Water Resources Engineering and Management

(CIVIL-466, A.Y. 2024-2025)

5 ETCS, Master course

Martin P. Bieri
martin.bieri@gruner.ch

Lesson	Content
WREM-L12.1	**Water Management: Investing in infrastructure**
WREM-L12.2	**Water Management: Value creation in finance – cash flows, NPV and IRR**
WREM-L12.3	**Water Management: Investing in infrastructure – case study**
WREM-L13.1	Water Management: Financing structures
WREM-L13.2	Water Management: Risk assessment
WREM-L13.3	Water Management: Risk assessment – case study

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

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Lecture WREM-L12.1: Water Management: Investing in infrastructure

Content and Goals

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- Why **investing in infrastructure**
- Understand the **time value of money**
- Understand **Net Present Value (NPV**) and **Internal Rate of Return (IRR)**
- Understand rules for **investment decisions**
- Understand relevant cash flows for **discounted cash flow** analysis
- Understand cash flows of a hydropower project for the **economic analysis**

Inspired by:

- Schmedders Karl: “Finance Stream – Unit 1 Discounted Cash Flows”, IMD Lausanne, 2020
- Bieri Martin Peter: “Financial Risks in Hydropower Investments in Southeast Asia – Identification, Analysis and Mitigation”, AIT Bangkok, 2019

Investments

Investments

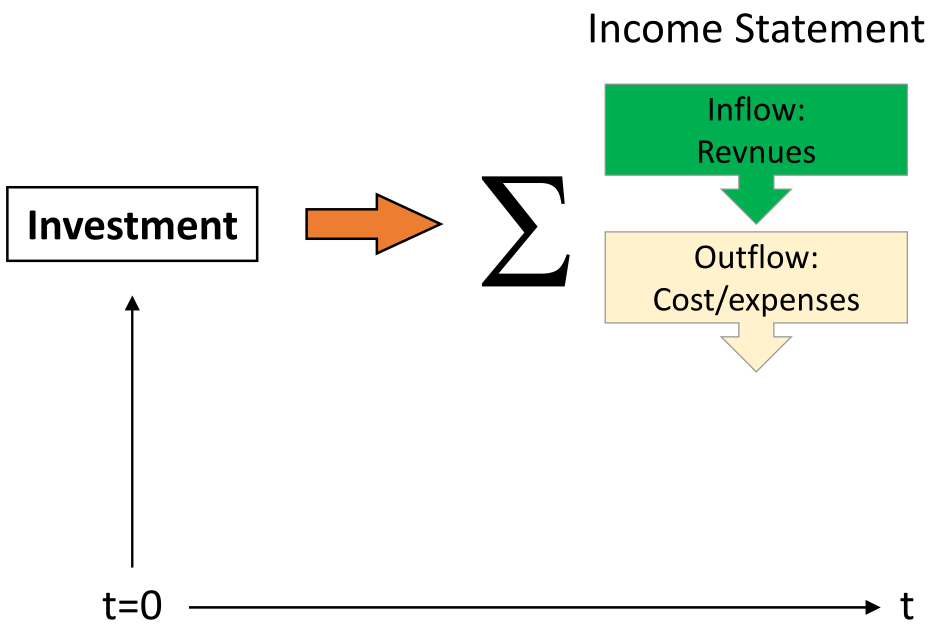
Investment =

- Process of exchanging income during one period of time for an asset that is expected to produce earnings in future periods

Encyclopedia Britannica

- Commitment of resources to achieve later benefits

Wikipedia



Investments and Cash Flow

Shall I invest?

- **Yes** or **No**? = Investment decision
- If yes, **how**? = Optimization of investment

By assessment and comparison of **cash flows** of a project to define **profitability of investment**

Cash flow =

Net balance of cash moving into and out of a business at a specific point in time from:

- Operating activities (net income, depreciations etc.)
- Investing activities (CAPEX)
- Financing activities

= **project's ability to generate wealth**

Investment Policies for Infrastructure Projects

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Infrastructure =
the **fundamental facilities** and systems serving a country, city or area *Encyclopedia*

- **Infrastructure investment to be substantially increased** to meet social needs and support more rapid economic growth
- Total **global infrastructure investment** requirements by 2030 for transport, electricity, water and telecommunications USD 71 trillion (**3.5% of world GDP**)
- Governments cannot afford through tax revenues and aid alone

- **Greater private investment in infrastructure needed** to reduce pressure on public finances
- Benefit from private sector skills to achieve **cost and efficiency gains** by delegating the construction and oftentimes management of infrastructure projects to private investors
- Quality of investment policies directly influencing decisions of all investors
- Policy principles for sound investment environment: **Transparency, property protection and non-discrimination**

(Fostering Investment in Infrastructure - Lessons learned from OECD Investment Policy Reviews, OECD, January 2015)

Investment Policies for Infrastructure Projects

Requirements for enhancing private participation in infrastructure investments (Lessons learned from country experiences for enhancing private participation):

- Investment regime providing **clarity and predictability for investors**
- Careful **project preparation**
- Varied sources of **project finance**
- Improving **public procurement regime**
- Improving **state-owned enterprises governance**
- Unbundling vertically integrated supply chains in **network infrastructure sectors** (transport, energy, water and sanitation)
- Changes in **regulatory regimes**
- Reforming **pricing structures** in infrastructure networks

(Fostering Investment in Infrastructure - Lessons learned from OECD Investment Policy Reviews, OECD, January 2015)

Investment Decision

Goal:

- **Maximizing the return on investments**
  and **minimizing the cost of capital for investors** (sponsors)
- **Minimizing/optimizing project related risks**
  for sponsors and creditors (lenders).

Investment Decision

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Approach:

- **Market assessment**: Models to assess/predict progression, stagnation and regression
- **Market sector analysis**: Assessment of type and nature of competition

→ Identification of market sector for investment opportunities

- **Forecast of costs**: Establishment/assessment of potential financial statement
- **Forecast of prices**: Establishment/assessment of potential financial statement

→ Identification (or not) of and decision-making on investment project

Example: Investment Decision in SE Asia

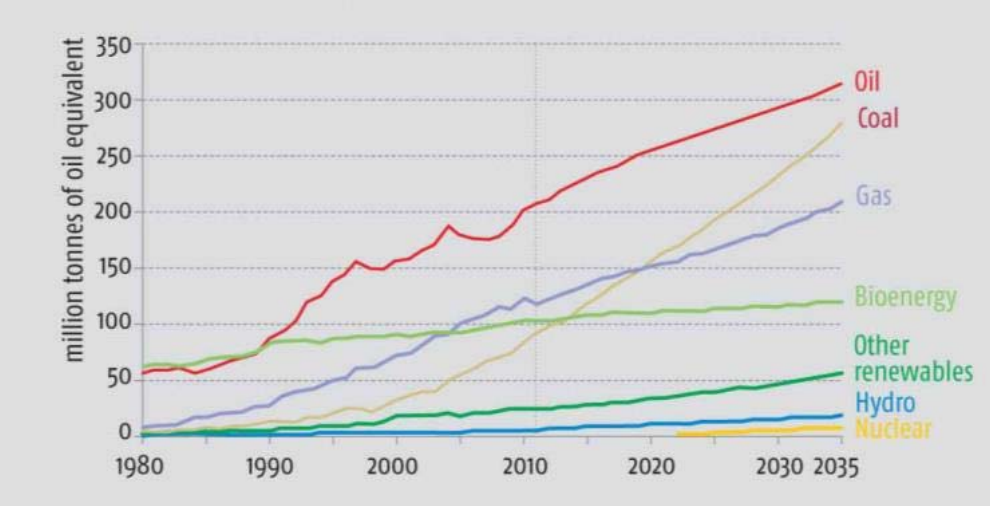
PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

- **Market assessment**:

million tonnes of oil equivalent

	1990	2011	2020	2025	2035	2011–2035*
Indonesia	89	196	252	282	358	2.5%
Malaysia	21	74	96	106	128	2.3%
Philippines	29	40	58	69	92	3.5%
Thailand	42	118	151	168	206	2.3%
Rest of Asean	42	119	161	178	221	2.6%
Total Asean	223	549	718	804	1,004	2.5%

* Compound average annual growth rate



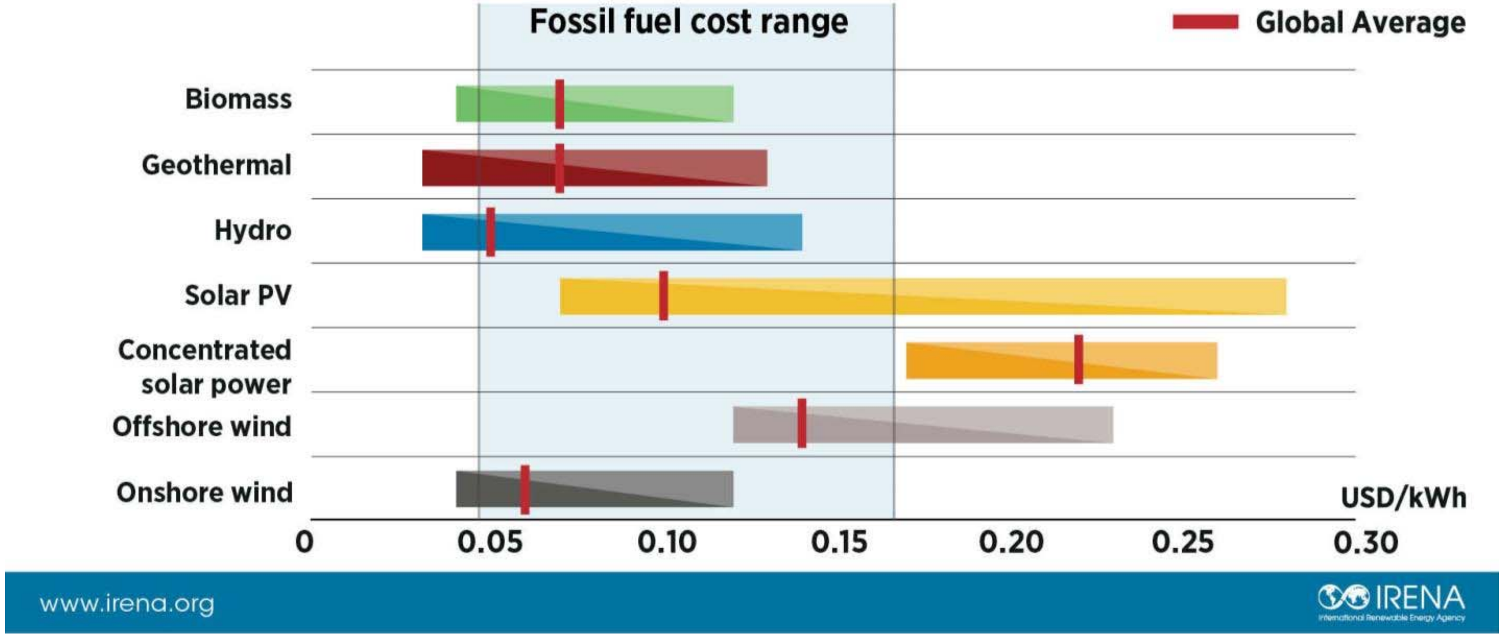
Source: International Energy Agency, Southeast Asia Energy Outlook, World Energy Outlook Special Report, 2013

→ Lack of investment in the power sector = bottleneck to the countries' economic development

→ Growing Energy Market in SE Asia

Example: Investment Decision in SE Asia

- **Market sector analysis**: Type of energy



→ Hydropower low development cost

Example: Investment Decision in SE Asia

- **Market sector analysis**: Country

Renewable Energy (RE) policies:

- Implementation of policy measures and dedicating funding to encourage deployment of RE generation
- Design and implementation of these incentives country-specific
- Most effective policy instruments attracting private sector investors:
  - Appropriate Feed-in-Tarif (FiT) system
  - Simplified permit procedures
  - Attractive incentives and financing support mechanisms

Example: Investment Decision in SE Asia

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

- **Market sector analysis**: Country

Policy	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	The Philippines	Singapore	Thailand	Vietnam
RE Target	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Selling Tariffs	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Incentives	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Financing support	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Permits and Licences	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Technical aspects	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

→ Indonesia, Malaysia, Philippines, Thailand and Vietnam providing RE policies for enhancing private participation in energy market

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Lecture WREM-L12.2: Water Management: Value creation in finance – cash flows, NPV and IRR

Cash Flows

Deriner HPP, Turkey

Cash Flows

Former reference in the course:

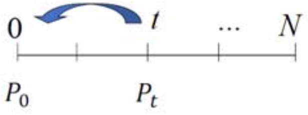
Present Value

Costs and benefits change their value with time and this depends on the capitalisation scheme and the discount factor that is the nominal cost of capital *r=i-e* (interest-inflation rate)
If capitalization follows the compound interest formula, then we can actualize the value of future capitals to today simply as follows

$$P_0 = \frac{P_1}{(1+r)^1}$$

$$P_t = \frac{P_t}{(1+r)^t}$$

Present value calculation



What is the "Present value" concept?

Costs and benefits at different times cannot be compared because they have different values due to the capitalization scheme.

In order to compare them they must be actualized to the same reference time, e.g. today --> Present Value

$$PCV = \sum_{t=0}^{L} \frac{C_t}{(1+r)^t}$$ Present Costs Value

$$PBV = \sum_{t=0}^{L} \frac{B_t}{(1+r)^t}$$ Present Benefits Value

$$NPV = \sum_{t=0}^{L} \frac{B_t - C_t}{(1+r)^t}$$ Net Present Value (cashflow actualization)

How can costs and benefits at different times be compared?

This can be done by calculating all present values and summing them up to obtain the so-called Net Present Value or NPV

Initial conditions of the investment plan

t=0

$$NPV(0) = -C_0 \qquad B_0 = 0$$

t=1

$$NPV(1) = \sum_{t=0}^{L} \frac{B_t - C_t}{(1+r)^t} = -C_0 + \frac{B_1 - C_1}{(1+r)^1}$$

t=N

$$NPV(L) = \sum_{t=0}^{L} \frac{B_t - C_t}{(1+r)^t}$$

How should the NPV evolve in time?

NPV starts negative and grows as benefits begin to compensate costs. At the project lifetime, NPV must be positive or the project has financially failed. A number of other fundamental economic indexes will be derived in future lectures

Cash Flows

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Two types of cash flows

- Inflows = positive cash flows
- Outflows = negative cash flows (-minus)

Financial decisions generally based on combination of cash flows or related comparing values, which **occur at different points in time**.

"The Three Rules of Time Travel"

1) Only cash flows **at the same point in time** can be compared or combined (added, subtracted).
2) To consider cash flow **from the past**, you must **compound** it.
   = "bring it forward"
3) To consider cash flow **from the future**, you must **discount** it.
   = "bring it backward"

Cash Flows: The 1st Rule of Time Travel

Only cash flows at the same point in time can be compared or combined (added, subtracted).

1 CHF or USD today ≠ 1 CHF or USD in one year

- What would you prefer USD 1’000 today or USD 1’210 in future?
- What is worth more?
- What does “in future” means (tomorrow or in 10 years)?

Cash Flows: The 2nd Rule of Time Travel

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

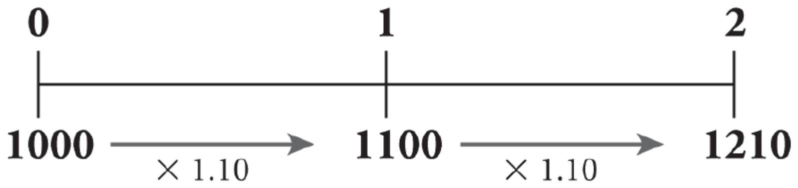
To consider cash flow **from the past**,
you must **compound** it.
= "bring it forward"

Compounding: increasing the value of an asset (or a liability) due to the interest earned on both a principal and accumulated interest.

Future value FV_n of year 0 cash flow C in year n:

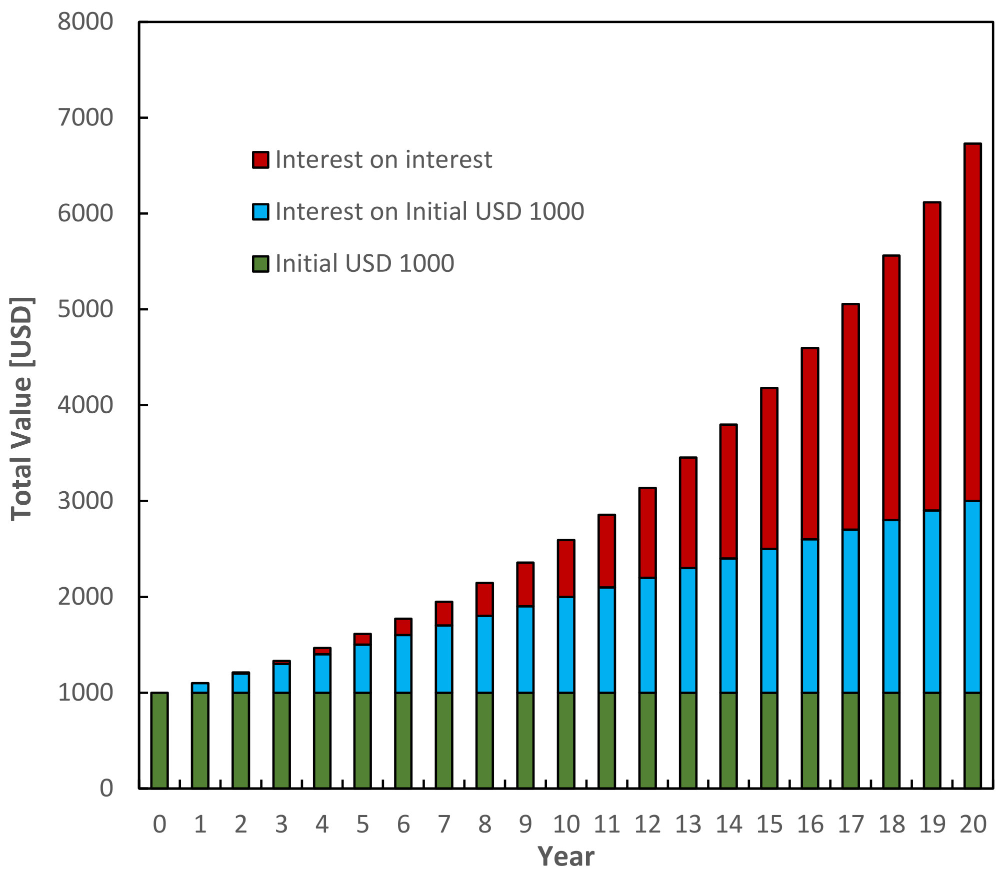
$$FV_n = C \times (1+r) \times (1+r) \times \ldots \times (1+r)$$
$$= C \times (1+r)^n$$

- You can choose between USD 1'000 today or USD 1'210 in two years.
- You expect an earning of 10% on the USD 1'000 in a year.



Cash flow today (year 0):	USD 1'000
Value in year 1:	USD 1'100
Value in year 2:	USD 1'210

Cash Flows: The 2nd Rule of Time Travel



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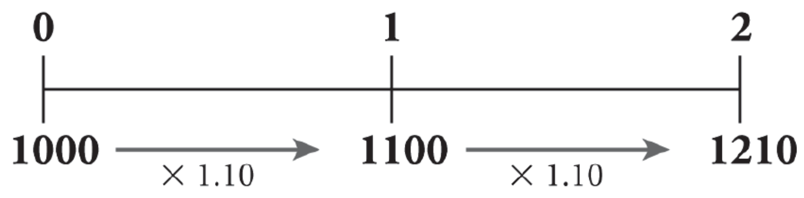
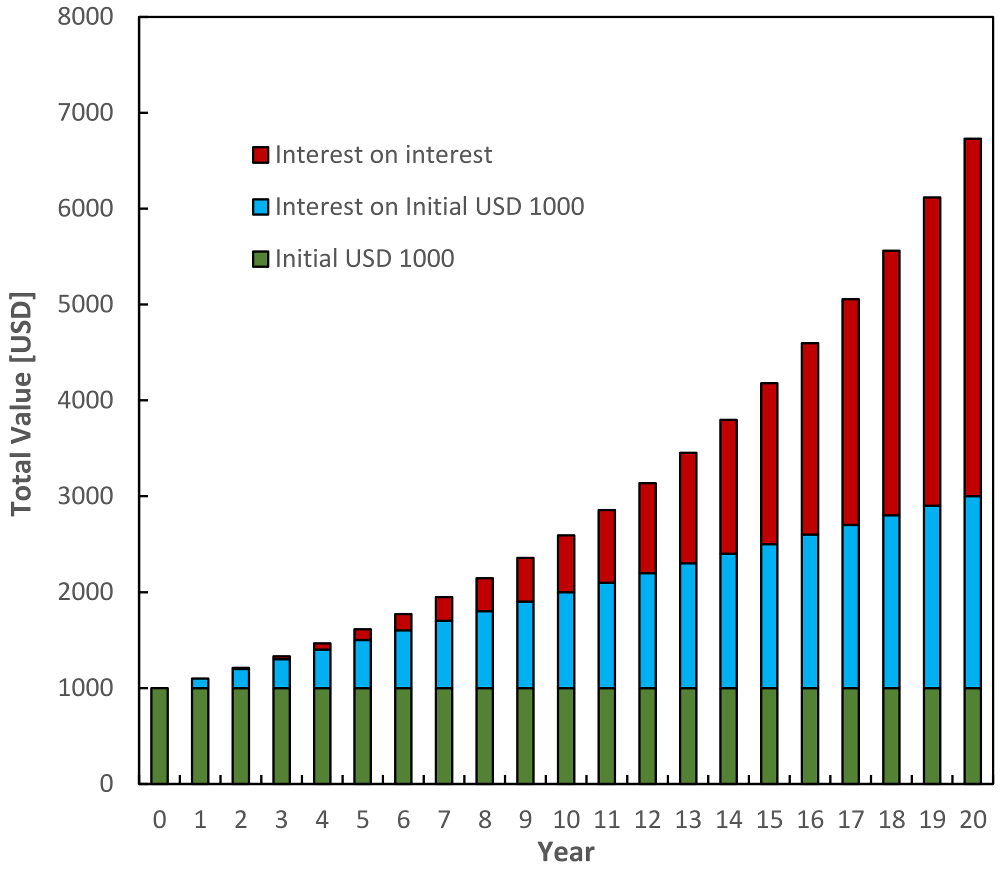


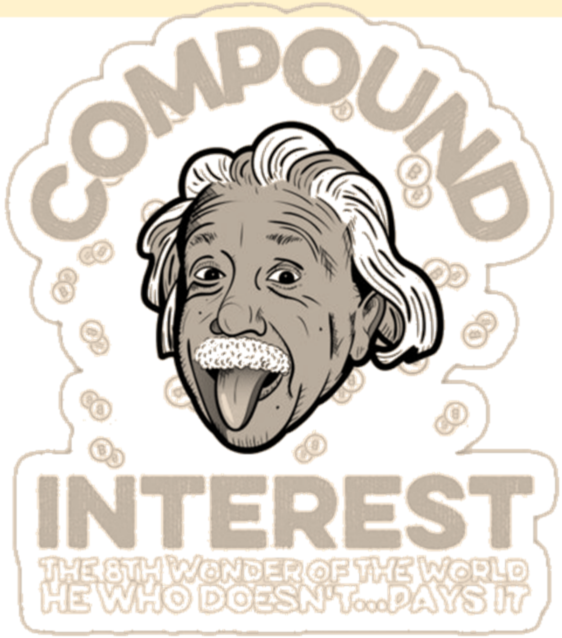
Cash flow today (year 0): USD 1'000
Value in year 1: USD 1'100
Value in year 2: USD 1'210

Cash Flows: The 2nd Rule of Time Travel



"Compound interest is the eighth wonder of the world. He who understands it, earns it; he who doesn't, pays it."

Albert Einstein



Cash Flows: The 2nd Rule of Time Travel

The time value of money:

A rational investor generally **prefers to receive a cash flow today rather than the same amount of cash at a future point in time** because of the potential to grow the cash position in value in the meantime (during the interim period).

Cash Flows: The 3rd Rule of Time Travel

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

To consider cash flow **from the future**,
you must **discount** it.
= “bring it backward”

Discounting: decreasing the value of an asset (or a liability) due to the interest earned on both a principal and accumulated interest.

Present Value PV of cash flow C in year n:

$$PV = C / ((1+r) \times (1+r) \times \ldots \times (1+r))$$
$$= C / (1+r)^n$$

Cash Flows: Example Zero-Coupon

In February 2022, Axpo (Holding AG) issued a three-year zero-coupon bond.

Suppose the annual interest rate on this zero-coupon bond issued by Axpo is 1%.

Suppose you want to receive CHF 10‘000 from an investment in this bond at the time of maturity.

How much would you need to have invested in 2022?

PV = 10’000 / $(1+0.01)^3$ = **9’705.90**

Axpo Holding AG

Domestic segment Switzerland: 35% withholding tax on coupon payments. Documentation in accordance with Swiss law; listed on the SIX Swiss Exchange.

Ratings

CS: High BBB, stable
UBS: BBB+, deteriorating
ZKB: BBB+, positive
Fedafin: A-, stable

Coupon	Issued amount*	Outstanding amount*	Date of issue	Repayment date	Securities no. / ISIN
1.750%	350	350	29.07.2016	29.05.2024	33014314 / CH0330143147
	200	200	04.02.2022	04.02.2025	243967619 / CH1160188335

Cash Flows: Example Zero-Coupon

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In February 2022, Axpo (Holding AG) issued a three-year zero-coupon bond.

If you wanted to receive CHF 10'000 from this investment after three years, you would need to invest USD 9'925.37.

What **interest rate r** does Axpo pay on this bond?

$$PV = 9'925.37 = 10'000 / (1+r)^3$$

$$\Leftrightarrow (1+r)^3 = 10'000 / 9'925.37$$

$$\Leftrightarrow r = (10'000 / 9'925.37)^{1/3} - 1 = \mathbf{0.25\%}$$

axpo

Axpo Holding AG

Domestic segment Switzerland: 35% withholding tax on coupon payments. Documentation in accordance with Swiss law; listed on the SIX Swiss Exchange.

Ratings

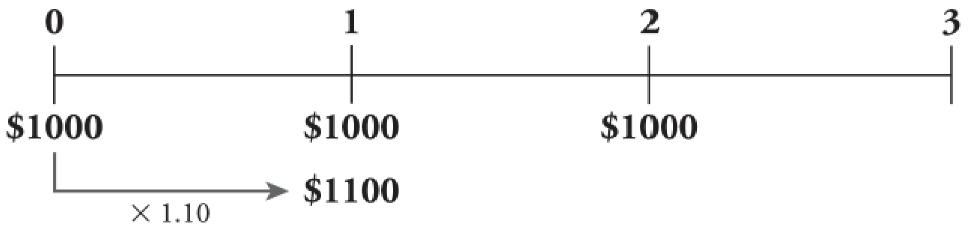
CS: High BBB, stable
UBS: BBB+, deteriorating
ZKB: BBB+, positive
Fedafin: A-, stable

Coupon	Issued amount*	Outstanding amount*	Date of issue	Repayment date	Securities no. / ISIN
1.750%	350	350	29.07.2016	29.05.2024	33014314 / CH0330143147
0.25%	200	200	04.02.2022	04.02.2025	243967619 / CH1160188335

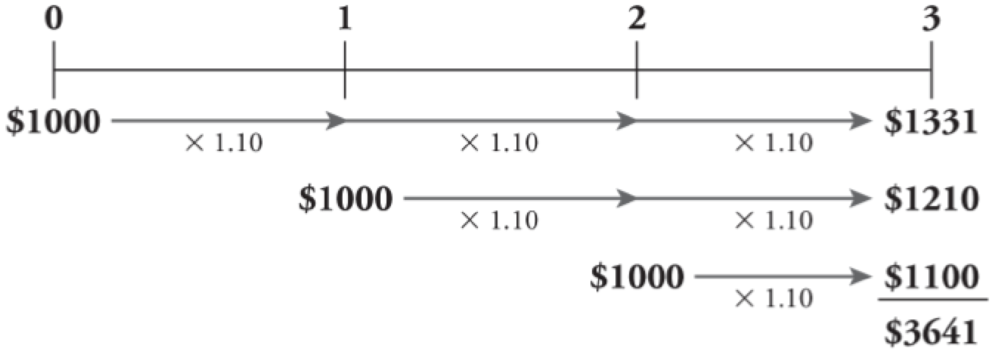
EPFL

Cash Flows: Example Combining Cash Flows over Time

Suppose we plan to save USD 1000 today, and USD 1000 at the end of each of the next two (2) years. If you can earn a fixed interest rate of 10% on your savings, how much will we have three (3) years from today?



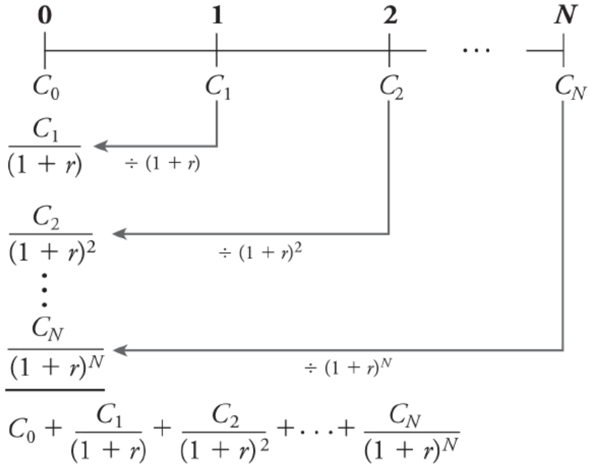
(Source: Corporate Finance, Jonathan Berk and Peter De Marzo, Pearson Prentice Hall, 2011)



Present Value (PV) & Future Value (FV)

- Present Value (PV)

$$PV = C_0 + \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \cdots + \frac{C_N}{(1+r)^N} = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n}$$



- Future Value (FV)

$$FV_n = \sum_{n=0}^{N} C_n \cdot (1+r)^{N-n} = PV \cdot (1+r)^N$$

Net Present Value (NPV)

- Typical investments have cash outflows and cash inflows.
- **Net Present Value (NPV)** = comparison of present value of cash inflows (benefits) to present value of cash outflows (costs)
- Calculating the NPV of future cash flows allows to **assess an investment decision**.

Value Creation in Finance

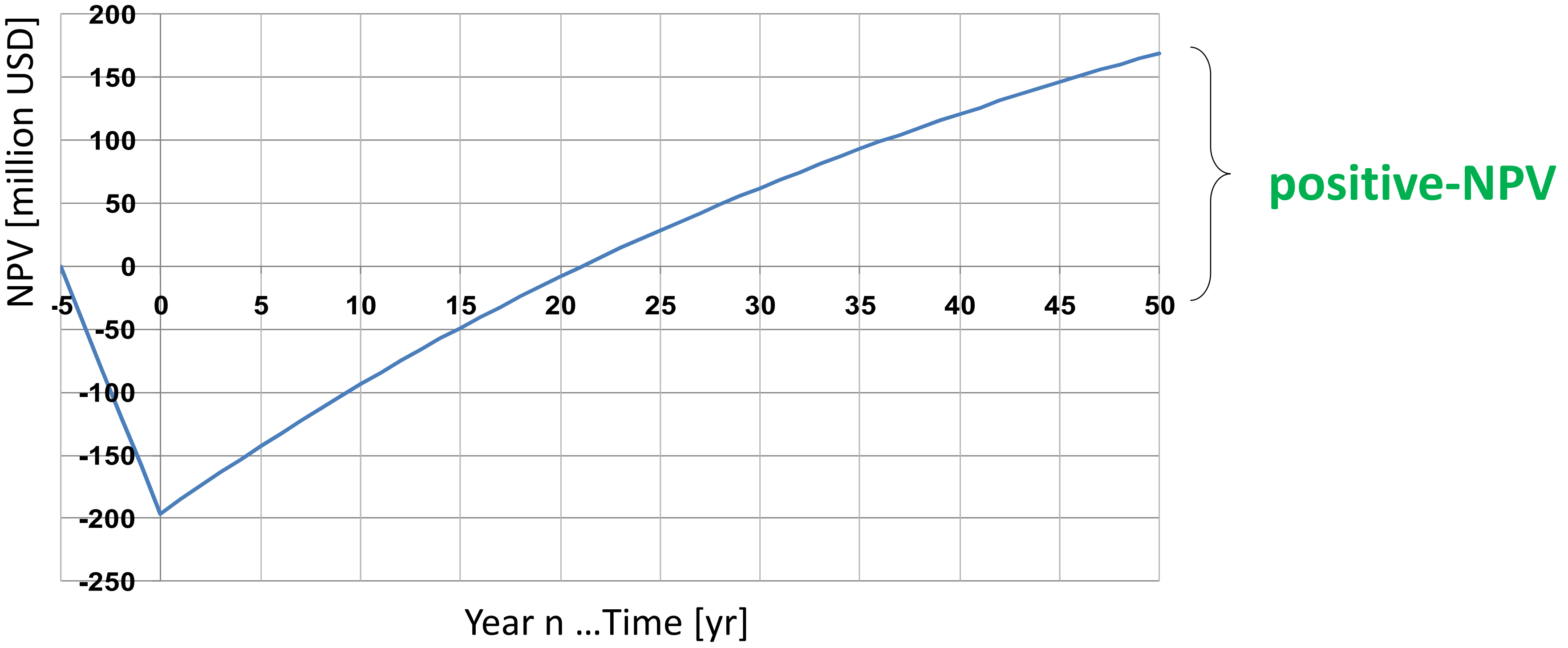
- "A crowning achievement of finance has been to transform value creation from a catchy management slogan into a **practical decision-making tool** that not only indicates which activities create value but also estimates the amount of value created."
- You want to create value for owners?

  Achieve positive-NPV activities (the higher the NPV, the better)
  … and avoid negative-NPV activities.

(Source: „Analysis for Financial Management," Robert C. Higgins, Jennifer L. Koski, Todd Mitton)

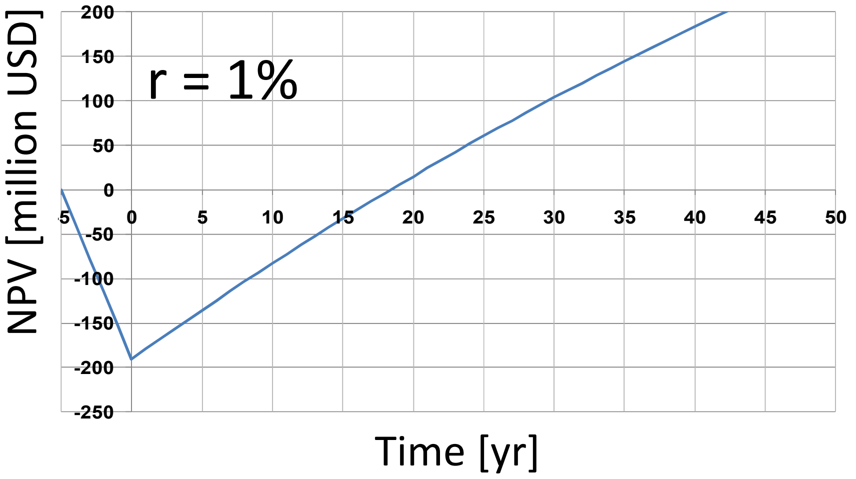
Net Present Value (NPV)

= present value of the cumulated project value until year n

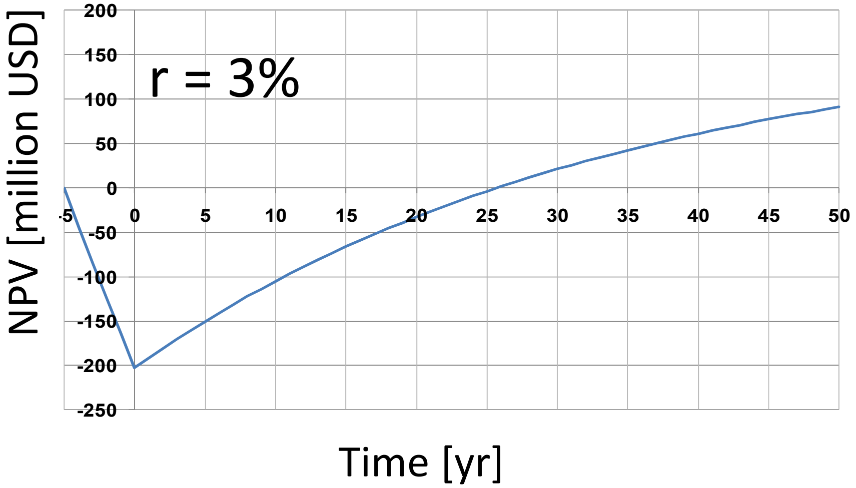


Net Present Value (NPV)

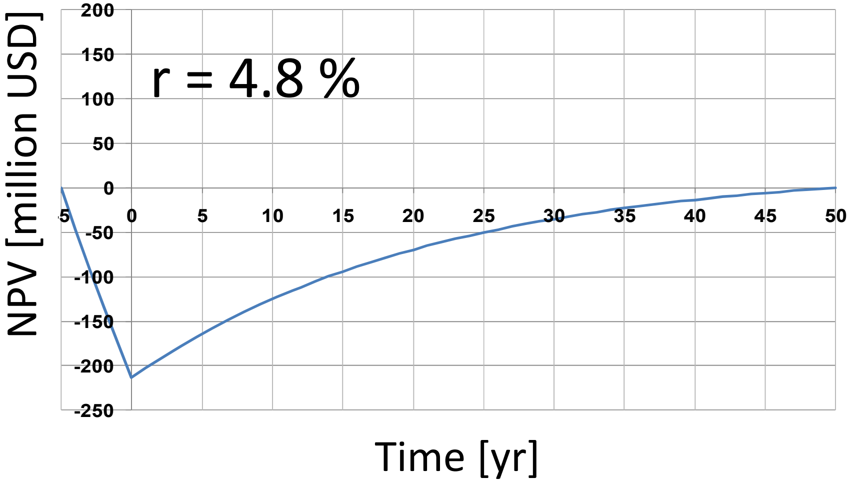
= function of discount rate r = f(r)

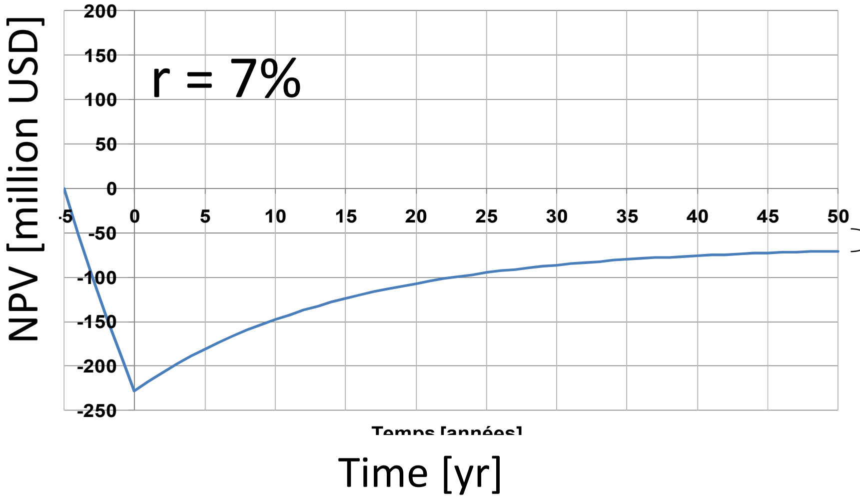


positive-NPV



positive-NPV





negative-NPV

Net Present Value (NPV) – Single Project

Alpiq gets the opportunity for a take-it-or-leave-it investment for a single, stand-alone power project:

- Project costs: CHF 250 million
- Cash flows: CHF 35 million per year starting at end of first year, lasting forever
- Discount rate: r

How does the NPV of the project change when the **discount rate ranges from 5% to 30%**?

Note:

Constant cashflow forever = **perpetuity**

$N \rightarrow \infty$ (infinity), $C_0=0$, $C_1=C_2=\ldots=C$

$$PV = \frac{C}{r}$$

Net Present Value (NPV) – Single Project

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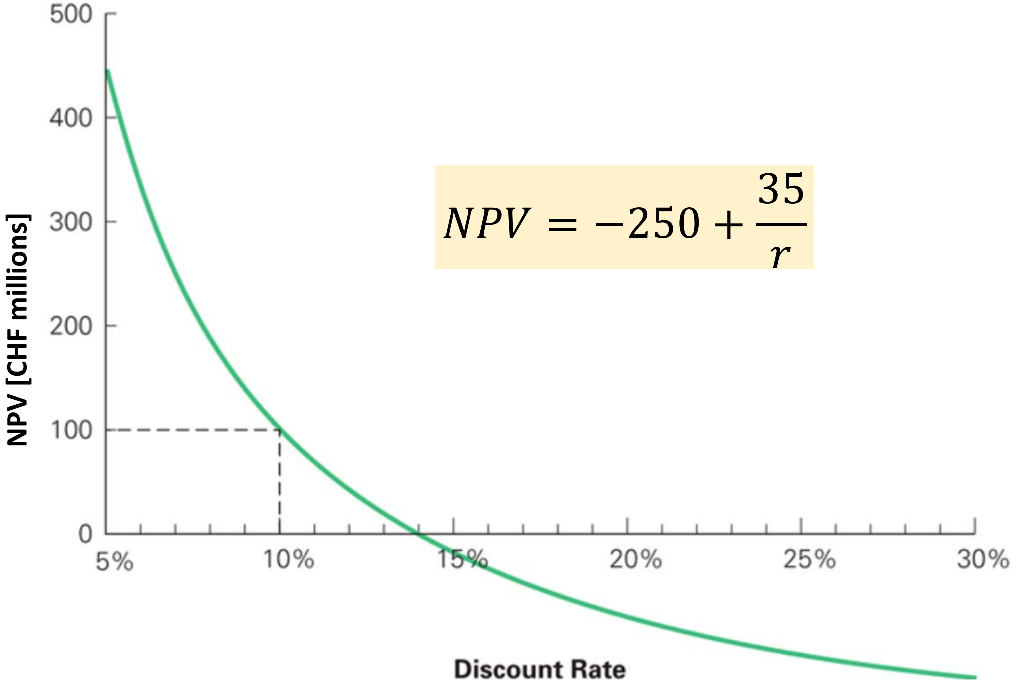

$$NPV = -250 + \frac{35}{r}$$

(Image: Corporate Finance, Jonathan Berk and Peter De Marzo, Pearson Prentice Hall, 2011)

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Internal Rate of Return (IRR)

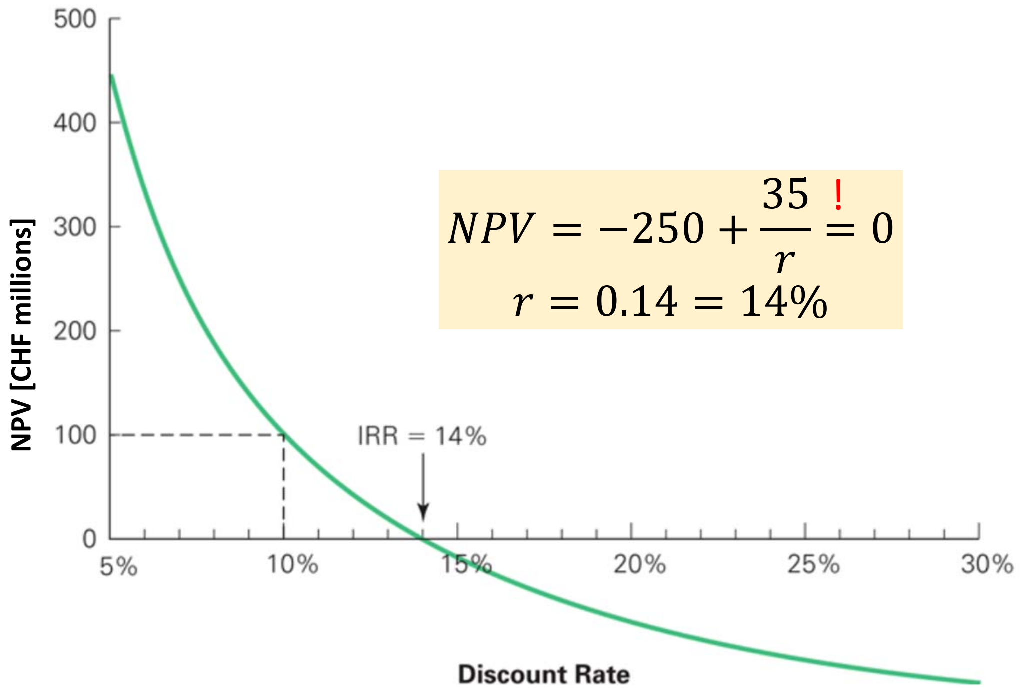
Internal Rate of Return (IRR)
= discount rate
that makes Net Present Value (NPV)
of all cash flows from the project equal to zero

Should Alpiq invest in this single, stand-alone power project with an IRR of 14%?

- NPV positive, if interest rate r < 14%
- NPV negative, if interest rate r > 14%

Key question for Alpiq: What is „cutoff“ interest rate? Is an annual return of 14% enough?

Answer: Alpiq‘s **cost of capital**



$$NPV = -250 + \frac{35}{r} \,!\, = 0$$

$$r = 0.14 = 14\%$$

(Image: Corporate Finance, Jonathan Berk and Peter De Marzo, Pearson Prentice Hall, 2011)

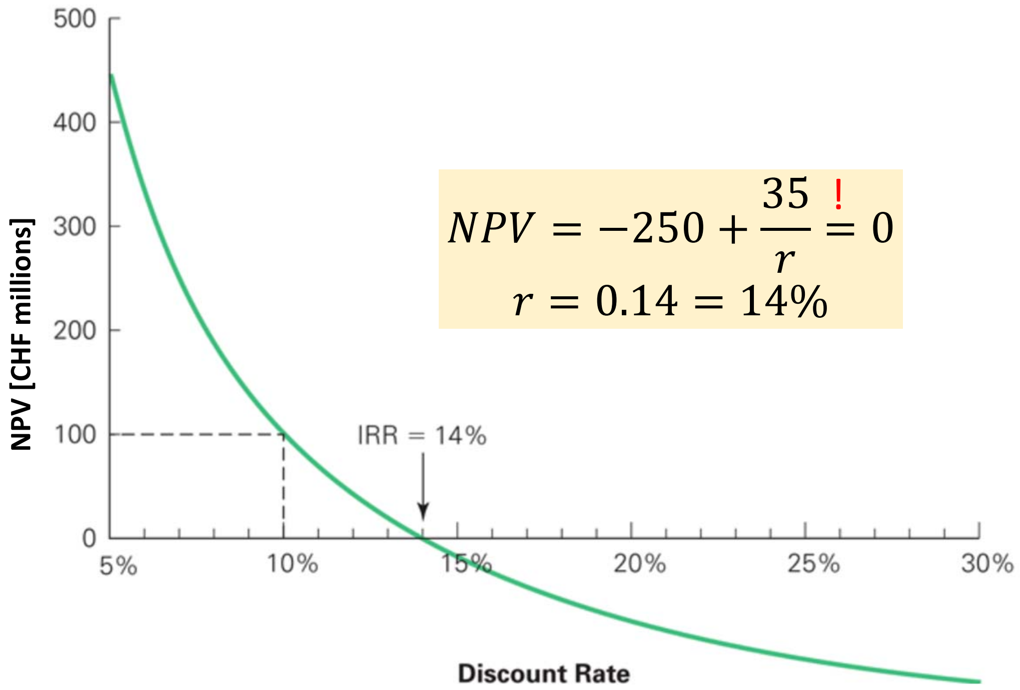
Cost of Capital

Cost of Capital =
cost of financing business activity through either debt or equity capital

Different (but similar) definitions exist:

- Opportunity cost of capital
- Weighted Average Cost of Capital (WACC)

→ Next lesson



$$NPV = -250 + \frac{35}{r} \overset{!}{=} 0$$

$$r = 0.14 = 14\%$$

(Image: Corporate Finance, Jonathan Berk and Peter De Marzo, Pearson Prentice Hall, 2011)

IRR Decision Rule for Investment

Internal Rate of Return (IRR)
= discount rate at which an investment's Net Present Value (NPV) equals zero

If

- IRR > Cost of Capital
  undertake investment
- IRR < Cost of Capital
  reject investment

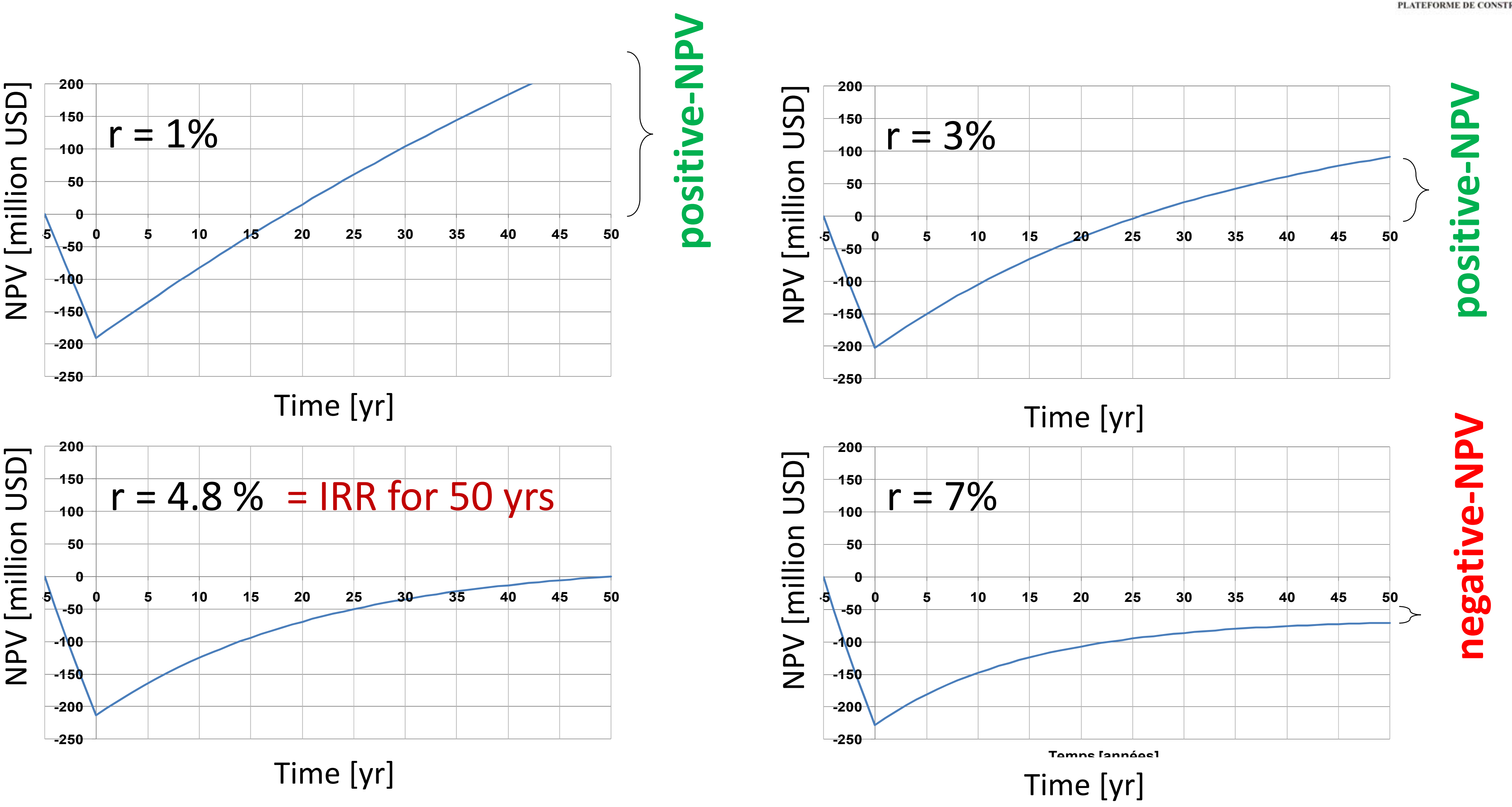
… however, discounted cash flow analysis of an investment faces a key challenge

… before we can even calculate NPV or IRR …

Determine relevant cash flows

= time and value of revenues and costs associated with the investment

IRR Decision Rule for Investment



Cash Flow Principle

Record cash flows when the money moves.

If the money does not move, do NOT count it.

Due to the time value of money, you need to properly account for the time money leaves or enters your accounts.

Some specifics to be considered:

- *Capital Expenditures (CAPEX)* = actual cash outflows, when asset is purchased
  → to be included in cash flow calculations
- *Depreciation* = non-cash expense
  → may not impact cash flow calculations
  BUT: depreciation affecting a company's taxes, and taxes are cash flows and to be included in cash flow calculations

With–Without Principle

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If decision does not affect a cash flow,
then the cash flow should not affect decision.

Sunk cost: Particular cost, which should NOT enter cash flow analysis

= costs to be paid regardless of decision whether or not investment is undertaken

Sunk cost not be included in cash flow analysis of an additional investment

Some specifics to be considered:

- *Fixed Overhead Expenses*
  = Overhead costs fixed and not incremental to the project, thus not be included in calculation of incremental earnings
- *Past Research/Development Expenditures*
  = Money already spent on R&D

Decision to continue or abandon a project to be based only on incremental costs and benefits of the product going forward

With–Without Principle – Sunk Cost

Concorde Fallacy

Idea that you should continue to spend money on a project, product etc. in order not to waste the money or effort you have already put

(Cambridge Business English Dictionary, Cambridge University Press)

"We've come too far to stop now!"

"If we cut and run, it will all have been in vain!"

No! **Emotions** attached to the person's "mental accounts" make sunk cost difficult to ignore.

Disciplined mindset to avoid the sunk cost fallacy

Examples of sunk cost fallacies:

- *Concorde:*
  Joint project between French and British governments; **Huge cost, limited revenue, all-around bad investment**; Both governments continued to fund project causing further financial loss
- *Servette HC:*
  Two fans plan to travel from Bern to Geneva to see their club playing. **One of them paid for the ticket; the other got it free from a friend.** A blizzard is announced for the night. Which fan is more likely to see the game?

Conclusion

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

The Three Rules of Time Travel:

- Only cash flows at the same point in time can be compared or combined (added, subtracted).
- To consider cash flow **from the past**, you must **compound** it.
  = "bring it forward"
- To consider cash flow **from the future**, you must **discount** it.
  = "bring it backward"

NPV and IRR:

Value creation in finance:

Undertake investments that satisfy

- Net Present Value: NPV > 0
- Internal Rate of Return: IRR > Cost of Capital

Inputs to Analysis:

Determining cash flows for project
= challenging task, following guiding principles:

- **Cash Flow Principle**
- **With–Without Principle**

… and beware of the sunk cost fallacy

Water Resources Engineering and Management

(CIVIL-466, A.Y. 2024-2025)

5 ETCS, Master course

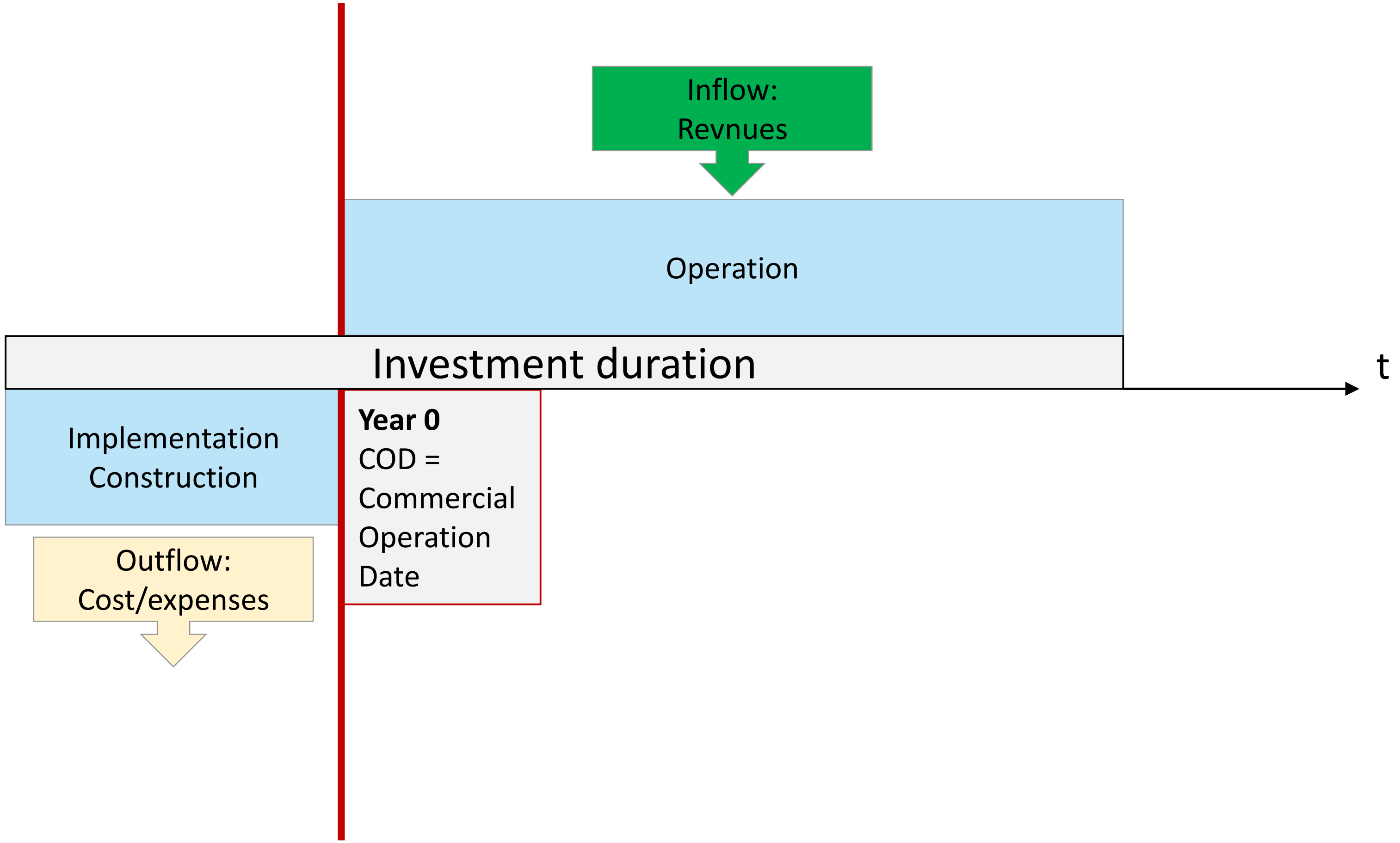
Martin P. Bieri
martin.bieri@gruner.ch

Lecture WREM-L12.3: Water Management: Investing in infrastructure – case study

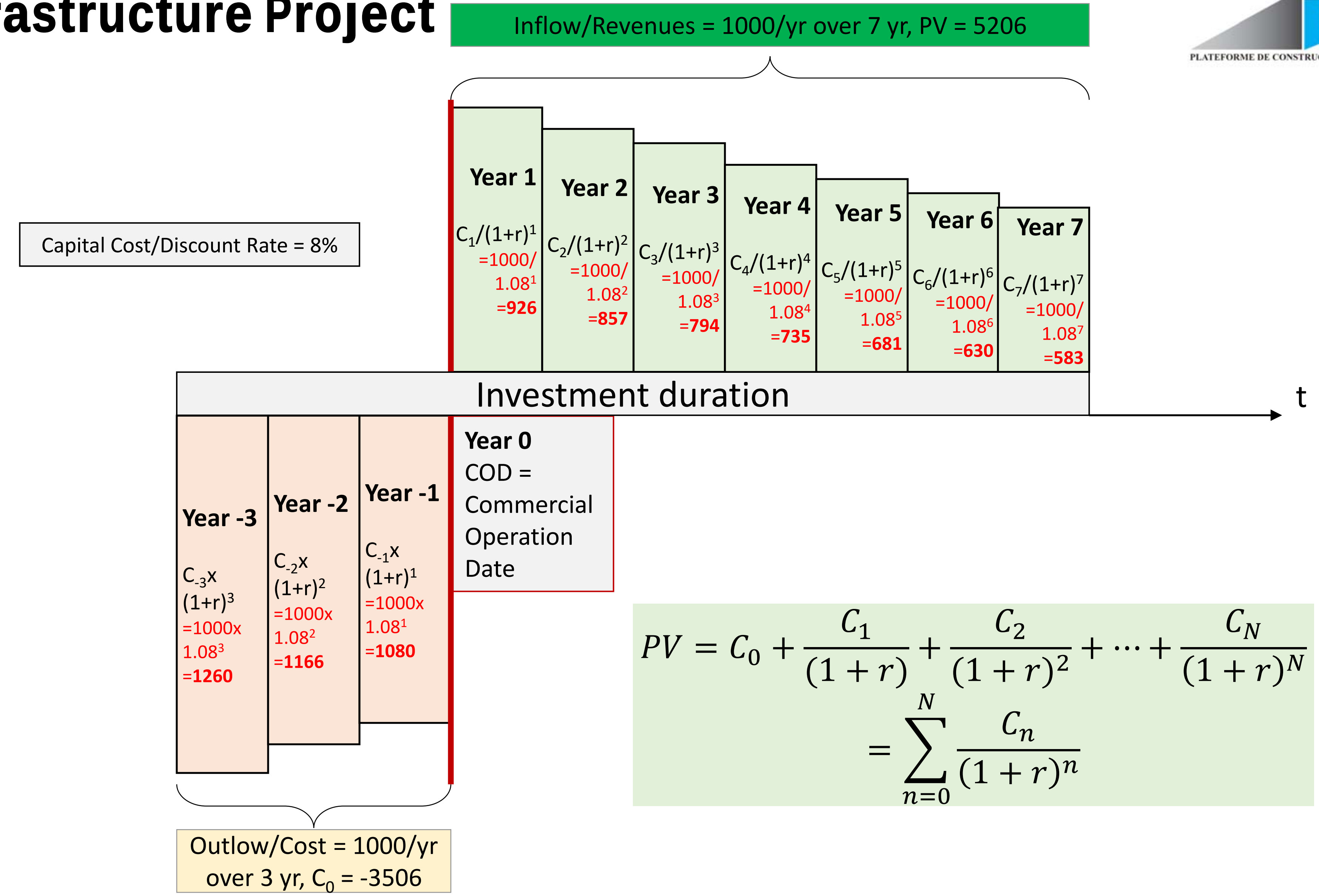
Example: Infrastructure Project

Penstock installation, Switzerland

Example: Infrastructure Project



Example: Infrastructure Project



$$PV = C_0 + \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \cdots + \frac{C_N}{(1+r)^N} = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n}$$

Example: Infrastructure Project

	Outflows = negative cash flows				Inflows = positive cash flows						
n	Year -3	Year -2	Year -1	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Cash Flow Cn	-1000	-1000	-1000		1000	1000	1000	1000	1000	1000	1000
Present Value	-1260	-1166	-1080		926	857	794	735	681	630	583
Invested cash flows Present Value of cash flows	-3506				5206						
Change in Cash Flow				-3506	-2580	-1723	-929	-194	487	1117	1700

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 1700$$

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1+IRR)^n} = 0 \quad IRR = 20\%$$

Pay-back period = 4.4 yr

Example: Use of IRR and NPV

Heightening of 21.5 m of
Vieux Emosson Dam
(H = 55 m), Switzerland

Example: Use of IRR and NPV

n	Project A1	Project A2
C_0	-1000	-5000
PV	2000	7000
IRR	100%	40%
$NPV_{(r=10\%)}$	818	1364

Which project should you choose?

Decide using IRR and NPV with r=10%.

Example: Use of IRR and NPV

n	Project A1	Project A2	A2-A1
C_0	-1000	-5000	-4000
PV	2000	7000	5000
IRR	100%	40%	25%
$NPV_{(r=10\%)}$	818	1364	545

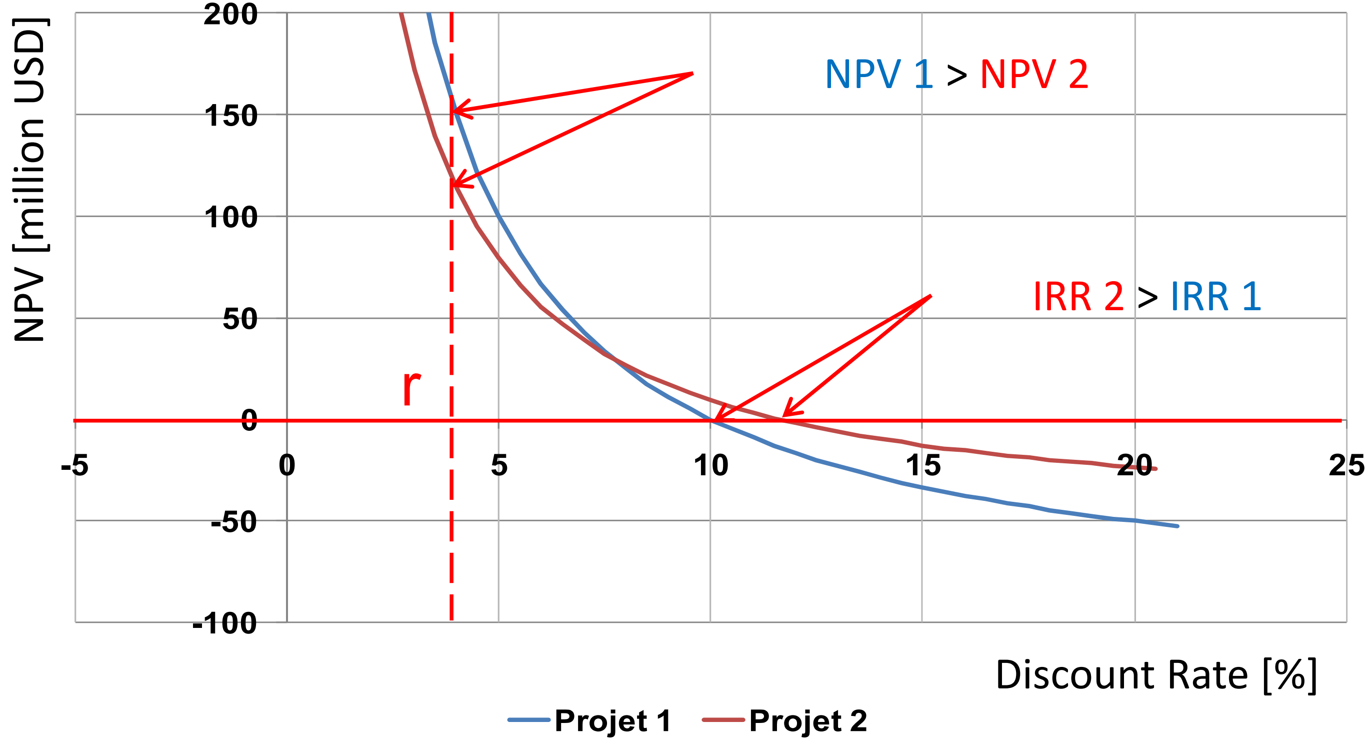
positive-NPV

Which project should you choose?

Decide using IRR and NPV with r=10%.

Differential analysis

Example: Use of IRR and NPV



Do not compare IRR between projects for decision making,
as higher IRR does not mean to be more economically viable!

Case Study Hydropower

Ilisu HPP, Turkey

1200 MW HPP with CFRD, spillway and powerhouse (6x vertical Francis units)

2008 to 2016

Case Study Hydropower: Investment Decision

Approach:

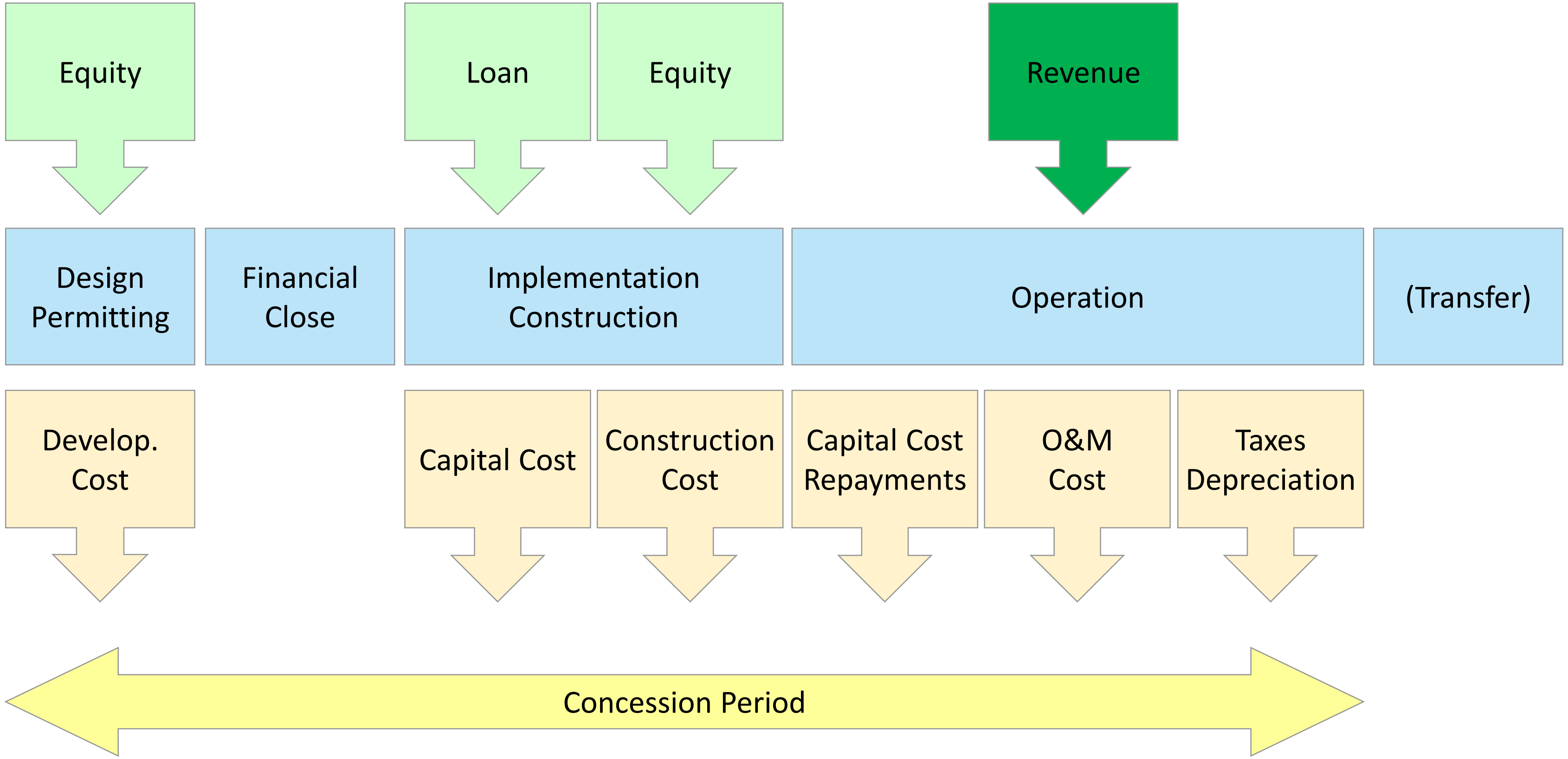
- **Market assessment**: Models to assess/predict progression, stagnation and regression
- **Market sector analysis**: Assessment of type and nature of competition

→ Identification of market sector for investment opportunities

- **Forecast of costs**: Establishment/assessment of potential financial statement
- **Forecast of prices**: Establishment/assessment of potential financial statement

→ Identification (or not) of and decision-making on investment project

Case Study Hydropower: Cash Flows



Case Study Hydropower: Construction Cost

Direct Costs (incl. contingencies)

Based on unit prices and estimated quantities or through equipment:

- Construction and Civil Works
- Electro-mechanical Works
- Hydromechanical Works
- Transmission Line Works

Possible breakdown structure as follows:

- Site installations and preparatory works
- Project access
- River diversion
- Dam and headworks
- Power waterway
- Powerhouse and tailrace
- Grid Connection

Case Study Hydropower: Construction Cost

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

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Indirect Costs

Not directly related to permanent works but in direct relation with costs thereof:

- Technical management services
- Client administration and project management
- Owner's engineering / site supervision
- Lender's engineering and owner-controlled insurance policy;
- Contractual requirements, e.g. Concession Agreement (CA) and Power Purchase Agreement (PPA) expenses
- Land acquisition, environmental and social impact cost

Interest During Construction (IDC)

Cost of financing the funds for project

Case Study Hydropower: Construction Cost

Input Parameters			
Discount rate			6%
Debt ratio			70%
Construction time			3 years
Operation period			27 years
Calculation			
Start of Year 1	10%	1.16	0.12
End of Year 1	25%	1.12	0.28
End of Year 2	30%	1.06	0.32
End of Year 3	35%	1.00	0.35
IDC			6.46%

To consider cash flow **from the past**,
you must **compound** it.
= "bring it forward"

Interest During Construction (IDC)

Cost of financing the funds for project

Case Study Hydropower: Construction Cost

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Revenue

Operation:

- Energy generation as function of:
  - Inflow (Hydrology)
  - Head and tailwater levels
  - Friction and form losses
  - Equipment efficiencies
- Electricity tariff

Production Losses
(generally as % of energy generation):

- Environmental flow release
- Production losses
  (forced and planned outages)
- Own consumption

Expenses

Not directly related to permanent works
but in direct relation with costs thereof:

- Operational cost
  (as % of project cost);
- Continuous refurbishment cost
  (as % of project cost);
- Major revision cost
  (as % of E&M cost).

Case Study Hydropower: Economic Analysis

Economic Analysis:

- Overall feasibility of the project, **regardless of the financing aspects**
- Economic cashflow for **construction period** and **operation period**
- Considering …
  - Capital Cost for Direct Construction Cost
  - Capital Cost for Indirect Construction Cost
  - Revenues resulting from the energy generation
  - Operational costs and losses
- Transfer payments, like subsidies and taxes, usually not taken into account
- Common indicators:
  - (Economic) Net Present Value (NPV)
  - (Economic) Internal Rate of Return (IRR)

Case Study Hydropower: Financial Analysis

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

To follow …