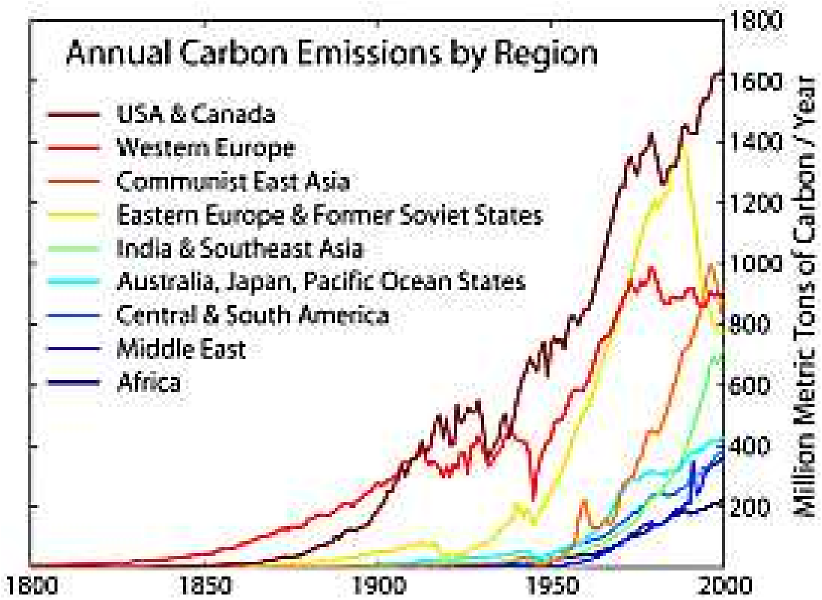


Energy Efficiency: economic motivations

In 1973, for the first time, energy efficiency became a "hot topic" on the agenda of the most influential policy makers

Since then many researchers have been devoted to energy efficiency, which has been referred to as a "hidden fuel"

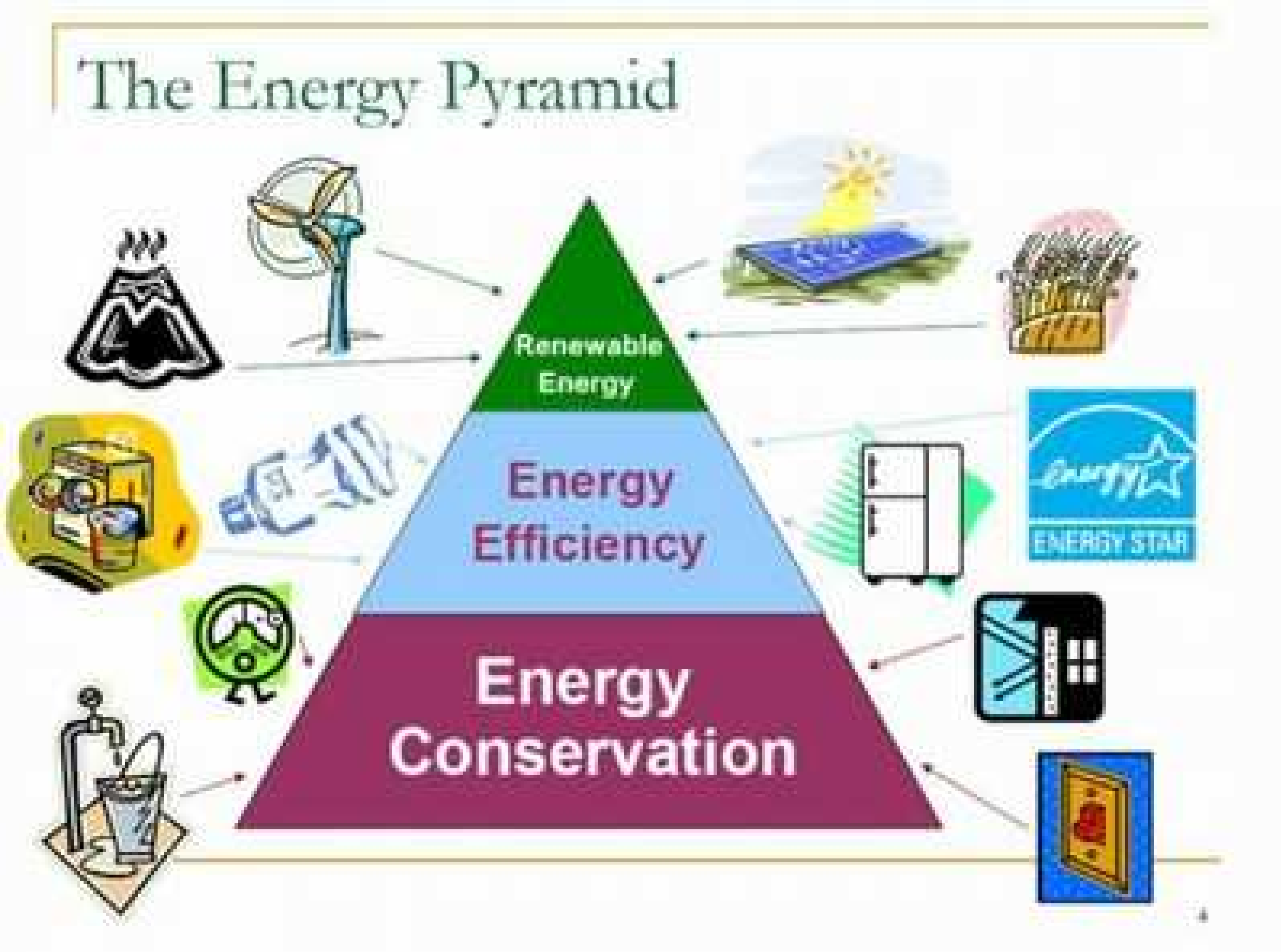
Energy Efficiency: environmental motivations



- The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets
- Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities."

Energy generation represents one of the most carbon intensive sectors, therefore an increase of its efficiency means less carbon emissions

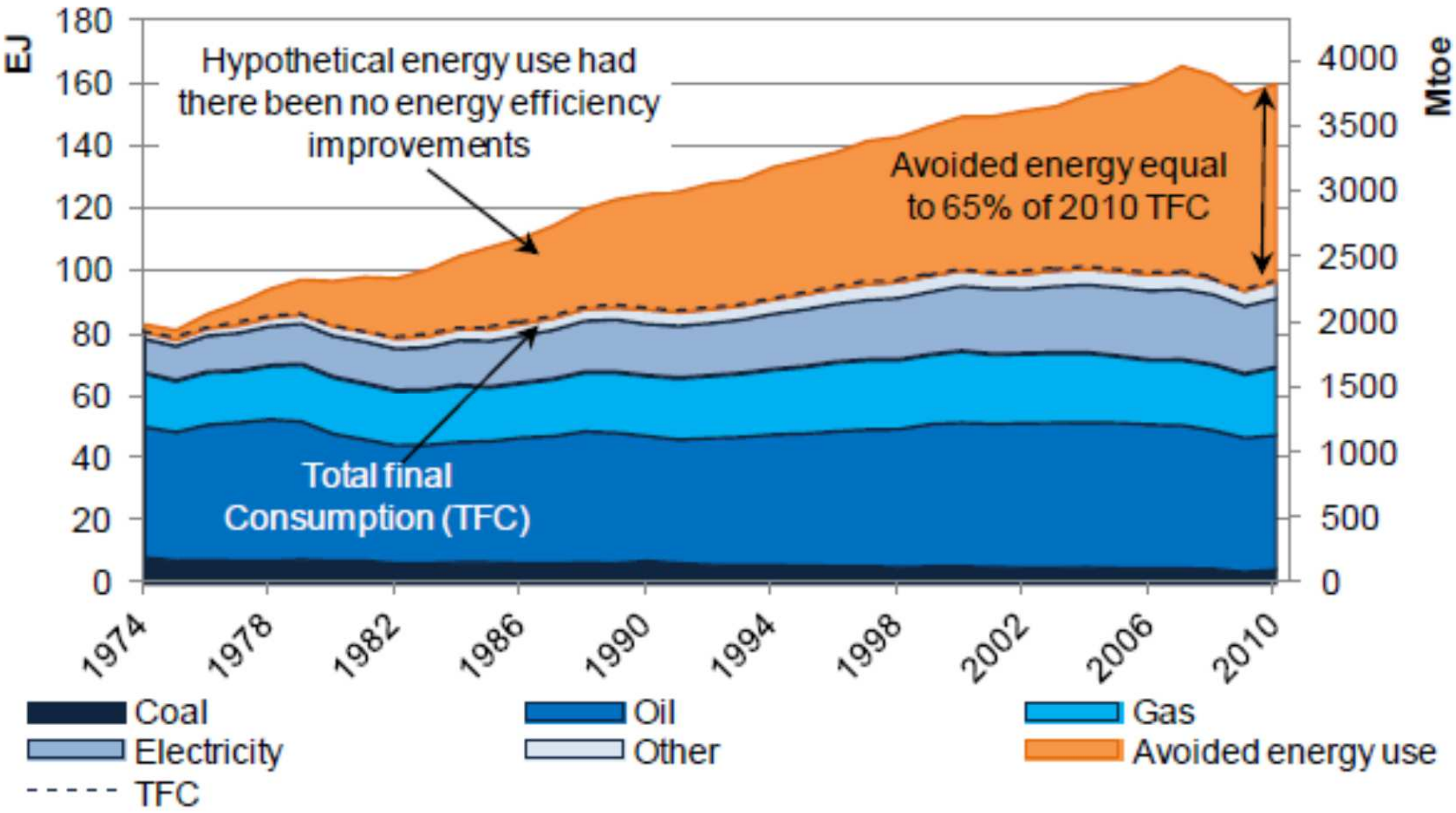
Energy Efficiency: paradigm



Energy Efficiency: definition

IEA: Energy efficiency is a way of managing and restraining the growth in energy consumption. Something is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input. For example, when a compact florescent light (CFL) bulb uses less energy (one-third to one-fifth) than an incandescent bulb to produce the same amount of light, the CFL is considered to be more energy efficient.

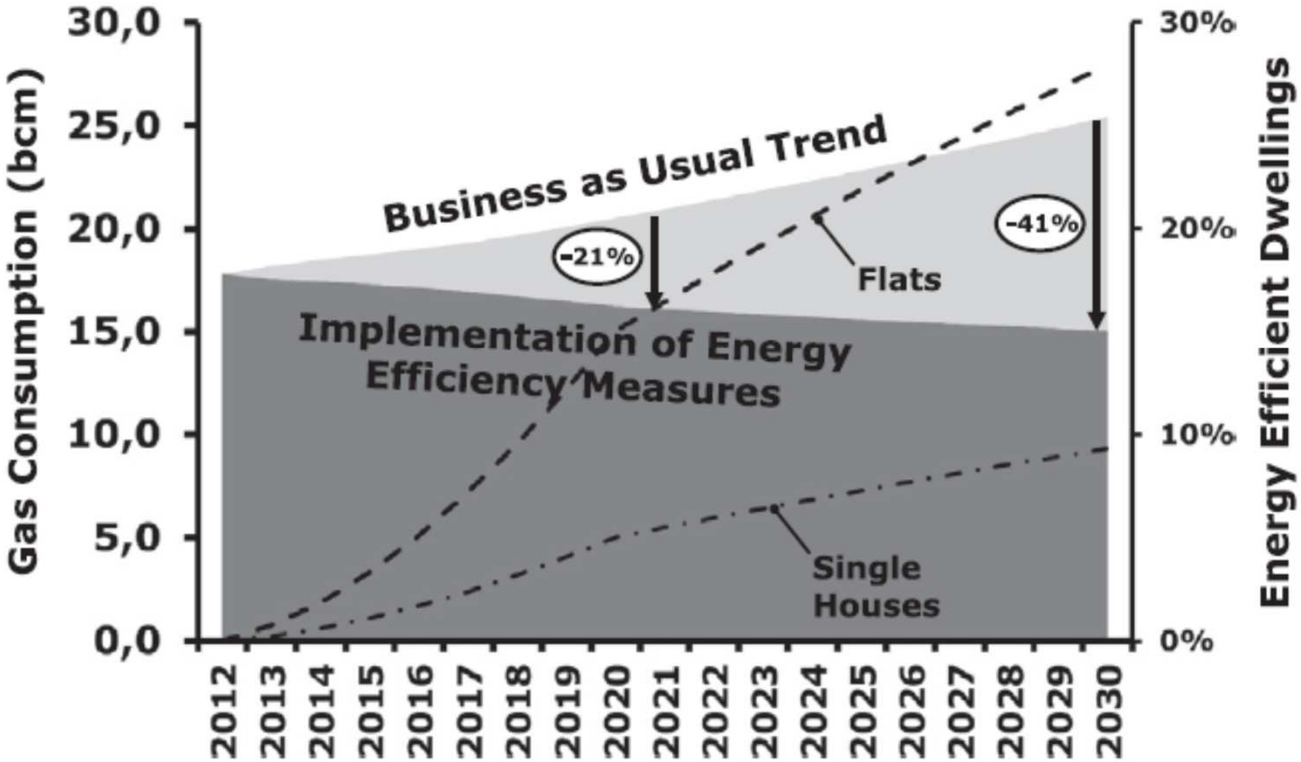
Energy Efficiency: impact



Source: IEA, 2011

Energy Efficiency: potential

Italian Residential Sector



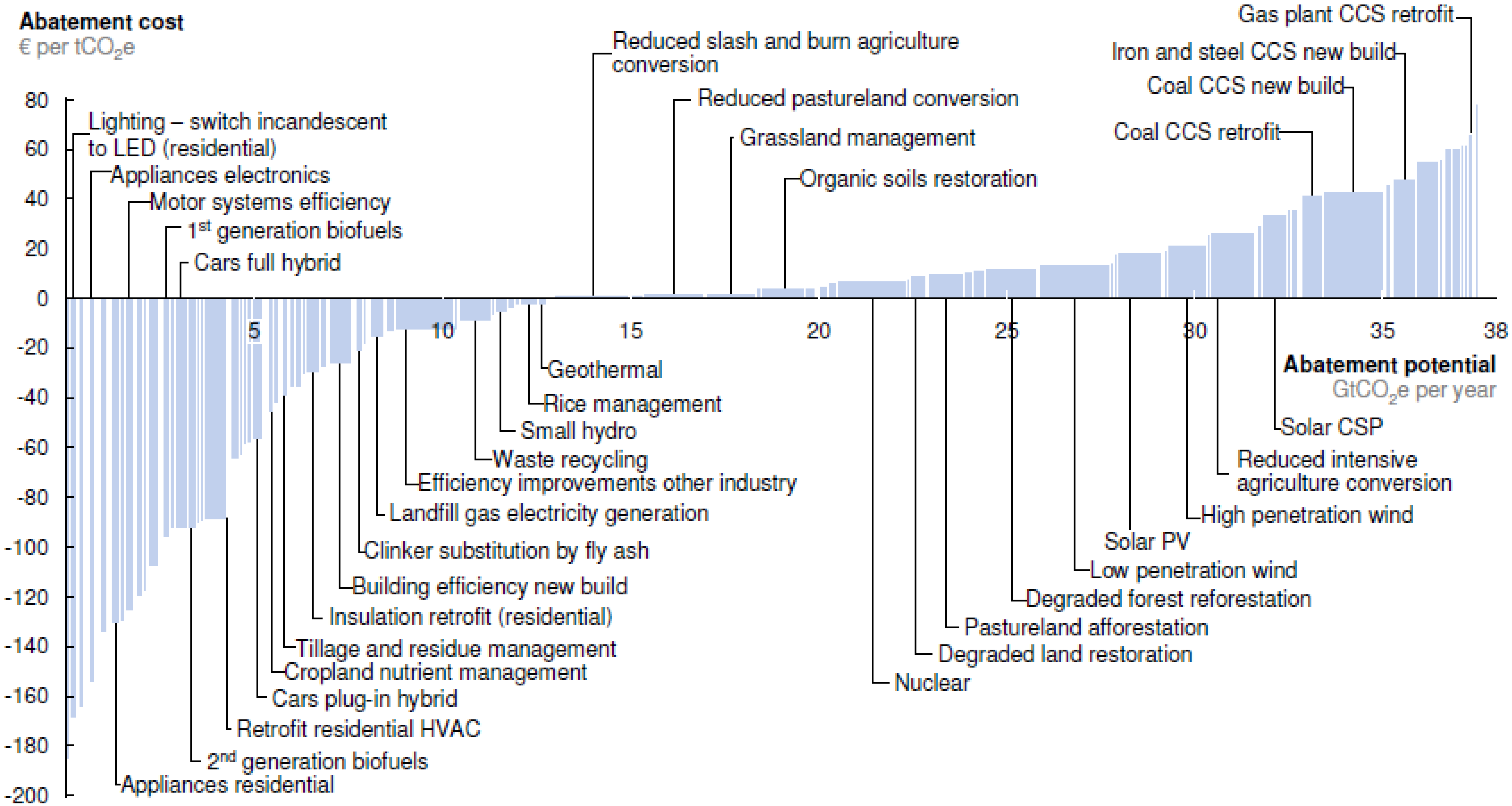
Source: Energy Conversion and Management 87 (2014) 754–764

Energy Efficiency: EU policies

EU Energy Efficiency Policy is based on different criteria, among which:

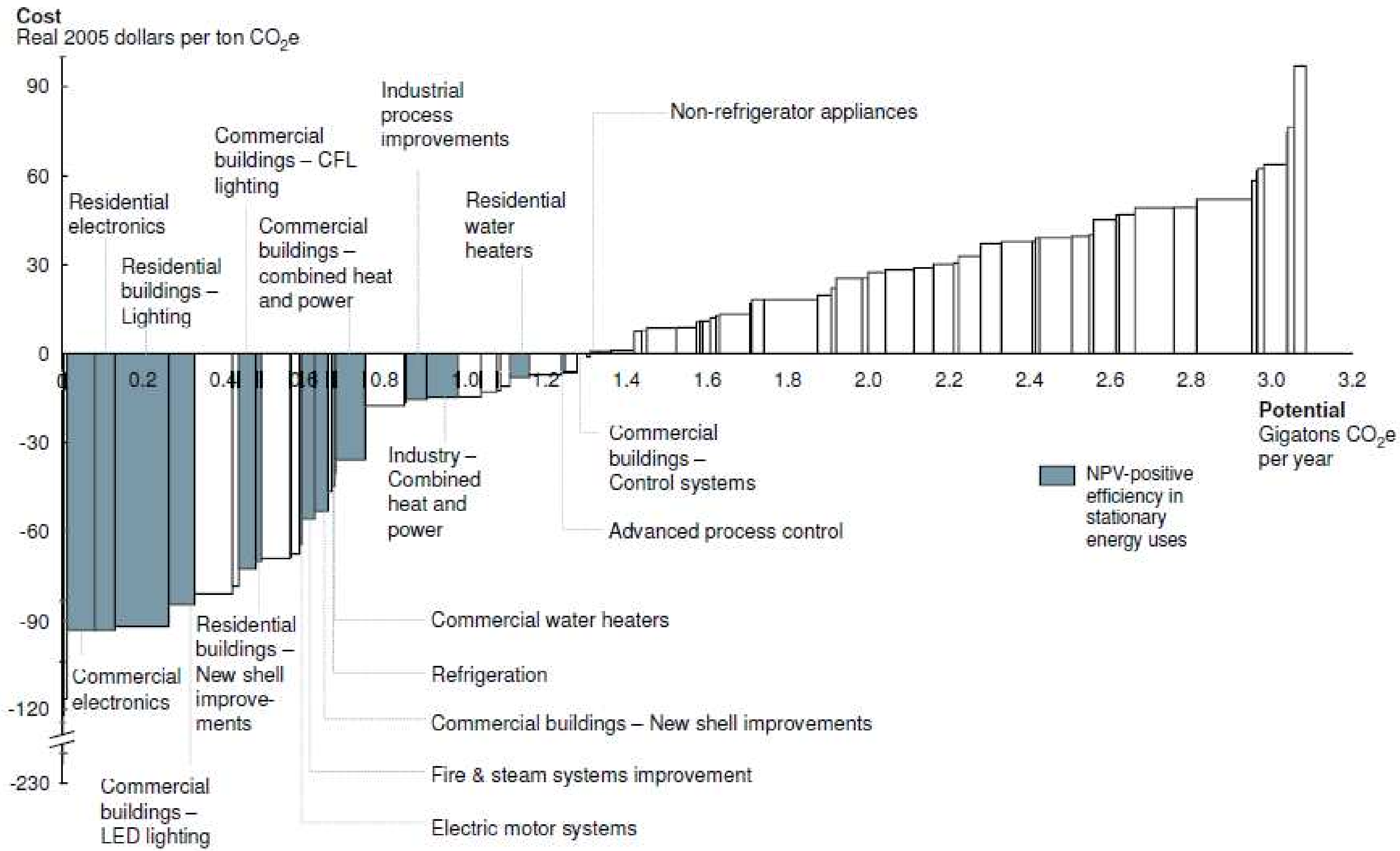
- **Definitions of target**
- **Mandatory planning**
- **Incentives linked to reach pre-determined target**
- **Product labelling**
- **Buildings/Processes certifications**
- **Creation of markets to sell energy efficiency titles or carbon emissions allowances**

Energy Efficiency: economics 1/2



Source: McKinsey & Company

Energy Efficiency: economics 2/2



Source: McKinsey & Company

Questions & Answers session

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Index

1 Introduction to Energy Efficiency

2 **Fundamentals of investment analysis**

3 Cases of study

Investment analysis: definition

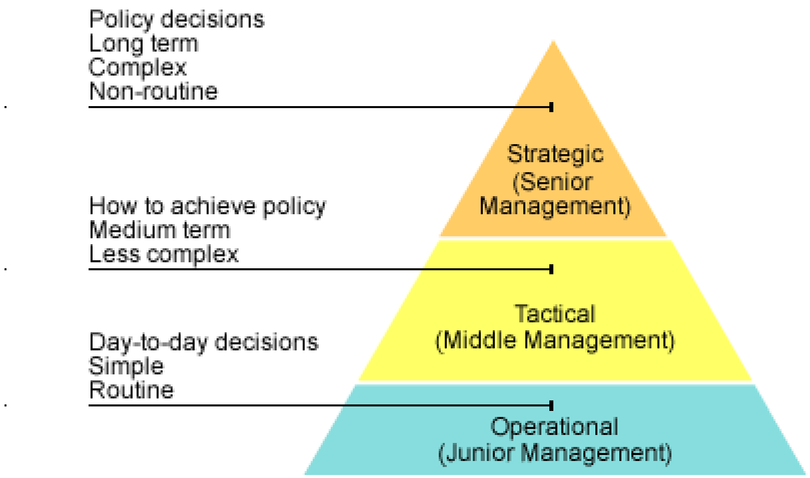
An examination and assessment of economic and market trends, earnings prospects, earnings ratios, and various other indicators and factors to determine suitable investment strategies.

Source: BusinessDictionary.com

What is an investment or a project?

Any decision that requires the use of resources (financial or otherwise) is a project.
The projects can be of different nature:

- Broad strategic decisions (entering new areas of business, new markets, etc.)
- Tactical decisions (open a new branch, etc.)
- Management decisions (product mix, level of inventory, etc.)
- Decisions on delivering a needed service (make or buy choices, etc.)



Present value: some observations

There are thee reasons way a certain amount of money tomorrow is worth less than today:

- Individuals prefer present consumption to future consumption. To induce people to give up present consumption you have to offer them more in the future.
- When there is **monetary inflation**, the value of currency decreases over time. The greater the inflation, the greater the difference in value between a certain amount of money today and tomorrow.
- If there is any uncertainty (risk) associated with the cash flow in the future, the less that cash flow will be valued.

The value of cash flows in future periods decrease as:

- The preference for current consumption increases
- Expected inflation increases
- The uncertainty in the cash flow increases

Present value: discounting and compounding

- To take into account all the previously mentioned factors a “discount rate” is considered
- **Discount rate**: The discount rate is a rate at which present and future cash flows are traded off (i.e. exchanged). It incorporates: preference for current consumptions, inflation, uncertainty in the future, etc.
- A higher discount rate will lead to a lower value for cash flows in the future
- The discount rate is also an opportunity cost, since it captures the returns that an individual would have made on the next best opportunity
- Discounting future cash flows converts them into cash flows in present value money. Just a discounting converts future cash flows into present cash flows.
- Compounding converts present cash flows into future cash flows

Present value: base principle

Cash flows at different points in time cannot be compared and aggregated. All cash flows have to be brought to the same point in time, before comparisons and aggregations are made.

What is the “inflation”?

Inflation refers to increase over time in the average price of goods and services.

Deflation is the opposite of inflation representing a decrease over time in the average purchasing power of money.

Inflation (and or Deflation) modify the cash flow associated with any project conducted over a period of time.

Inflation (and or Deflation) can be quantified through the “cost price index” (CPI), which represents the average variation of price of a basket of goods in a given period.

The CPI provides a means to differentiate between the **real** worth (i.e. referred to a specific year) and the **nominal** worth of a currency (i.e. referred to the actual value of the year considered).

Present value: calculation

The present value of a delayed payoff may be found by multiplying the payoff by a discount factor. If we are in the period 0 and C_1 denotes the expected payoff at period 1 (one year hence), then:

Present Vale (PV)=Discount Factor (DF) x C_1 *discounting*

$$DF = \frac{1}{1+r}$$

r is a rate of return

The present value of a cash flow two years hence can be written in a similar way as:

$$PV = \frac{C_2}{(1+r)^2}$$

Present value: cash flow in several periods

One of the nice things about present values is that they are all expressed in current values, so they can be added. In other words, the present value of cash flow A+B is equal to the present value of cash flow A plus the present value of cash flow B:

$$PV = \frac{C_1}{1+r_1} + \frac{C_2}{(1+r_2)^2}$$

We can obviously continue in this way to find the present value of an extended stream of cash flows:

$$PV = \frac{C_1}{1+r_1} + \frac{C_2}{(1+r_2)^2} + \frac{C_3}{(1+r_3)^3} + \dots$$

And the discounted cash flow (or DCF) formula can be obtained as:

$$PV = \sum_{t=1}^{n} \frac{C_t}{(1+r_t)^t}$$

Project valuation: introduction

- Valuation analysis is used to evaluate the potential merits of an investment or to objectively assess the value of a business or asset.

- Valuation analysis is one of the core duties of a fundamental investor, as valuations (along with cash flows) are typically the most important drivers of asset prices over the long term

- Valuation analysis should answer the simple yet vital question: what is something worth? The analysis is then based on either current data or projections of the future.

To evaluate a project it is necessary to determine its *cash-flow,* therefore it is fundamental to estimate:

- Initial Investment
- Operating Cash-Flow over the project life
- Terminal Year Cash flow
- Figure of merit to rate the

Net Present Value (NPV)

- The NPV of a project is one way of examining costs (cash outflows) and revenues (cash inflows) together.
- A NPV analysis can be composed of many different cost and revenue streams.
- The analyst must know the form of the different streams (current or constant dollars), so the correct discount rate can be used for the present value analysis
- NPV analysis is recommended when evaluating investment features and decisions such as mutually exclusive projects and social costs
- It is also recommended that NPV be used in most other evaluations as well, specifically as a secondary measure to check the validity of any primary measure used.

$$NPV = -C_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

Internal Rate of Return (IRR)

- The internal rate of return (IRR) for an investment that has a series of future cash flows is the rate that sets the NPV of the cash flows equal to zero.
- The IRR analysis allows for the comparison of a wide variety of investment activities.
- IRR is commonly used for accept/reject decisions, allowing a quick comparison with a minimum acceptable rate of return (hurdle rate).
- The viability of a project is usually assessed with IRR by comparing the IRR of the project with a "hurdle rate" that represents the IRR of the next best alternative (the opportunity cost of capital).
- IRR also has the advantage that it can be used to directly compare the after-tax return on readily available financial instruments, such as bonds, thereby providing the investor with a quick qualitative assessment of the project.

$$-C_0 + \sum_{t=1}^{n} \frac{C_t}{(1+IRR)^t} = 0$$

Pay-back period

- The discounted payback period (DPP) is the number of years necessary to recover the project cost of an investment while accounting for the time value of money.
- DPB is recommended when risk is an issue because DPB allows for a quick assessment of the duration during which an investor's capital is at risk.
- DPB is also not recommended when selecting among mutually exclusive alternatives because differing investment sizes are not considered

$$\sum_{t=1}^{n} \frac{C_t}{(1+r)^t} = C_0$$

t is the parameter to be determined

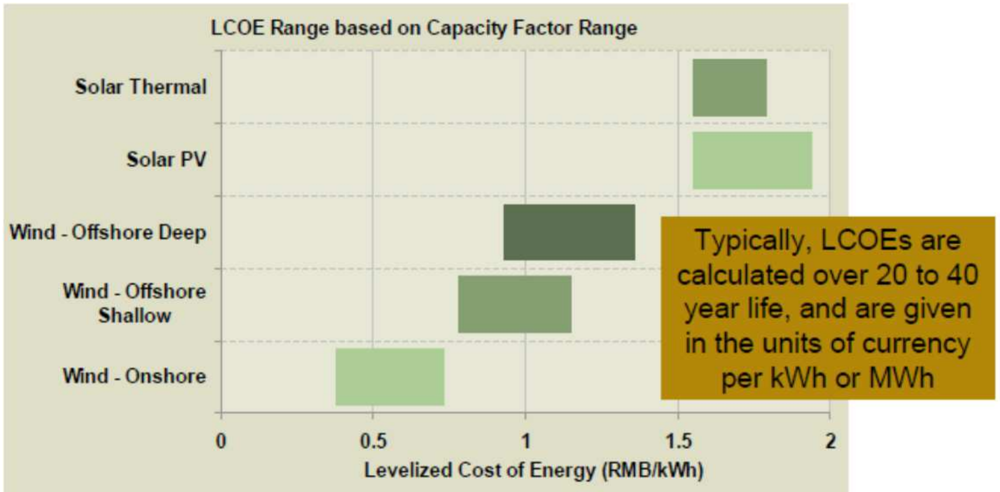
Profitability Index (PI)

- Profitability index (PI), also known as profit investment ratio (PIR) and value investment ratio (VIR), is the ratio of payoff to investment of a proposed project.
- It is a useful tool for ranking projects because it allows you to quantify the amount of value created per unit of investment.
- A profitability index of 1 indicates breakeven. Any value lower than one would indicate that the project's PV is less than the initial investment. As the value of the profitability index increases, so does the financial attractiveness of the proposed project.

$$PI = \frac{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{C_0}$$

Levelized Cost of Energy (LCOE)

- The levelized cost of energy is defined as the constant price per unit of energy that causes the investment to just break even: earn a present discounted value equal to zero.
- LCOE is very useful in comparing technologies with different operating characteristics
- LCOE is recommended for use when ranking alternatives given a limited budget simply because the measure will provide a proper ordering of the alternatives, which may then be selected until the budget is expended



Exercises

- **Exercise 1.** Calculate the NPV for each of the following investments. The opportunity cost of capital is 20% for all of therm. Initial cash flow,C_0, 1:-10000$, 2:-5000$, 3:-5000$, 4:-2000$. Cash Flow in Year 1,C_1, 1:+18000$, 2:+9000$, 3:+5700$, 4:+4000$. Which investment is most valuable? Which investment would you do?

- **Exercise 2.** A company is evaluating a project which requires an initial investment of 600000$ and it is supposed to generate a cash flow of 160000 $/year. The project will last 8 years and the equipment can be sold at the end of the project for 40000$. The company uses a discount rate of 18%. Determine NPV and IRR of the project.

- **Exercise 3.** A new truck will cost $50,000 and bring in additional revenues over operating costs of $4,000 per year over a twenty year period. Is it a good investment, if the discount rate is 14%? Determine the IRR.

Index

1- Investment valuation of a CCGT plant

The project concerns the construction and operation of 460 MW_e (Gross Power) CCGT power plant with an average fuel efficiency of 57%, plus associated grid connections. Project implementation is scheduled to be undertaken from 2016 until 2018, with the start of commercial operation in beginning of 2019.

The project is planned to operate as a mid-merit/peaking plant with a yearly load factor of 60% to match the requirements of the industrial off-taker. The risk of lower load factor due to rising shares in wind and solar power is mitigated through a favorable offtake structure.

Natural gas price is supposed to be equal to 25 €/MWh_t in 2019 and to increase of 3% per year up to 2029 and of 2% per year from 2030 until 2039. CO2 price is assumed to be equal to 12 €/t in 2019 and it increases at a peace of 2% per year. The emission factor is equal to 0,198 t/MWht

The offtake agreement establishes a price of 75 €/MWh_e for the firs ten year and 85 €/MWh_e for the following 10 years. The investment cost is 700 k€/MW_e.

Determine if the investment is profitable and which is the LCOE.

2- Investment valuation of an on-shore wind park

The example concerns an investment in the construction and operation of a small onshore wind farm located in northern Europe. The new plant will have a total capacity of 120 MW and it is expected to be committed in 2016. The economic life of the plant is estimated at 15 years and the load factor at 30%. The wind park is constituted of turbines with a power of 3 MW and their cost is 4,5 M€ each. The power price in 2016 is expected to be 70 €/MWhe with an increase of 2% per year. Each year a VOM cost equal to the 5% of the CAPEX is sustained and a load curtailment of 3% is estimated.
Determine if this investment is profitable and which is its LCOE

3 – Investment valuation of a CCGT plant

Repeat “Case of Study 1” by assuming a tax rate of 30%.

4 – Rehabilitation of multi-storey building in an EU country (1/2)

The project concerns the refurbishment of 365 buildings with nearly 20,000 apartments of 75 m^2 in a district of the capital city. The proposed investment is to be executed within 4 years.

The investment will focus on thermal energy efficiency improvements of the building envelope (wall insulation, windows, roof and cellar insulation). The main source of energy used for heating in these blocks is heat from the district heating network with only a limited share of owners having switched to individual gas boilers. In addition, the renovation of the district heating system (production, pipes and sub-stations) could result in substantial energy savings, but this is not included in the project.

The average specific energy demand in multi-family residential buildings is some 190 kWh/m^2 per year in the region.

Based on existing studies and the preliminary results of the refurbishments carried out previously, the average potential energy savings with the planned investment scope are estimated to 50% of the present consumption. Therefore, the estimated energy consumption in the refurbished buildings can be expected to reach 95 kWh/m^2.

4 – Rehabilitation of multi-storey building in an EU country (2/2)

The economic cost of heat supply is estimated at around 62 €/MWh_{th} in 2016, including CO_2 and other external environmental costs (SO_2, NO_x and dust) and it is supposed to increase of 5% per year.
The total investment is estimated in 75 M€ and the useful life of the efficiency measures is estimated in 15 years. The investment will start in 2016

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