Water Resources Engineering and Management

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

5 ETCS, Master course

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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**

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Lecture WREM-L13.1: Water Management: Financing structures

Content and Goals

- Understand **economic vs. financial analysis**
- Understand **equity vs. debt**
- Understand **equity vs. project financing**
- Understand **leverage effect of debt**
- Understand **risk assessments**
- Understand **impact of risks on economic/financial performance from sponsor's and lender's perspective**
- Understand cash flows of a hydropower project for the **financial analysis**

Inspired by:

- Schmedders Karl: "Finance Stream – Unit 5 Debt and Equity Financing", IMD Lausanne, 2020
- Bieri Martin Peter: "Financial Risks in Hydropower Investments in Southeast Asia – Identification, Analysis and Mitigation", AIT Bangkok, 2019

Recall Lesson 10

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

Financing Structures

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

Economic vs. Financial Analysis

Economic Analysis:

- Society's economic perspective
- Excl. taxes, tariffs, subsidies etc.
  to reflect value of project to society
- Incl. externalities (positive and negative)
  included and quantified in monetary terms
  (such as reduction in GHG emissions), if any

Financial Analysis:

- Investor's perspective
- Based on market prices
- Incl. taxes, tariffs, subsidies etc.
- Excl. externalities

Capital Structure

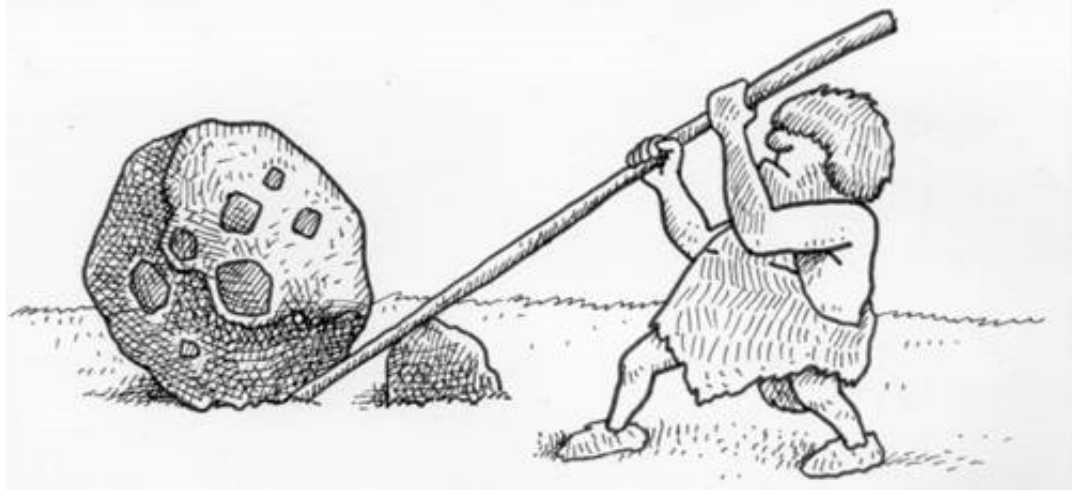
Definitions:

- **Investor = Sponsor = Owner = Borrower**
- **Lender = Bank**

- **Equity** = value of owners' stake in company
- **Debt** = borrowed money

- **Commercial banks** (UBS, HSBC, BCV etc.) lend to both individuals and businesses.
- **Development banks** (World Bank, ADB etc.) lend to governments.

- **Leverage:**
  - Use of debt to finance investments
  - Control greater amount of assets by debt
  - Increase returns on owner's investment



Capital Structure

Example:

Initial investment: USD 1’000

Weak economy: USD 900 (return -10%)
Strong economy: USD 1’400 (return +40%)

Probability weak/strong: 50%
Expected investment return:
0.5 (-10% + 40%) = 15%

Interest rate to Lenders: 10%

Financing		Weak economy			Strong economy			Expected Return
Debt	Equity	Lenders	Investors	Return	Lenders	Investors	Return	Investors
0	1000	0	900	-10%	0	1400	40%	**15.00%**
200	800	220	680	-15%	220	1180	48%	**16.25%**
500	500	550	350	-30%	550	850	70%	**20.00%**
800	200	880	20	-90%	880	520	160%	**35.00%**

- **When earnings on debt > interest rate, returns on equity rise as debt increases**
- **The larger debt-to-equity-ratio, the larger expected return to investors**
- **BUT risk grows as well! Investors in levered equity requiring higher expected return to compensate for increase in risk**

Financing Structures

Equity or Corporate Finance:

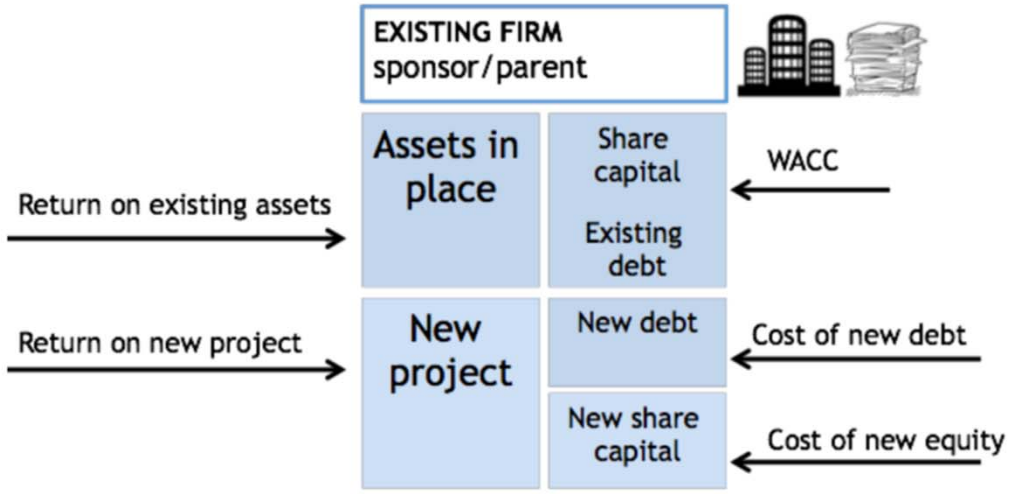
- Finance project from company's existing operation
- Investing **own funds** to develop project (equity only or unlevered equity)
- Pure equity finance rare in private infrastructure development as capital intensive and long gestation periods
- Equity investor **exposed to full risk**
- Risk exposure limited by blending equity with debt (i.e., taking a loan), as long as **interest rate of loan < IRR**
- Profitability of investment increases with higher debt-to-equity-ratio (leverage effect)

Project Finance:

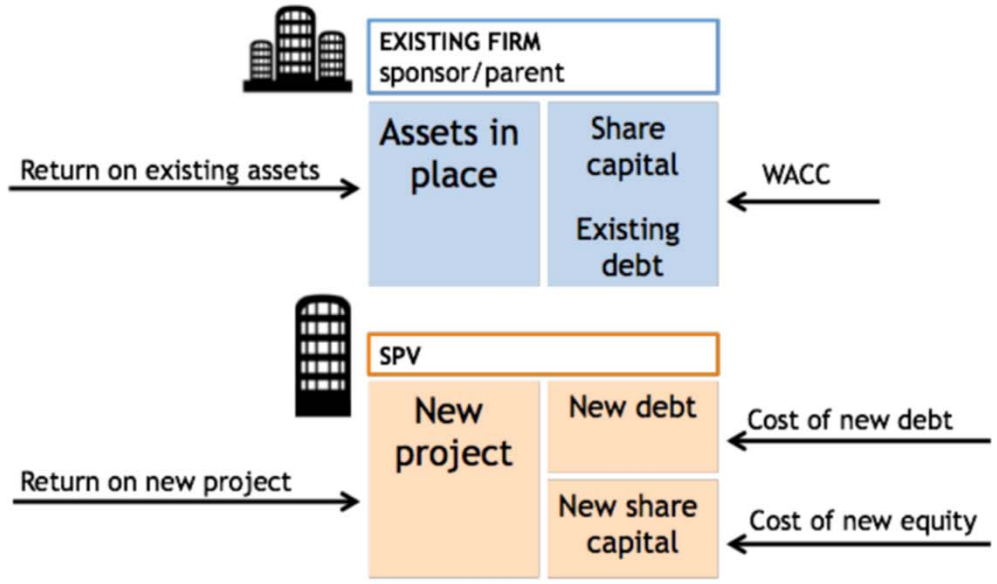
- **Special purpose entity/company** (Special Purpose Vehicle = SPV) created for each infrastructure project
- Legally independent from sponsors to shield other sponsors' assets from project failure
- Project company **no assets other than the infrastructure project**
- Capital contribution commitments by owners of project company sometimes necessary to **ensure financial soundness** of project or to **assure lenders of sponsors' commitment**
- Project financing often more complicated

Financing Structures

Equity or Corporate Finance:



Project Finance:



Discounted Cash-Flow Model

Project Finance:

- Long-term financing of infrastructure and industrial projects
- Based upon **projected cash flows** of project rather than balance sheets of its sponsors (project off-balance-sheet)
- Loan structure primarily relying on the project's cash flow for repayment, with the project's assets, rights and interests held as secondary collateral:
  - **Sponsors = Investors** providing **equity**
  - **Lenders = Banks** providing **loans**
- Non-recourse loans secured by project assets and **paid entirely from project cash flow** rather than from general assets or creditworthiness of project sponsors
- Financing typically secured by all project assets, incl. revenue-producing contracts (CA or PPA)
- Lenders given a lien on all project assets and able to assume control of project if project company difficulties complying with loan terms

Discounted Cash-Flow Model

Special Purpose Vehicle (SPV):

- Infrastructure projects often suitable for project finance, such:
  - Highways
  - Oil and gas
  - Telecom
  - Power generation (incl. hydropower)
  - …
- As a result of:
  - Long-term assets with long economic life
  - Provision of key public services
  - Strongly non-elastic demand
  - Natural monopoly or near-monopoly of market context
  - High entry barriers and regulated assets

Discounted Cash-Flow Model

Free Cash Flow to Equity (FCFE):

- Project's profitability from sponsor's perspective as well as ability to pay its obligation to lenders
- Compared to economic analysis, additional information relevant to sponsors and finance structure, depreciation and corporate income taxes
- Based on pro-forma profit/loss statement over concession period of project (construction and operation)

- Annual profit/loss based on revenues from sales, reduced by operation and maintenance (O&M) costs (including refurbishment and major revision), depreciation, interest and corporate taxes:

	Net Income
+	Depreciation
-	Capital Costs
-	Principal Repayments
+	New Debt Issued
=	**Free Cash Flow to Equity (FCFE)**

Discounted Cash-Flow Model

Indicators measuring profitability of investment and ability to produce enough cash for debt servicing (interest and loan payments) and other obligations (liquidity or solvency of project):

Profitability from sponsor's perspective:

- **FCFE Internal Rate of Return (IRR)**
- **FCFE Net Present Value (NPV)**
- Other indicators:
  - Return on Equity (ROE)
  - Payback period

Liquidity (solvency) to assess credit quality from lender's perspective:

- **Debt Service Coverage Ratio (DSCR)**
- **Loan Life Coverage Ratio (LLCR)**

Discounted Cash-Flow Model

Liquidity (solvency) to assess credit quality from lender's perspective:

- **Debt Service Coverage Ratio (DSCR)**
  as ratio of net operating income and debt services of a period

$$DSCR = \frac{Annual\ Net\ Operating\ Income}{Total\ Debt\ Service}\ [-]$$

- DSCR shall be >1.0 (break-even level)
- The higher DSCR, the less potential risk for lender

- **Loan Life Coverage Ratio (LLCR)**
  as ratio of net present value of cash flow available for debt services (CFADS, measured until maturity of debt tranche) and outstanding debt in period

$$LLCR = \frac{NPV\ of\ CFADS}{PV\ Outstanding\ Debt}\ [-]$$

- LLCR shall be >1.0 (break-even level)
- The higher LLCR, the less potential risk for lender

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Lecture WREM-L13.2: Water Management: Risk assessment

Risk Assessment

Cambambe Arch Dam, Angola
Rehabilitation and
heightening by 28 m

Risk Assessment

Risk Management =
Process of identification, analysis and acceptance or mitigation of uncertainty in investment decisions for sponsors and lenders

- Project subject to several technical, environmental, economic and political risks, particularly in developing countries and emerging markets
- Sponsors/lenders may conclude that risks inherent in project development and operation unacceptable (unfinanceable)

- Project finance to be distributed among multiple parties to distribute risk associated with project while simultaneously ensuring profits for each party involved
- Long-term contracts (e.g., construction, supply, off-take and concession agreements) along with a variety of joint-ownership structures = align incentives

Risk Assessment

Methods of Risk Management:

- **Risk Avoidance:** avoiding high-risk activities which could result in catastrophic impacts on project finances
(e.g., speeding, smoking)
- **Risk Retention:** assuming risks and choosing not to mitigate them at all
(e.g., forgoing long-term care insurance)
- **Risk Reduction:** (loss prevention and control) minimizing risk
(e.g., installation of smoke alarms)
- **Risk Sharing:** assuming limited degree of manageable risk and transferring risks to one or more organizations
(e.g., medical insurance)
- **Risk Transfer:** transferring risk to a third-party in consideration of an insurance premium
(e.g., life, disability, liability insurances)

Risk Assessment

Methods of Risk Management for Infrastructure Development:

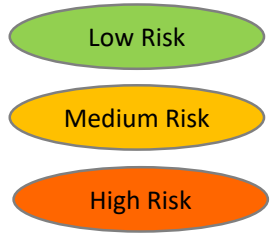
- **Design criteria and employer's requirements**
- **Contingency provision**
- **Transfer of risks** (suppliers, contractors, off-takers)
- **Insurance** (general and product liability insurances contract)

- **Acceptance** (taken by owner):
  - Detailed studies quantifying certain risks, e.g. climate change, energy price forecasts, hydrological variability etc.
  - Sensitivity analysis to assess economic and financial viability
  - Training of O&M staff and procedures
  - Monitoring system for early detection of irregularities
  - Automatization of critical components reducing risks of human failure
  - Spare parts to reduce replacement time

Risk Assessment

Project Finance:

- **Preparation of discounted cash-flow model** and calculation of the economic/financial performance parameter (such as the NPV) of the baseline scenario
- Elaboration of **project-specific register of uncertainties**
- Preliminary **impact assessment** of each uncertainty of project-specific register:
  - clearly significant
  - possibly significant
  - probably insignificant

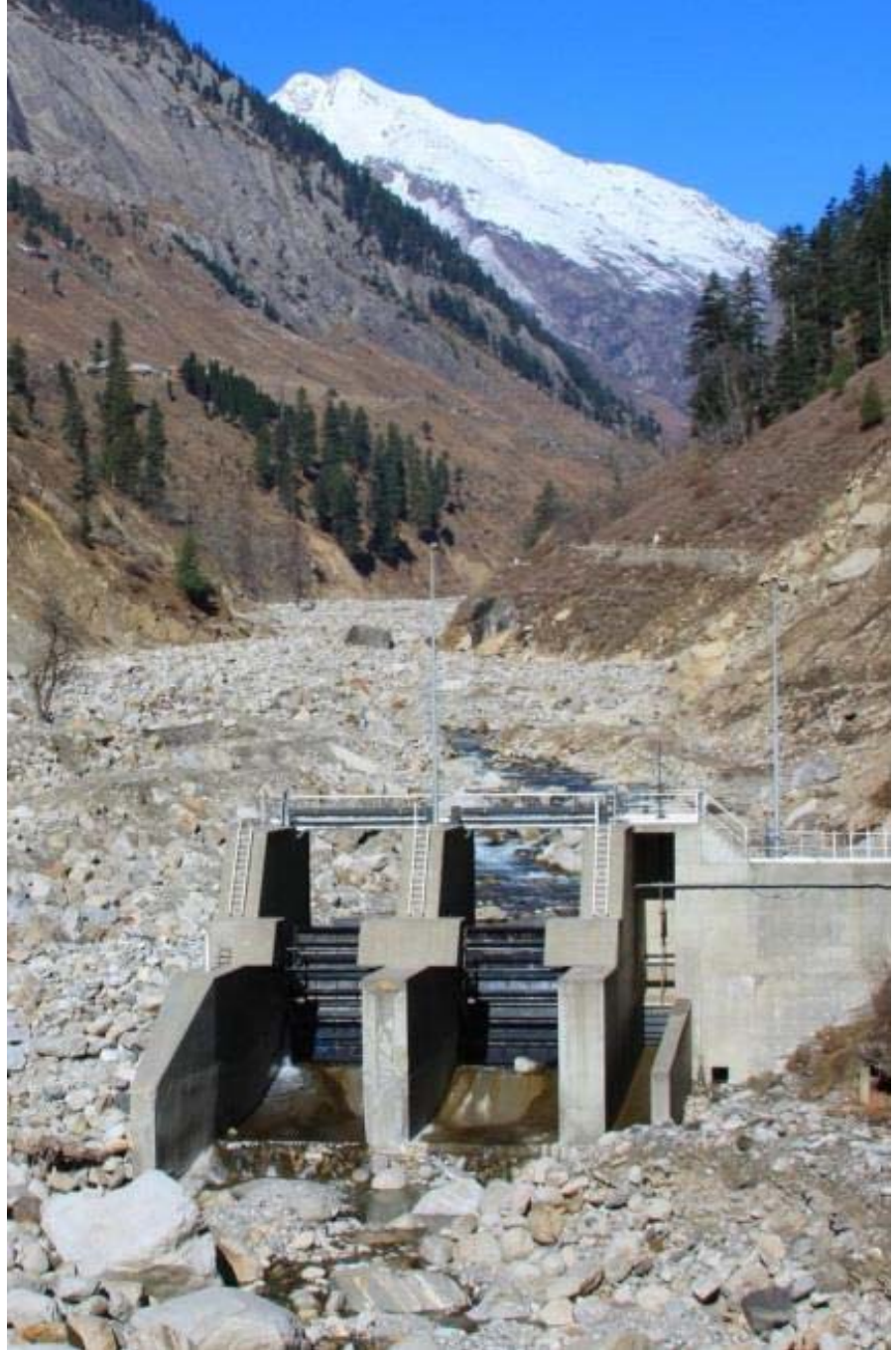


- In-depth studies on **uncertainties with significant impact**
- Estimating probability of occurrence of uncertain event during economic lifetime
- Estimating **impact or consequence** of uncertain event
- Calculation of **risk-adjusted economic/financial performance parameter** (such as risk-adjusted NPV)

Risk Assessment

Specific Risks to Hydropower Projects:

- **Site specific design**: design according to specific hydrological, geological and topographic conditions
- **Remote areas**: usually exposed to natural hazards (floods, seismicity, landslides etc.) with limited/difficult access
- High civil work content, incl. associated risks, making **cost prediction difficult**
- **Variations in water resources** (hydrological risk), leading to uncertainties in energy production due to natural fluctuations



PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

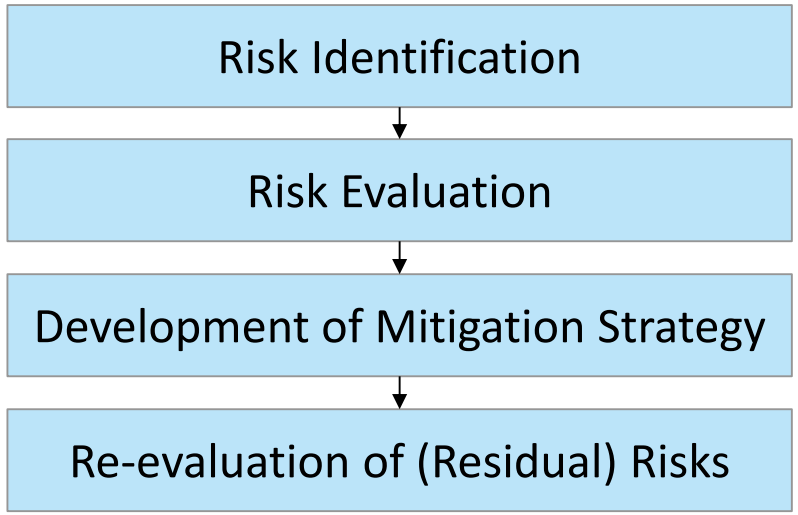
Risk Assessment

Construction risk:

- Risks occurring prior to start of operation, usually during project construction

Operational risk:

- Risks occurring after commissioning of project



Risk Assessment

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Variations

Variations in cost and time are very common (likely), especially in large hydropower projects.

It is common practise to cover these items by **contingency provision** (in monetary terms) and by a **float** in the construction schedule.

Contingency / Float

Power worries grow as Snowy 2.0 finish date blows out

Angela Macdonald-Smith
Senior resources writer

Updated May 3, 2023 – 5.46pm, first published at 8.10am

Save Share

A further two-year delay in the troubled Snowy 2.0 project in NSW has triggered warnings about potential blackouts and higher prices as coal power plants retire, and stoked fresh worries that Australia's energy transition will take longer and cost more than anticipated.

Federal government-owned Snowy Hydro advised on Wednesday that the 2000-megawatt pumped hydro storage project in NSW may not be fully online until the end of 2029. It will also see another blowout in its already revised $5.9 billion budget, with no figure put on the final cost.

The news revived speculation that pending closures of coal power stations in NSW over the next few years, starting with Origin Energy's Eraring targeted for August 2025, will need to be put back to keep electricity supplies secure and reliable.

FINANCIAL REVIEW

Risk Assessment

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Uncertainties

Uncertain events are generally foreseeable and their impact on the project can be assessed.

The main uncertainties and risks in a hydropower project are for instance:
hydrology (accuracy inflow)
geology (time/cost overrun),
failure of equipment etc.

Risk Assessment

Functionnal entity Hazard	Characteristics, Consequences 1	Consequences 2	Likelihood	Consequences	Risk level	Mitigation measures	Likelihood	Consequences	Risk level
Catchment area									
Low inflow in winter	less generation	economic losses	2	2		update hydrology with the most recent data	1	2	
Higher flood than foreseen	overflow of the protecting dykes, inundation	damage to houses, weir and intake	3	3		update hydrology with the most recent data	1	3	
Inefficiency of ice blocking dams	obstruction or damage of the intake structure	lower production, economic losses	2	2		rely on the experience of the local operator	1	2	
Sediment transport	obstruction or damage of the intake structure	lower production, economic losses	2	3		regular flushing	1	1	
Higher turbidity	too frequent desander cleaning, abrasion of turbines	economic losses	3	3		perform sampling and testing to design the desilting facility	2	2	
Slope instability upstream	formation of a natural dam, collapse,sudden flow	overflow of the protecting dykes, inundation, damage to the weir and intake, accumulation of sediments in the reservoir	3	4		geological survey to assess the hazard	3	4	
GLOF	sudden flow	overflow of the protecting dykes, inundation, damage to the weir and intake, accumulation of sediments in the reservoir	3	4		geological survey to assess the hazard	3	4	
Weir and intake									
Inapropriate diversion design	construction site overflow, high seepage, underestimated presence of boulders	high pumping costs, delays in construction, costs increase	3	3		additional geological survey, detailed diversion design	2	2	
Inapropriate hydraulic design	sediment accumulation, erosion LB D/S, reduced flood evacuation capacity	frequent sluicing, protection of banks	3	2		design modification, hydraulic design improved, numerical model	1	2	
Inapropriate structural design	seepage and uplift pressures, compromised stability in staic and dynamic conditions	cracks, settlements, displacements, high maintenance costs	3	4		appropriate design, design improvement and calculation	2	2	
Inapropriate desilting facility	frequent cleaning, frequent outages, debris accumulation	abrasion of turbines, economic losses	3	3		perform sampling and testing to design the desilting facility, integrate flushing, consider 2 basins	2	2	
Headrace pipe									
Adverse local geological conditions	construction time extension	cost increase	3	3		complementary geological investigations, complementary design alternatives	2	2	
Inapropriate gully crossing	rupture of the pipe	repair works, economic losses	3	4		appropriate design	2	2	
Erosion of the river banks	local instability, rupture of the pipe	repair works, economic losses	3	4		appropriate design	2	2	
Landslide	rupture of the pipe	repair works, economic losses	3	4		additional investigations, consider steel pipe with deformation absorbing elements	2	2	
Surge Arrangement									
Adverse geological and topographic conditions	construction delays, construction cost increase		4	4		additional investigations, appropriate design	2	2	

Risk Assessment

Cathastrophic Events

Catastrophic events are very rare events and are often not covered in the risk assessment.

For large projects addressed in the design criteria to withstand certain catastrophic impacts, and not to fail due to catastrophic events.

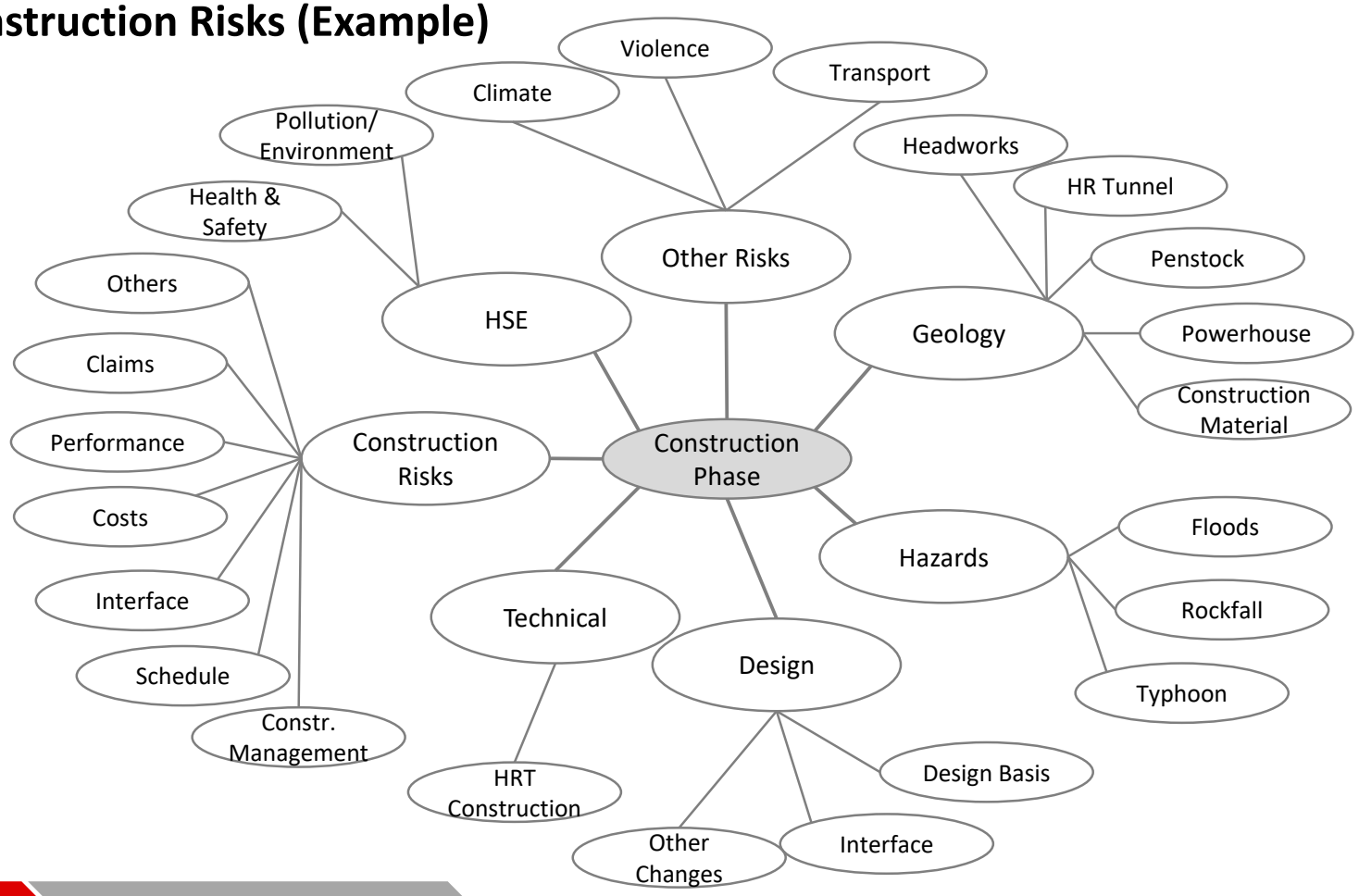
Design Criteria


Oroville Dam, USA, Accident 2017


Palagnedra Dam, Switzerland, 1978

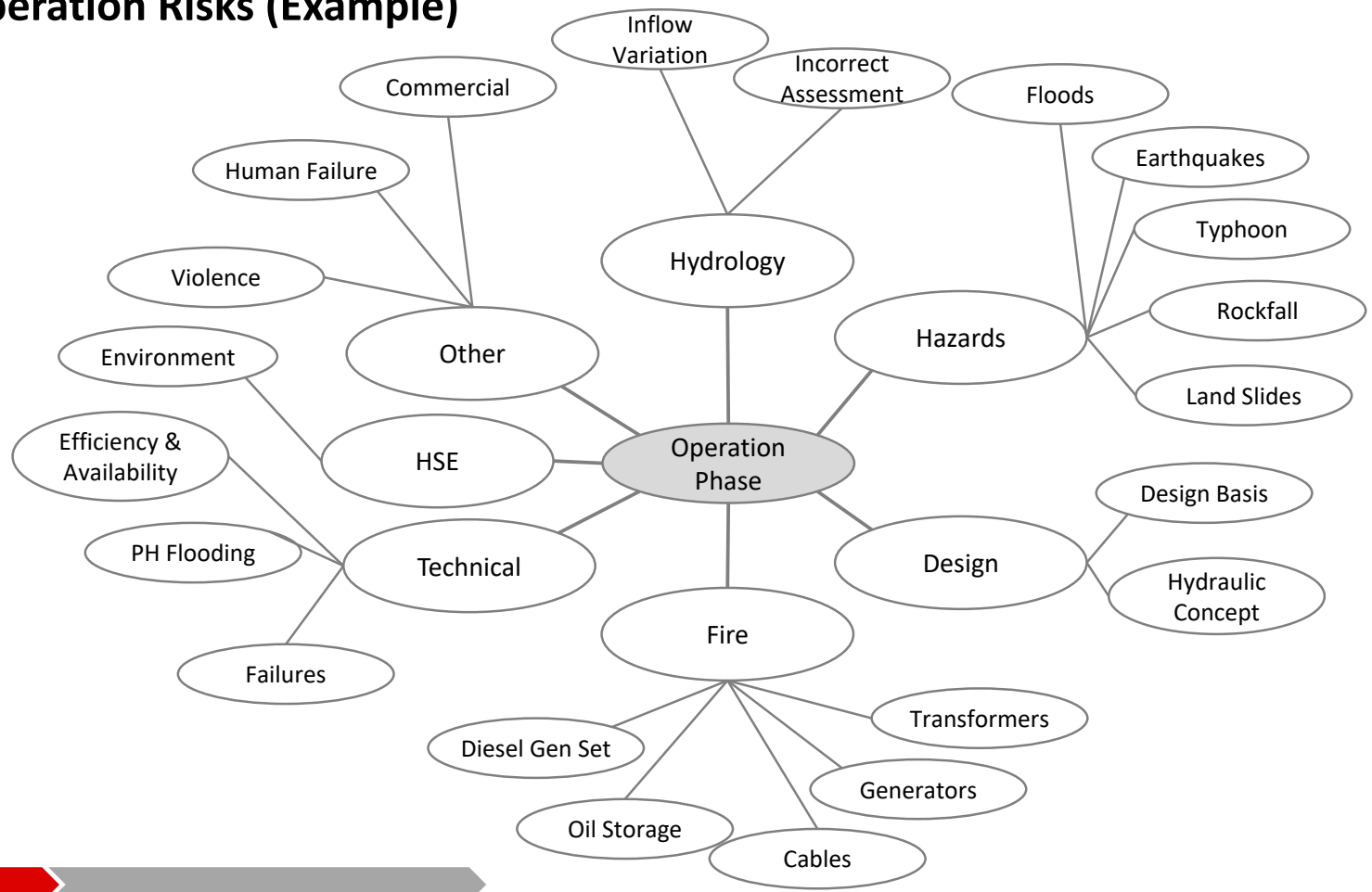
Risk Assessment

Identification of Construction Risks (Example)



Risk Assessment

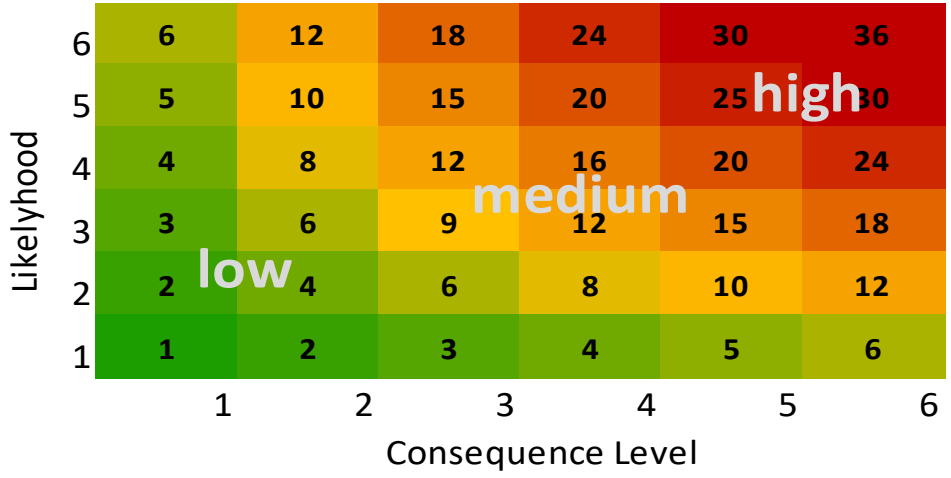
Identification of Operation Risks (Example)



Risk Assessment

Risk Scores and Definition of Risk Levels

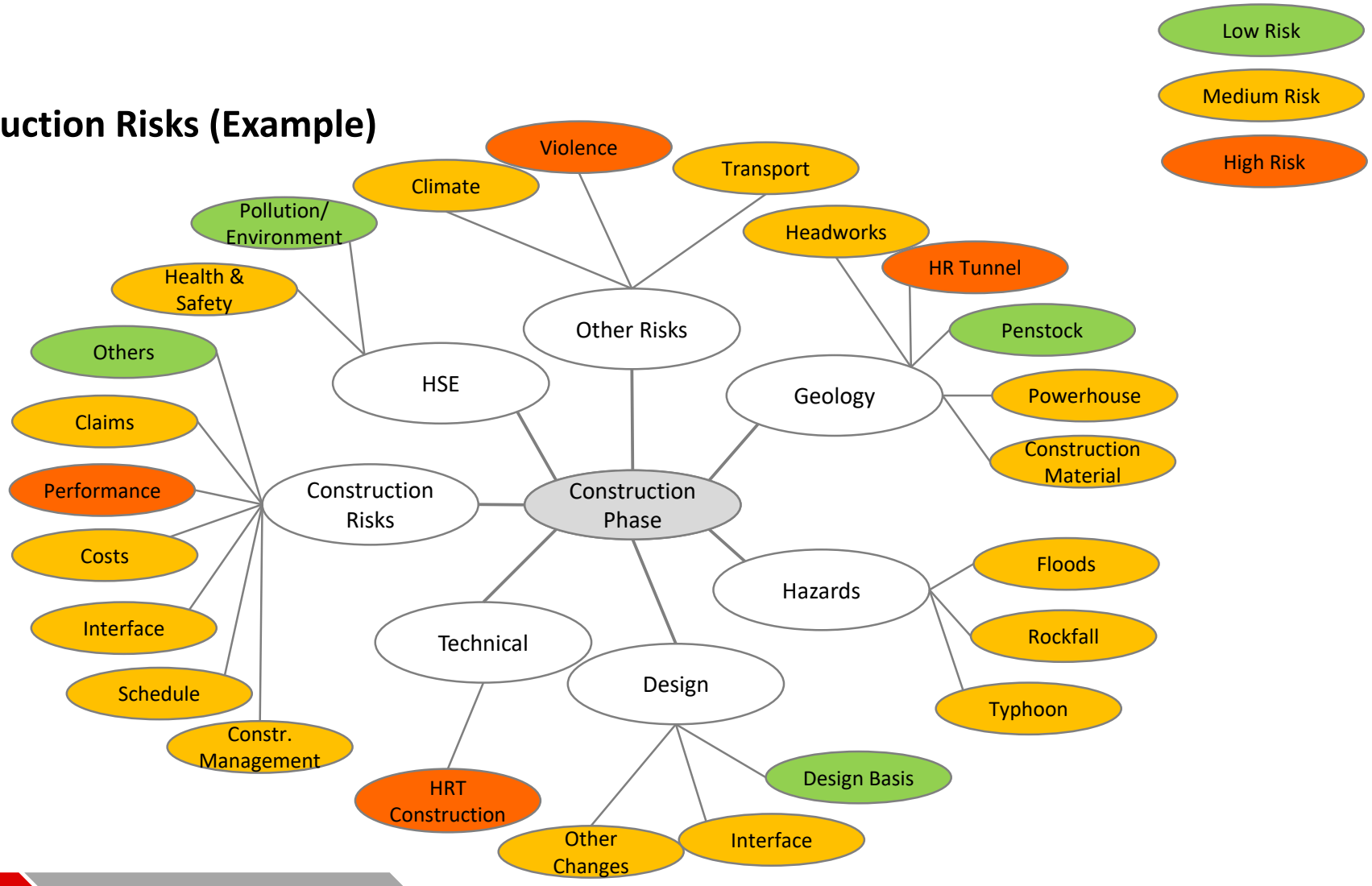
Product of consequence and likelihood:



Risk Score	Risk Level
1-6	Low Level Risk
7-15	Medium Level Risk
16-36	High Level Risk

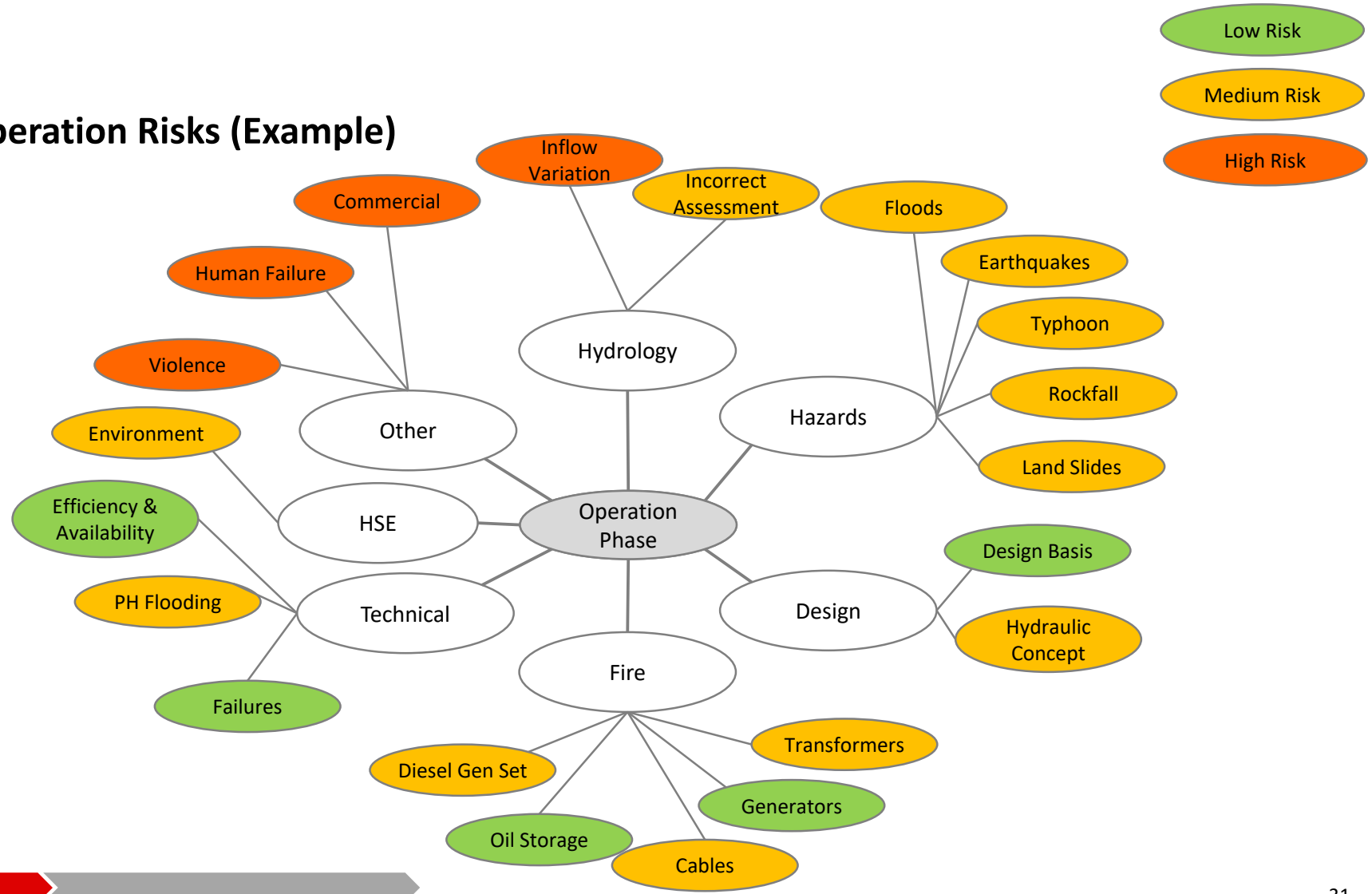
Risk Assessment

Evaluation of Construction Risks (Example)



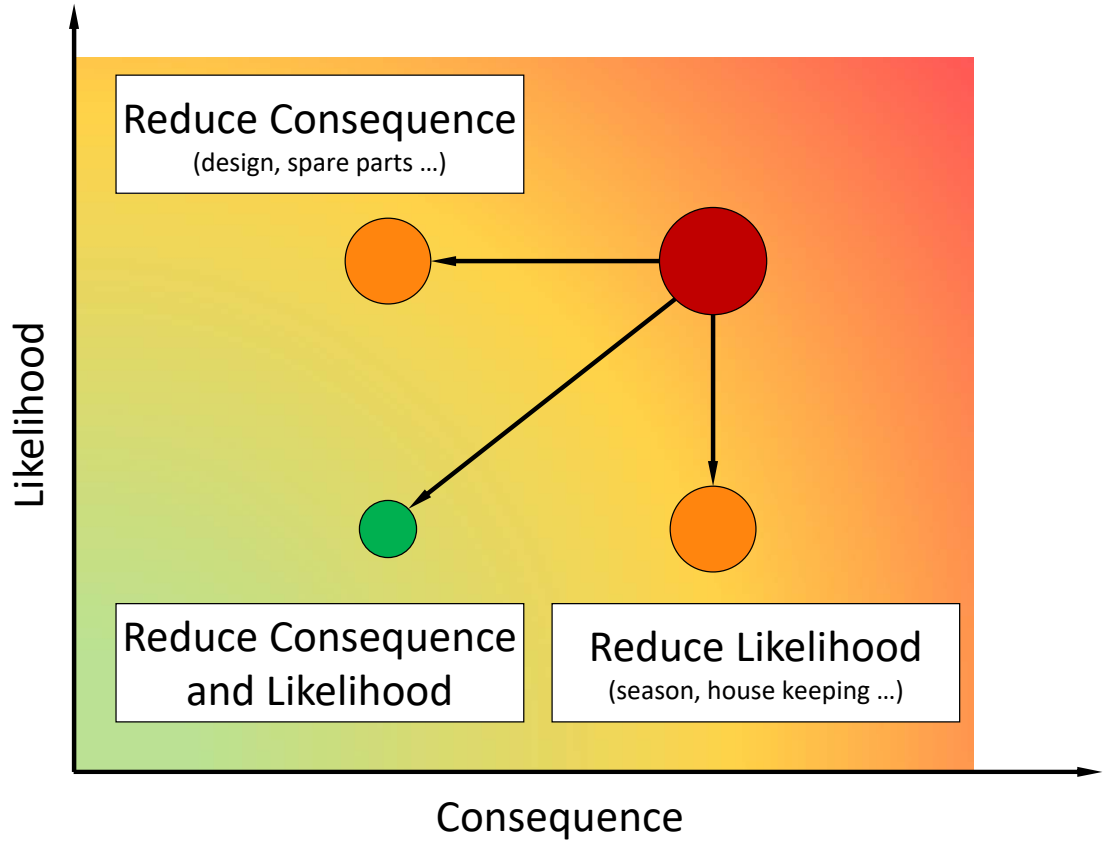
Risk Assessment

Identification of Operation Risks (Example)



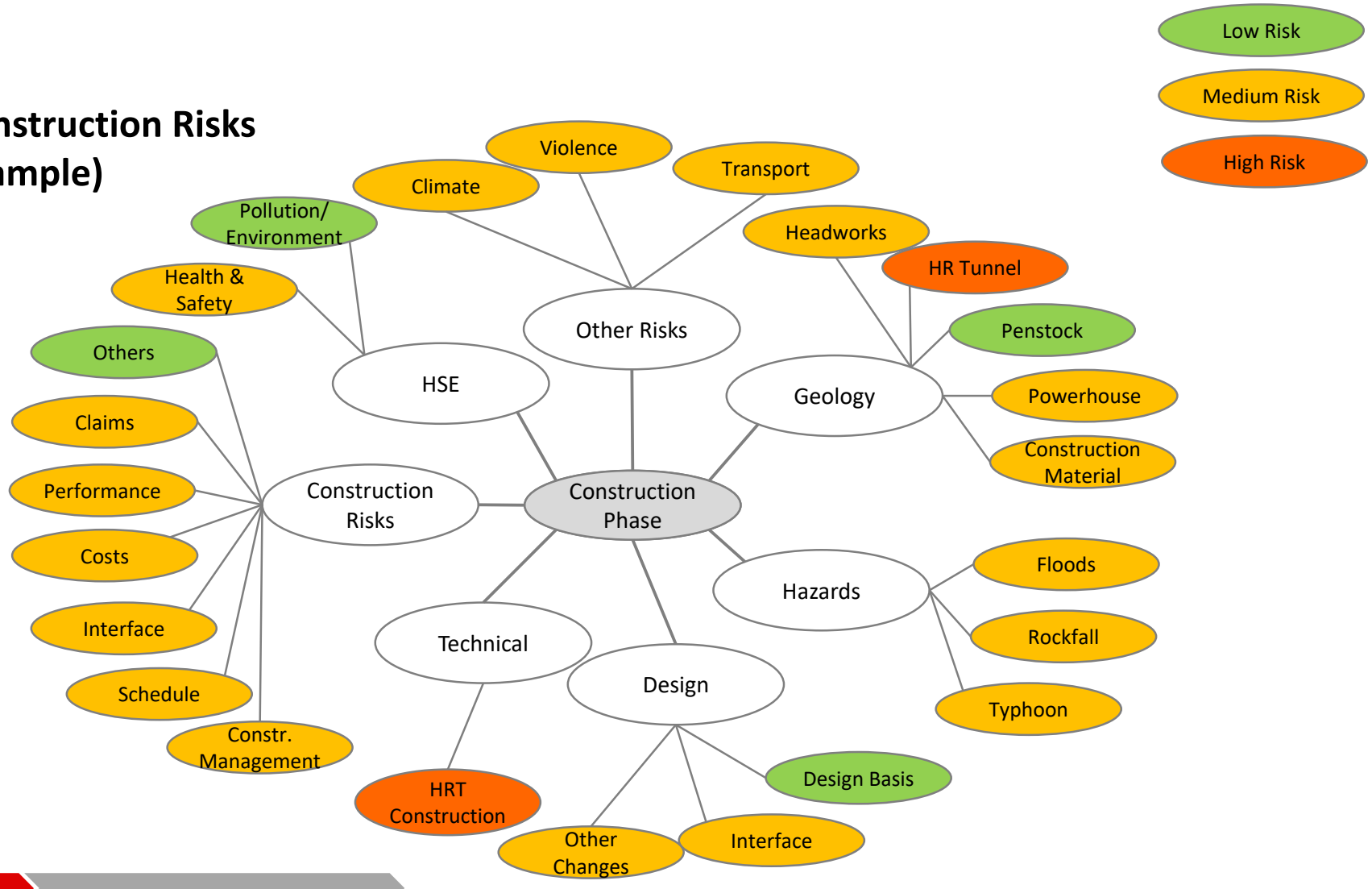
Risk Assessment

Risk Mitigation



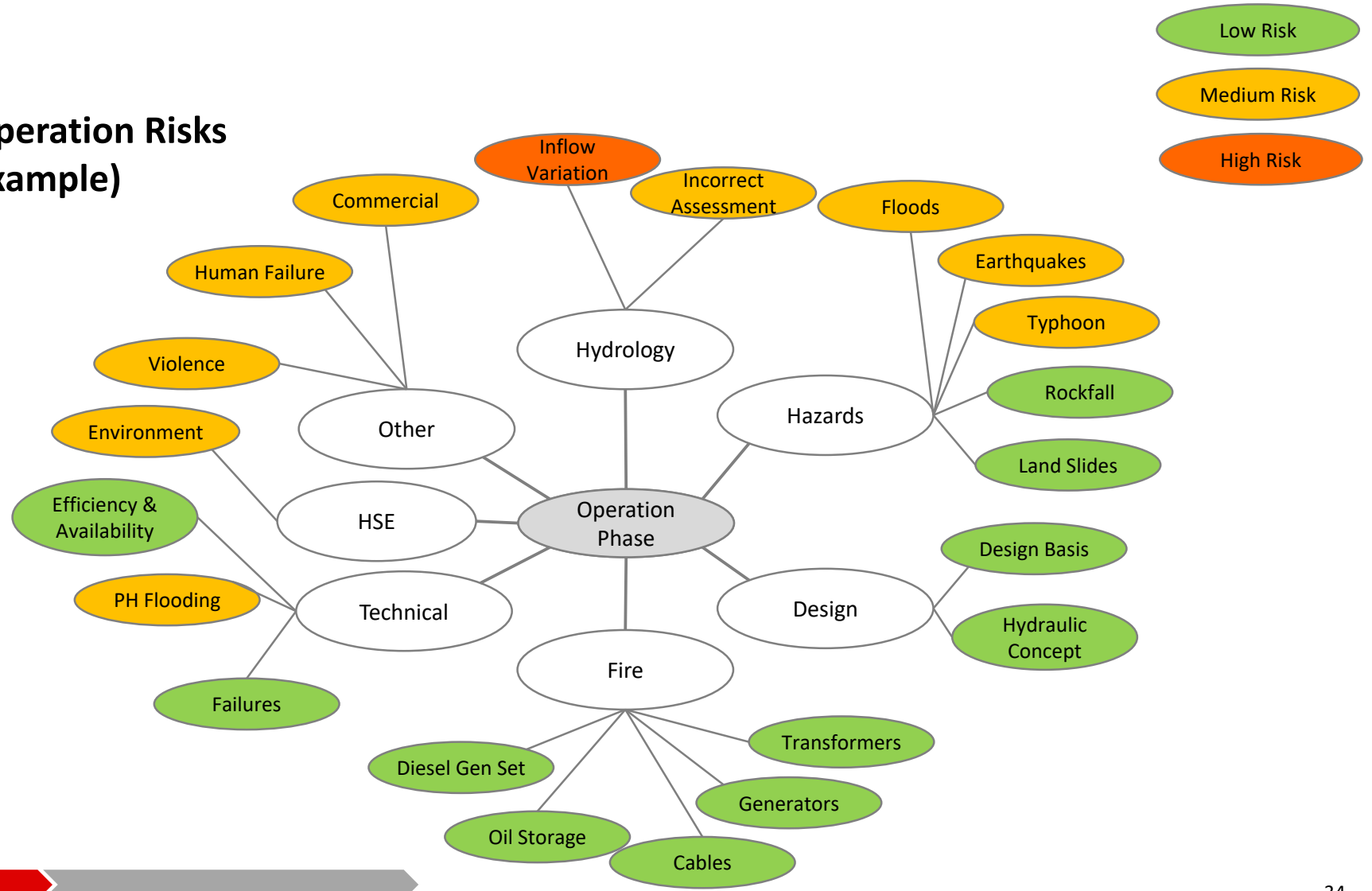
Risk Assessment

Re-evaluation of Construction Risks after Mitigation (Example)



Risk Assessment

Re-evaluation of Operation Risks after Mitigation (Example)



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Lecture WREM-L13.3: Water Management: Risk assessment – case study

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:

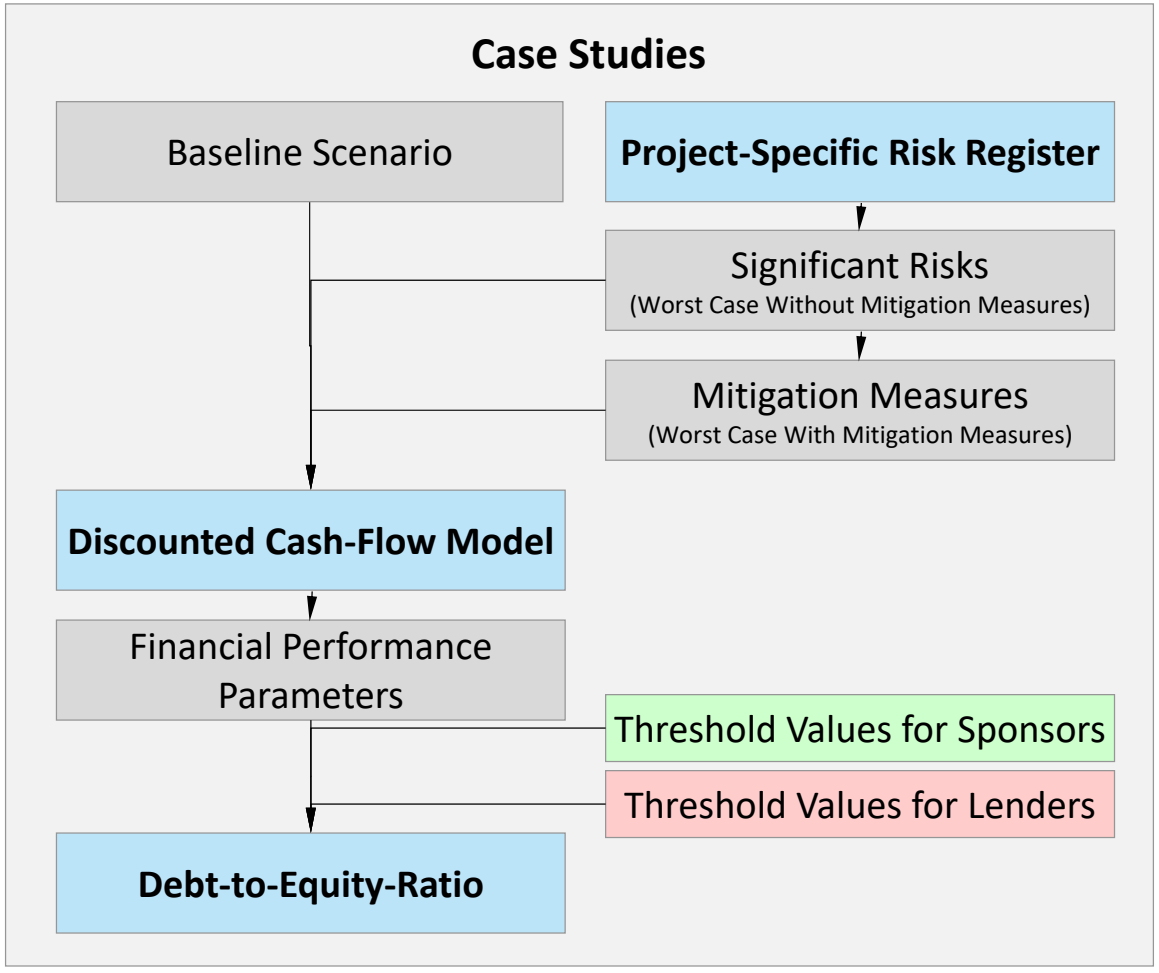
- **Market assessment**: Models to assess/predict progression, stagnation and regression
- **Market sector analysis**: Assessment of type and nature of competition

→ 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: Approach



Case Study Hydropower: Case Studies

Case Study 1

Two existing assets

114 MW, Lao PDR

Chinese contractor
Chinese equipment

Commissioned
in 2015 and 2016

27-y PPA with EDL

Developer to divest majority share to an investor

Case Study 4

Under development

270 MW, Philippines

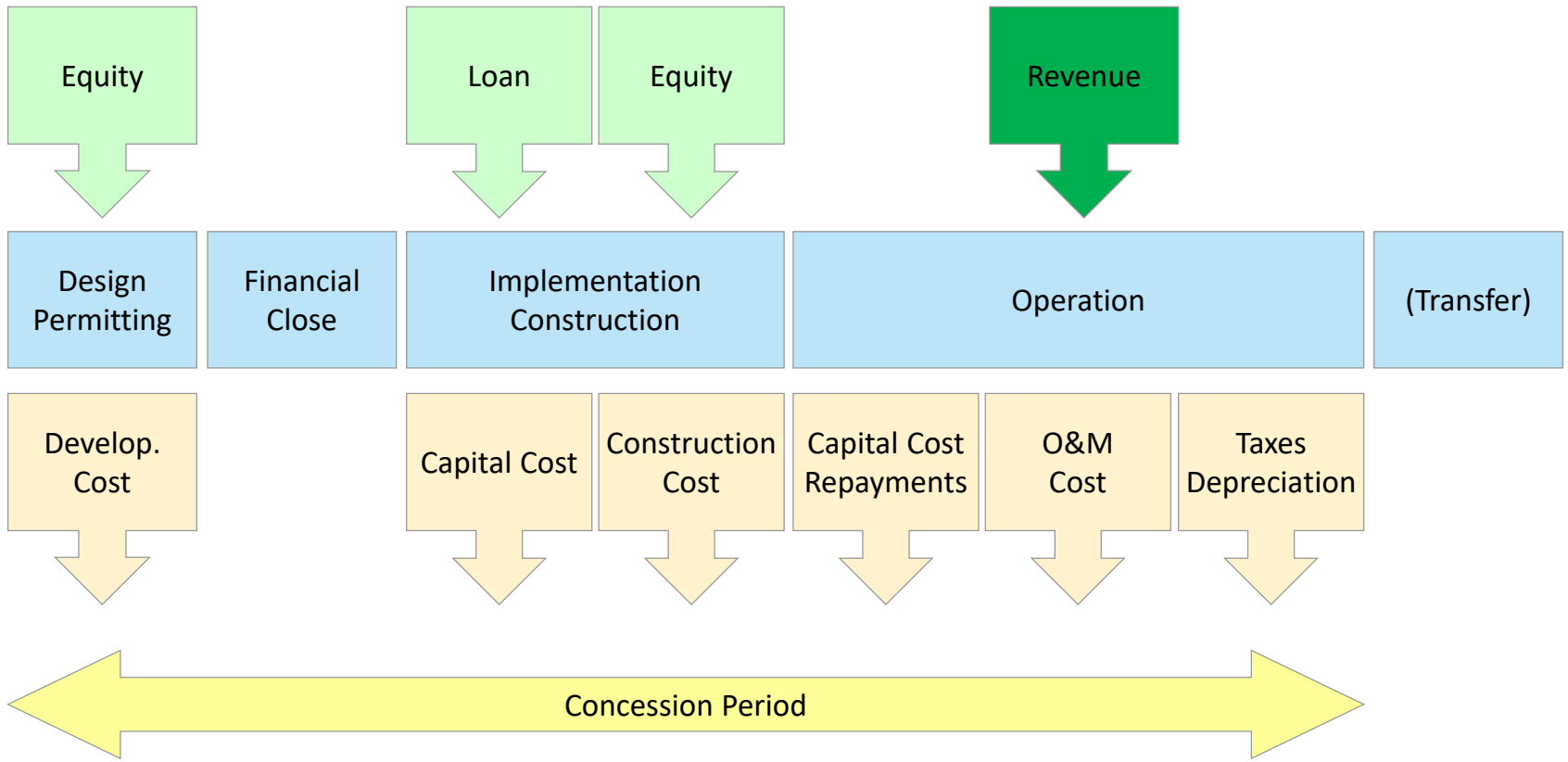
Chinese contractor
Western equipment

To be commissioned
in 2027

Spot market (WESM)

High equity required by Filipino commercial banks

Case Study Hydropower: Cash Flows



Case Study Hydropower: Cash Flows

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Sponsor's vs. Lender's Perspective

- Indicators measuring profitability of the investment and ability to produce enough cash for debt servicing (interest and loan payments) and other obligations (liquidity or solvency of project)

- Profitability of project from **sponsor's perspective**:

  Internal Rate of Return (FCFE IRR)
  = measure of investment profitability

- Liquidity (solvency) of project analysing credit quality of project from **lender's perspective**:

  Debt Service Coverage Ratio (DSCR)
  = ratio of net operating income and debt services of a period

Case Study Hydropower: Case Studies

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Installed Capacity:	240	MW	**Total Costs (without IDC)**	**362**	**mUSD**		
Annual Energy	1'311	GWh	**Total Costs (with IDC):**	**398**	**mUSD**	**(CAPEX)**	
Average Gross Revenue:	105.00	m USD					
Construction Period:	3	years					
Operating Period:	25	years					
NPV Discount Rate:	8.0%						
Rate of Price Increase:	2.0%						
Depreciation Period:	20	years					
Taxes:	10%						
Tax Holidays:	7	years					

Sponsors		
Equity:	30%	
Equity:	119	mUSD
FCFE IRR:	**16.4%**	
Financial NPV:	170	mUSD
Payback Period:	8	years
ROE:	**37.0%**	

Lenders			
Debt:	70%		
Interest on Debt:	5.0%		
Loan Maturity:	8	years	
	Average	Min	Max
DCR:	**1.12**	**0.80**	**1.46**
LLCR:	**1.15**	**0.95**	**1.33**

Year	Total O&M Costs	Capital Costs	Total Costs	Revenues	New Debt Issued	Outstanding Loan (start)	Interest on Loan	Principal Repayments (Payoff Loan)	Outstanding Loan (end)	Depreciation	Gross Income	Taxes & Royalties	Net Income	Free Cash Flow to Equity (FCFE)	FCFE cumulated	FCFE Discounted	FCFE Discounted cumulated	Discount factor	Return on Equity (ROE)	Debt Coverage Ratio (DCR)	CFADS	NPV(CFADS)	Loan Life Coverage Ratio (LLCR)
	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[mUSD]	[-]	[%]	[-]	[mUSD]	[mUSD]	[-]
-3.5		39.82	39.82		28.56	27.87	0.69		28.56					-11.26	-11.26	-11.26	-11.26	1.00					
-3		59.72	59.72		45.33	70.37	3.52		73.89					-14.40	-25.66	-13.33	-24.59	0.93					
-2		99.54	99.54		76.86	143.56	7.18		150.74					-22.68	-48.34	-19.45	-44.04	0.86					
-1		119.45	119.45		95.33	234.36	11.72		246.07					-24.12	-72.46	-19.14	-63.18	0.79					
0		79.63	79.63		70.83	301.82	15.09		316.91					-8.80	-81.26	-6.47	-69.65	0.74					
1	5.59		5.59	49.86		316.91	15.85	39.61	277.30	19.91	8.52		8.52	-11.19	-92.44	-7.61	-77.26	0.68	-9%	0.80	44.27	300.68	0.95
2	5.79		5.79	53.64		277.30	13.86	39.61	237.68	19.91	14.07		14.07	-5.63	-98.07	-3.55	-80.81	0.63	-5%	0.89	47.85	280.46	1.01
3	5.88		5.88	54.51		237.68	11.88	39.61	198.07	19.91	16.83		16.83	-2.87	-100.94	-1.67	-82.48	0.58	-2%	0.94	48.63	255.05	1.07
4	6.24		6.24	62.14		198.07	9.90	39.61	158.45	19.91	26.09		26.09	6.38	-94.56	3.45	-79.04	0.54	5%	1.13	55.90	226.82	1.15
5	6.35		6.35	63.48		158.45	7.92	39.61	118.84	19.91	29.30		29.30	9.59	-84.97	4.80	-74.24	0.50	8%	1.20	57.13	189.07	1.19
6	6.38		6.38	62.86		118.84	5.94	39.61	79.23	19.91	30.63		30.63	10.92	-74.04	5.06	-69.18	0.46	9%	1.24	56.48	147.07	1.24
7	6.50		6.50	64.45		79.23	3.96	39.61	39.61	19.91	34.08		34.08	14.37	-59.67	6.16	-63.01	0.43	12%	1.33	57.95	102.36	1.29
8	6.68		6.68	67.36		39.61	1.98	39.61	0.00	19.91	38.79	3.88	34.91	15.21	-44.46	6.04	-56.97	0.40	13%	1.46	56.80	52.60	1.33
9	6.91		6.91	71.71						19.91	44.90	4.49	40.41	60.31	15.85	22.18	-34.80	0.37	50%				
10	6.96		6.96	71.46						19.91	44.59	4.46	40.13	60.04	75.89	20.44	-14.36	0.34	50%				
11	7.10		7.10	73.31						19.91	46.30	4.63	41.67	61.58	137.47	19.41	5.06	0.32	52%				
12	7.22		7.22	74.75						19.91	47.63	4.76	42.86	62.77	200.24	18.32	23.38	0.29	53%				
13	7.30		7.30	75.38						19.91	48.17	4.82	43.35	63.26	263.50	17.10	40.48	0.27	53%				
14	7.53		7.53	79.34						19.91	51.91	5.19	46.72	66.63	330.13	16.67	57.15	0.25	56%				
15	7.61		7.61	79.79						19.91	52.28	5.23	47.05	66.96	397.09	15.51	72.66	0.23	56%				
16	24.27		24.27	79.97						19.91	35.79	3.58	32.21	52.12	449.20	11.18	83.85	0.21	44%				
17	7.75		7.75	79.82						19.91	52.17	5.22	46.95	66.86	516.06	13.28	97.13	0.20	56%				
18	7.81		7.81	79.82						19.91	52.09	5.21	46.88	66.79	582.86	12.29	109.41	0.18	56%				
19	7.88		7.88	79.79						19.91	52.00	5.20	46.80	66.71	649.57	11.36	120.78	0.17	56%				
20	7.96		7.96	79.99						19.91	52.12	5.21	46.91	66.81	716.38	10.54	131.31	0.16	56%				
21	8.03		8.03	79.83							71.80	7.18	64.62	64.62	781.00	9.44	140.75	0.15	54%				
22	8.10		8.10	79.80							71.70	7.17	64.53	64.53	845.53	8.72	149.47	0.14	54%				
23	8.17		8.17	79.75							71.58	7.16	64.42	64.42	909.96	8.06	157.54	0.13	54%				
24	8.25		8.25	79.94							71.68	7.17	64.52	64.52	974.47	7.48	165.02	0.12	54%				
25	26.72		26.72	79.93							53.20	5.32	47.88	47.88	1022.35	5.14	170.15	0.11	40%				

Case Study Hydropower: Cash Flows

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Threshold Values

- Criteria to allow for decision-making depending on competition, energy market regulation, political system, alternative investment opportunities, experience or investment guidelines of sponsor/lender etc.
- Author's experience from hydropower project development in Southeast Asia:

From **sponsor's perspective** :	**Internal Rate of Return (IRR)**
FCFE IRR > 12%	for Baseline Scenario
FCFE IRR > 10%	for the Worst Case Scenario With Mitigation
From **lender's perspective** :	**Debt Service Coverage Ratio (DSCR)**
Minimum DSCR > 1.2	for Baseline Scenario
Minimum DSCR > 1.0	for the Worst Case Scenario With Mitigation

- Debt-to-equity-ratio allowing for the highest FCFE IRR and fulfilling the above lending criteria (**How much a hydropower project allows borrowing?**)

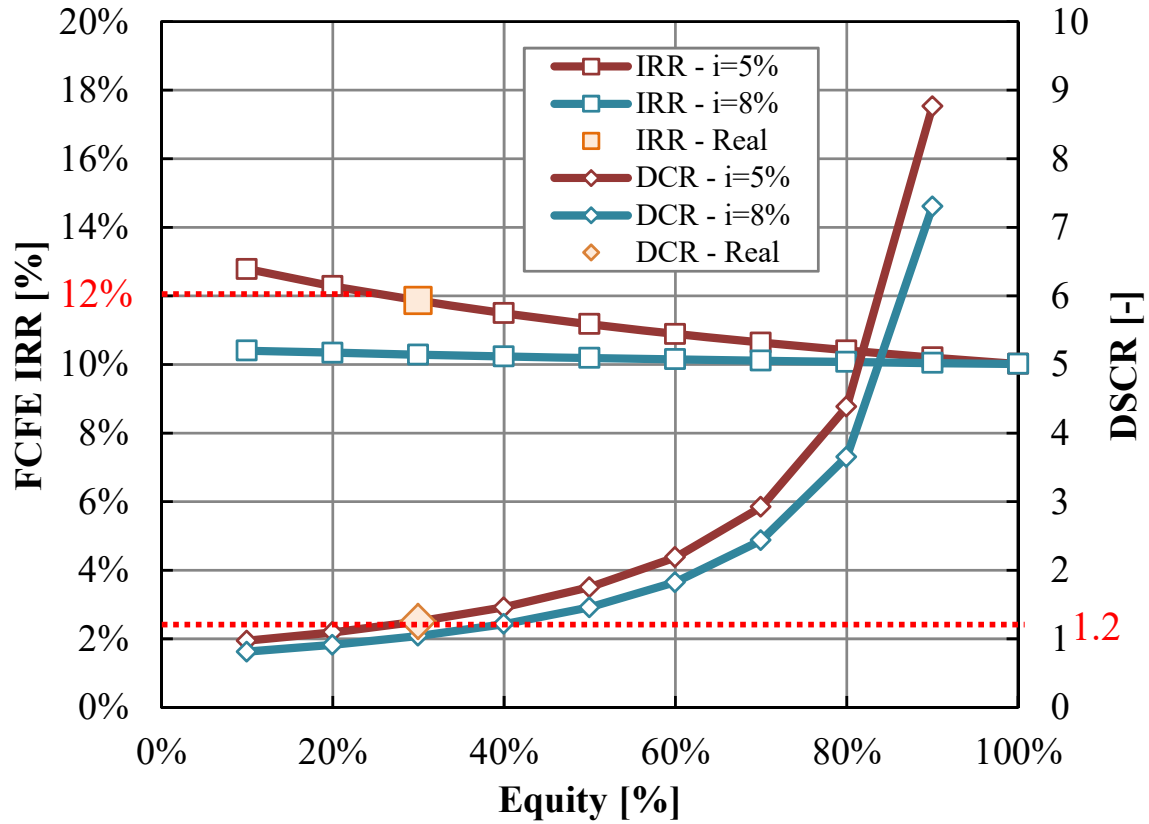
Case Study Hydropower: Cash Flows

Baseline Scenario

Parameter	Unit	Case Study 1	Case Study 2
CAPEX/Assets	MUSD	239.0	398.2
Average Annual Revenue	MUSD	33.3	72.1
OPEX	MUSD	5.3	8.6
Construction Period	years	built	3
Remaining Operating Period	years	24 of 27	25
Equity	%	30%	30%
Debt	%	70%	70%
Interest on Debt	%	5%	5%
Loan Maturity	years	10	8
FCFE IRR	%	**11.9%**	**16.4%**
DSCR – Minimum	-	**1.3**	**0.80**

Case Study Hydropower: Cash Flows

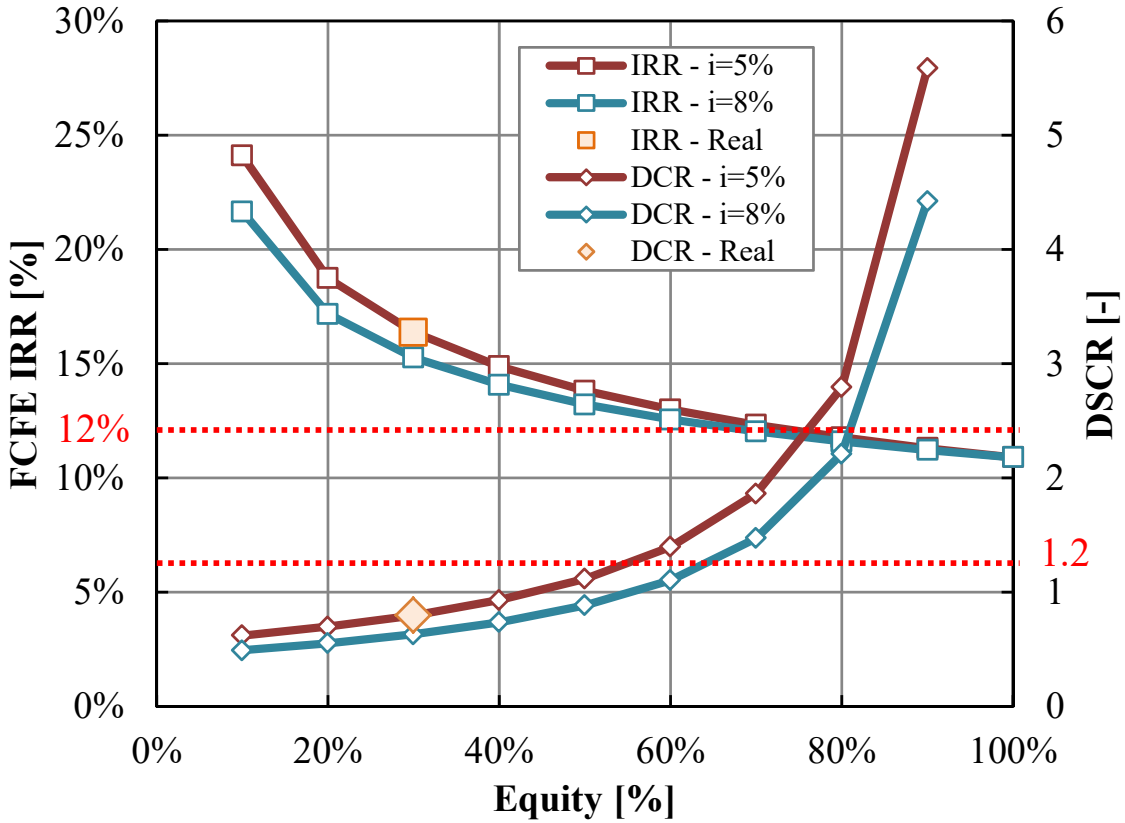
Debt-to-Equity-Ratio for Case Study 1 (Baseline Scenario)



→ Reasonable profitability for sponsors, acceptable for lenders

Case Study Hydropower: Cash Flows

Debt-to-Equity-Ratio for Case Study 2 (Baseline Scenario)



→ High profitability for sponsors, not acceptable for lenders

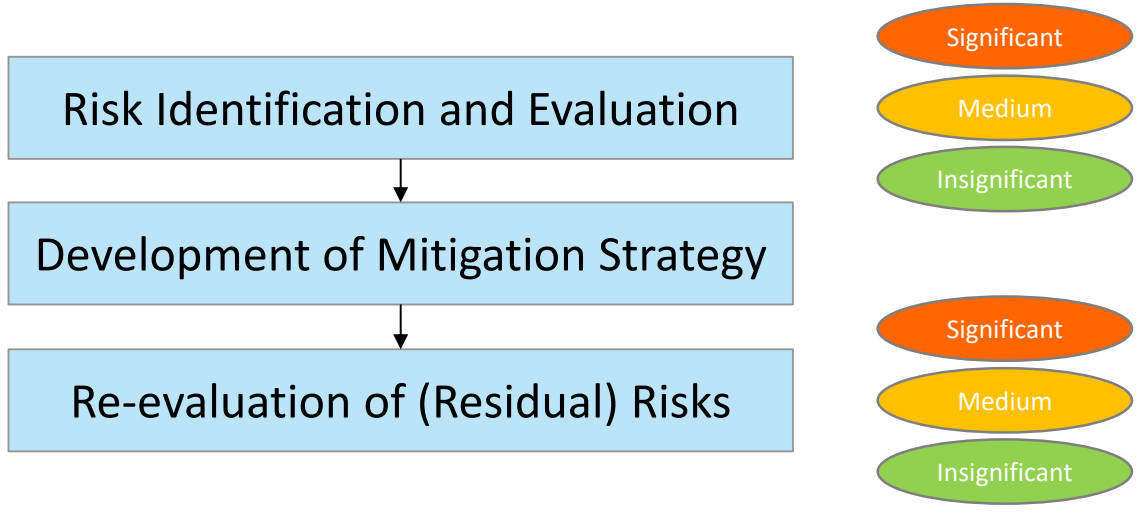
Case Study Hydropower: Risk Assessment

Construction and Completion Risks

- Risks which can occur prior to start of operation, usually during the construction of the power plan

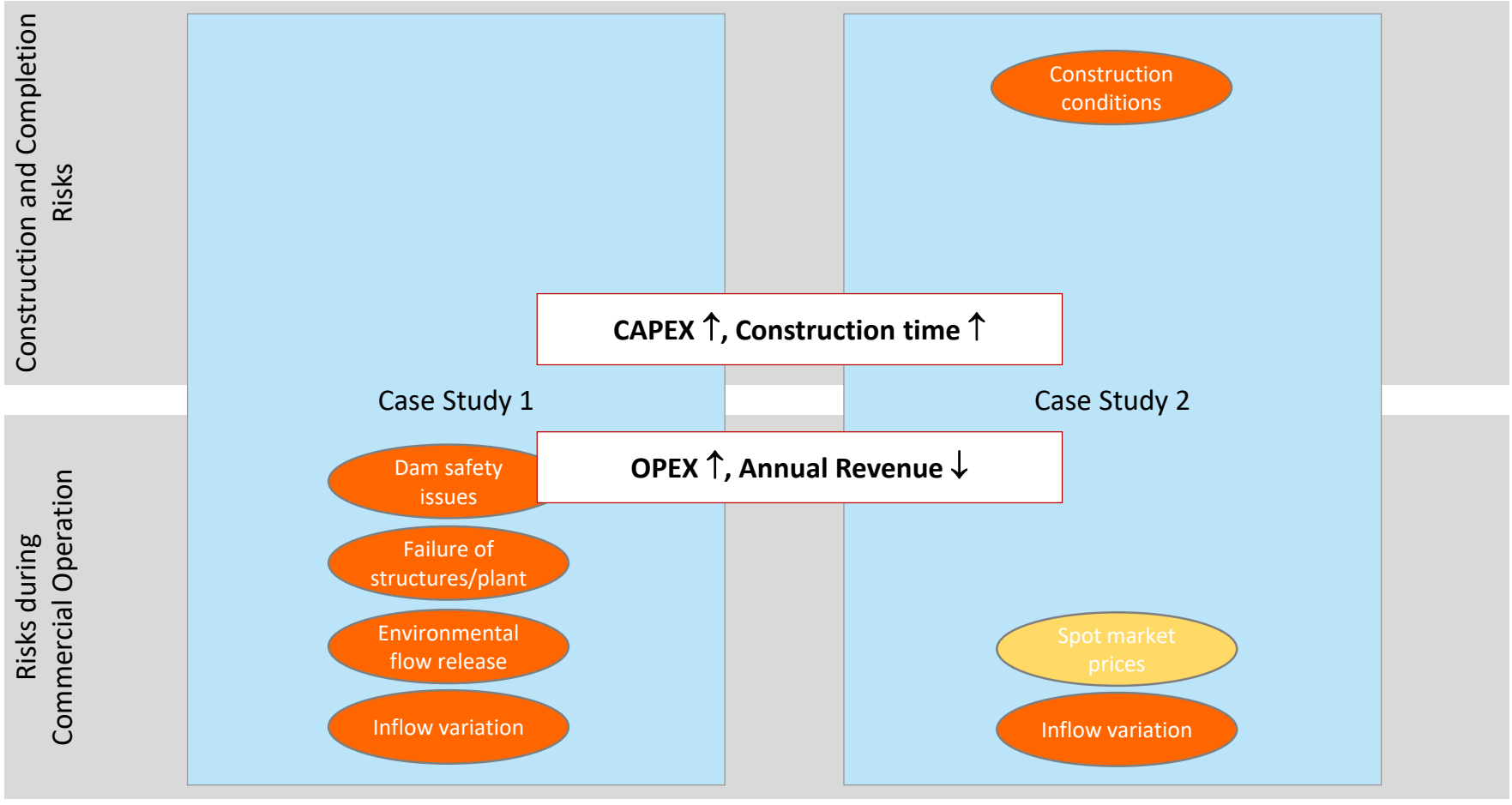
Risks during Commercial Operation

- Risks which can occur after commissioning of the power plant



Case Study Hydropower: Risk Assessment

Significant Risks (Worst Case <u>Without</u> Mitigation Measures)



Case Study Hydropower: Risk Assessment

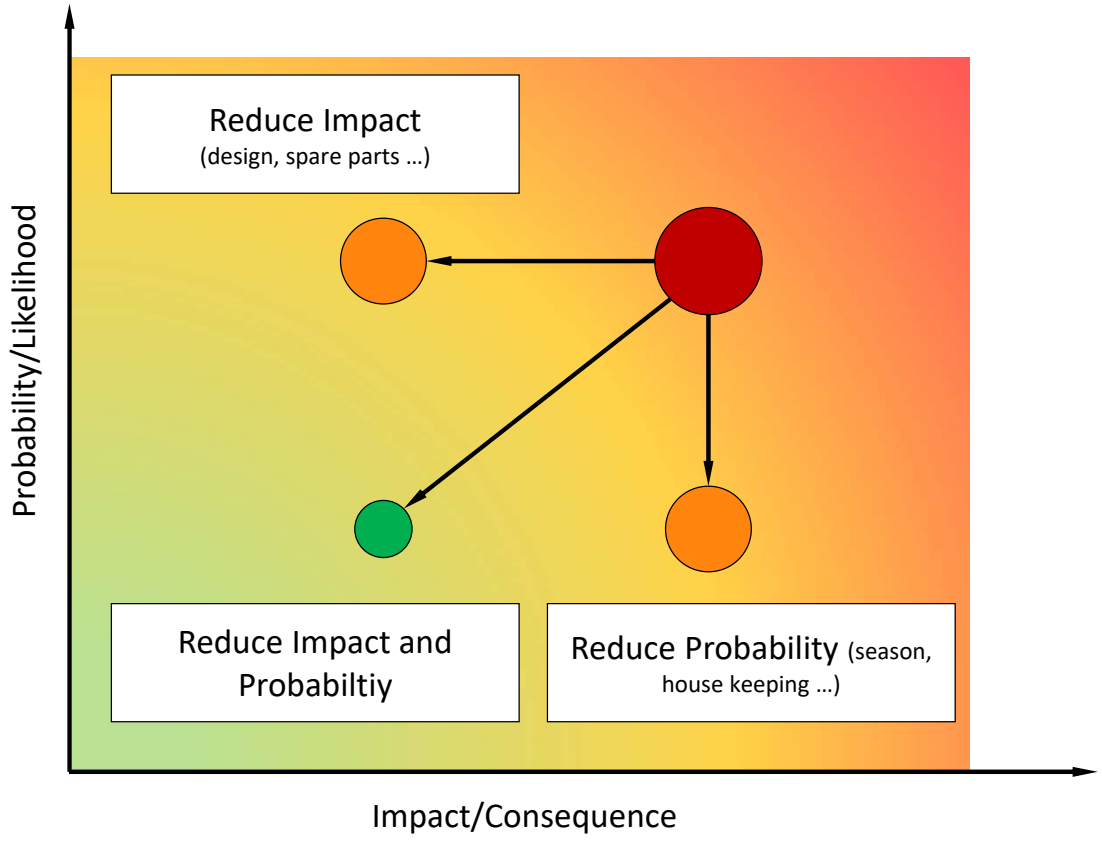
Significant Risks (Worst Case Without Mitigation Measures)

Case Study	Risk	Impact	Proba-bility
1	• Lower revenue due to failure of structures or plant (spare parts) • Lower revenue due to environmental flow release • Lower revenue due to inflow variation (incl. climate change) • Higher OPEX due to government requirements	-20% -5% -20% -20%	20% 50% 20% 20%
2	• Longer construction time and higher construction cost due to hydrological/geological conditions • Lower revenue due to lower spot market prices (WESM) • Lower revenue due to inflow variation (incl. climate change)	+1 year +20% -5% -20%	30% 30% 20% 20%

Case Study Hydropower: Risk Assessment

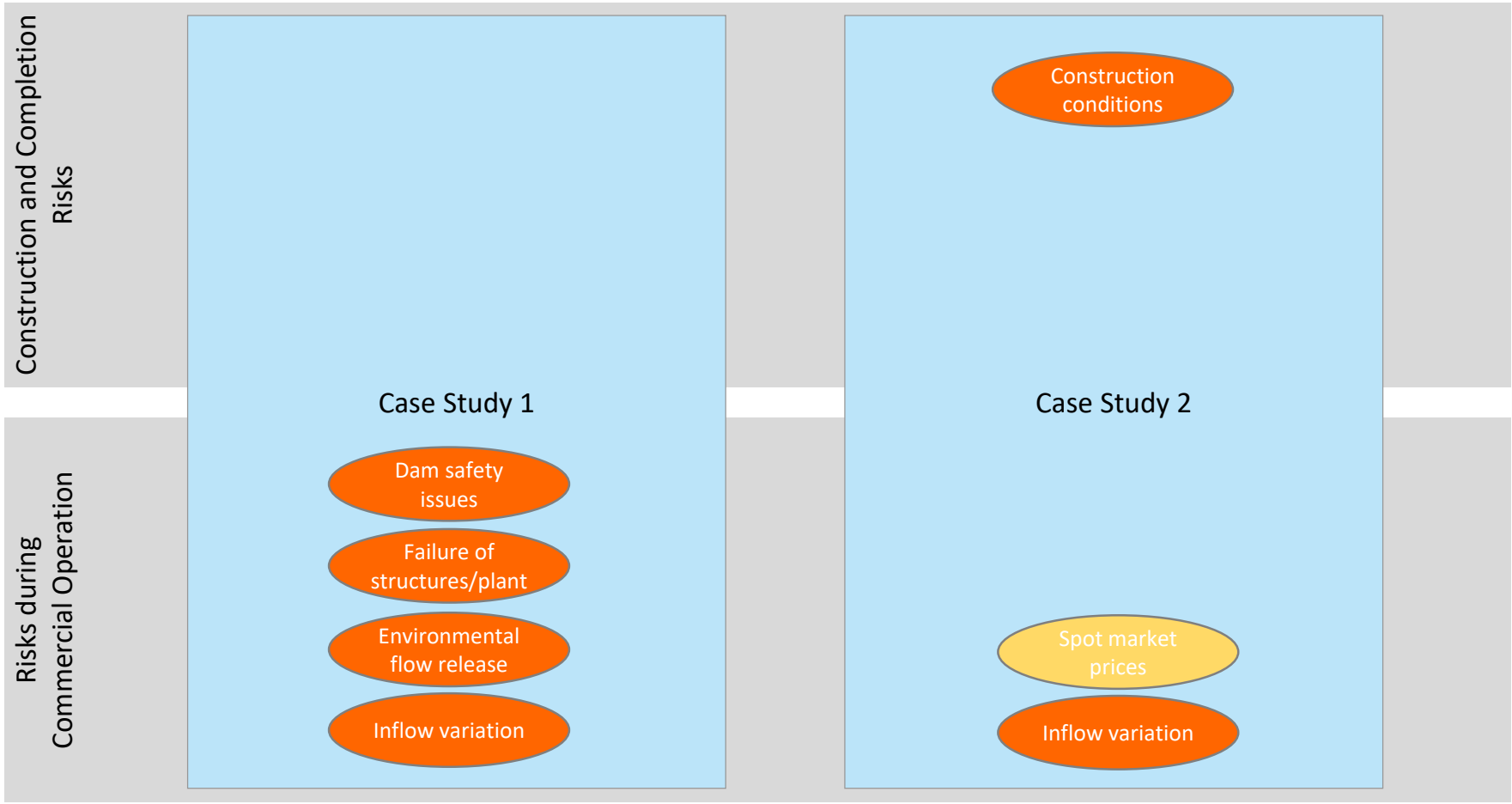
Mitigation Measures (Worst Case <u>With</u> Mitigation Measures)

Select risks and discuss mitigation measures …



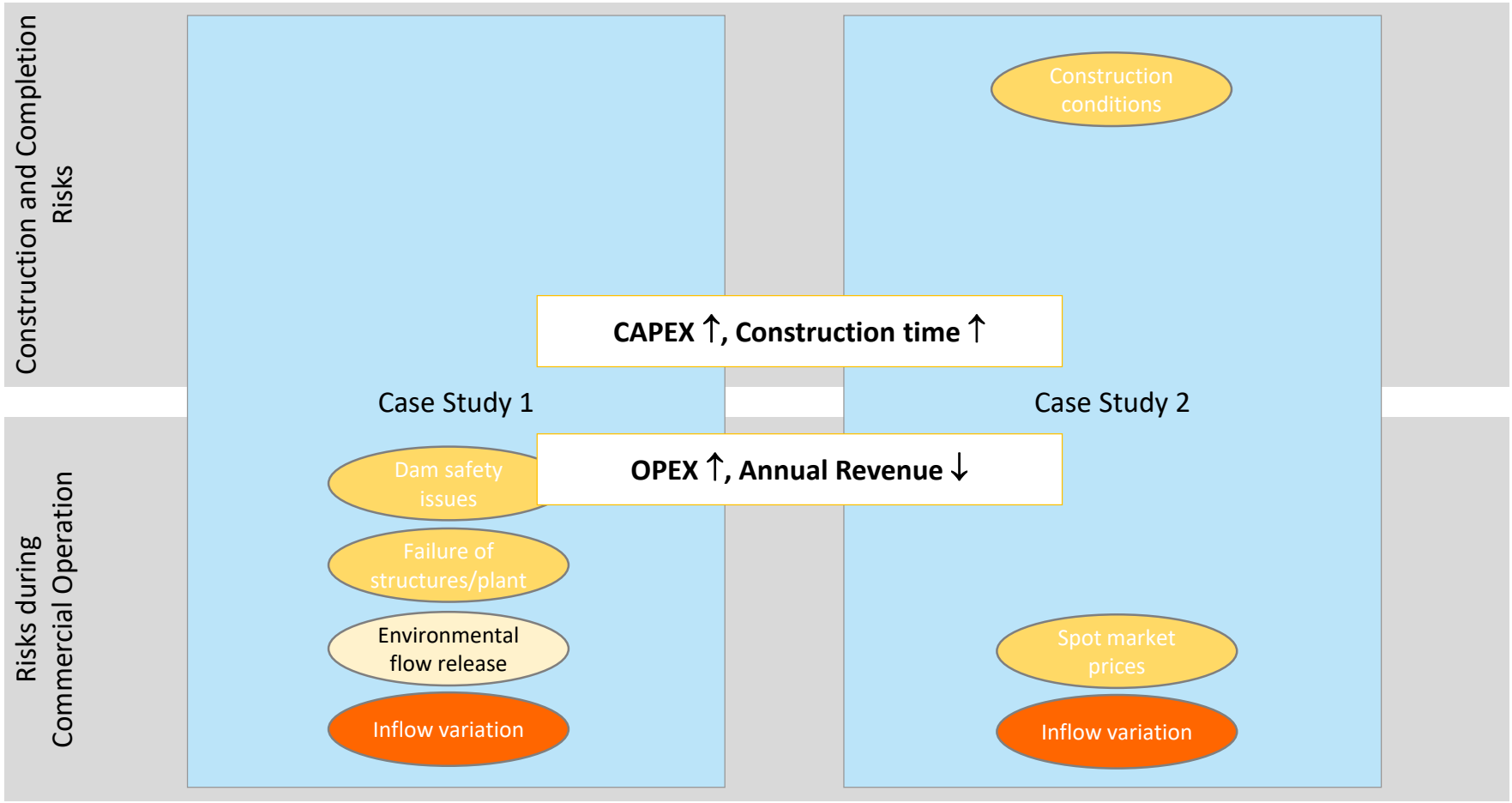
Case Study Hydropower: Risk Assessment

Significant Risks (Worst Case <u>Without</u> Mitigation Measures)



Case Study Hydropower: Risk Assessment

Significant Risks (Worst Case <u>With</u> Mitigation Measures)



Case Study Hydropower: Risk Assessment

Significant Risks (Worst Case Without and With Mitigation Measures)

Case Study	Risk	Impact	Proba-bility	Mitigation	Impact	Proba-bility
1	• Lower revenue due to failure of structures or plant (spare parts) • Lower revenue due to environmental flow release • Lower revenue due to inflow variation (incl. climate change) • Higher OPEX due to government requirements	-20% -5% -20% -20%	20% 50% 20% 20%	• Refurbishment measures (~USD 3.5 million) • Clarification with government • Accepted • Clarification with government	-10% -5% -20% -20%	10% 10% 20% 10%
2	• Longer construction time and higher construction cost due to hydrological/geological conditions • Lower revenue due to lower spot market prices (WESM) • Lower revenue due to inflow variation (incl. climate change)	+1 year +20% -5% -20%	30% 30% 20% 20%	• Selection of competent contractor and owner's representative • Accepted • Accepted	+1 year +20% -5% -20%	10% 10% 20% 20%

Case Study Hydropower: Cash Flows

Baseline Scenario vs. Worst Case Without and With Mitigation Measures

Parameter	Case Study 1	Case Study 2
Baseline Scenario		
FCFE IRR	11.9%	16.4%
DSCR – Minimum	1.25	0.80
Worst Case Scenario Without Mitigation		
FCFE IRR	9.2%	13.9%
DSCR – Minimum	1.09	0.71
Worst Case Scenario With Mitigation		
FCFE IRR	10.2%	15.0%
DSCR – Minimum	1.15	0.77

From sponsor's perspective:
FCFE IRR > 12% for Baseline Scenario
FCFE IRR > 10% for the Worst Case Scenario With Mitigation

From a lender's perspective:
Minimum DSCR > 1.2 for Baseline Scenario
Minimum DSCR > 1.0 for the Worst Case Scenario With Mitigation

Case Study Hydropower: Cash Flows

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Case Study 1

Actual debt-to-equity-ratio of 70/30

- From **sponsor's perspective**:

  FCFE IRR = **11.9%** > 12% for Baseline Scenario
  FCFE IRR = **10.2%** > 10% for the Worst Case Scenario With Mitigation

- From **lender's perspective**:

  Minimum DSCR = **1.25** > 1.2 for Baseline Scenario
  Minimum DSCR = **1.15** > 1.0 for the Worst Case Scenario With Mitigation

Actual debt-to-equity-ratio of 75/25

- From **sponsor's perspective**:

  FCFE IRR = **12.1%** > 12% for Baseline Scenario
  FCFE IRR = **10.3%** > 10% for the Worst Case Scenario With Mitigation

- From **lender's perspective**:

  Minimum DSCR = **1.17** ~ 1.2 for Baseline Scenario
  Minimum DSCR = **1.07** > 1.0 for the Worst Case Scenario With Mitigation

Case Study Hydropower: Cash Flows

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Case Study 2

Actual debt-to-equity-ratio of 70/30

- From **sponsor's perspective**:

  FCFE IRR = **16.4%** > 12% for Baseline Scenario
  FCFE IRR = **15.0%** > 10% for the Worst Case Scenario With Mitigation

- From **lender's perspective**:

  Minimum DSCR = **0.80** > 1.2 for Baseline Scenario
  Minimum DSCR = **0.77** > 1.0 for the Worst Case Scenario With Mitigation

Actual debt-to-equity-ratio of 50/50

- From **sponsor's perspective**:

  FCFE IRR = **13.8%** > 12% for Baseline Scenario
  FCFE IRR = **12.7%** > 10% for the Worst Case Scenario With Mitigation

- From **lender's perspective**:

  Minimum DSCR = **1.12** ~ 1.2 for Baseline Scenario
  Minimum DSCR = **1.08** > 1.0 for the Worst Case Scenario With Mitigation

Case Study Hydropower: Conclusion

- Project financing = company no other assets than hydropower project
  → **In-depth qualification and quantification of project risks**:
  Construction and Completion Risks: CAPEX ↑, Construction time ↑
  Risks during Commercial Operation: OPEX ↑, Annual revenue ↓
- For most of the risks adequate mitigation measures reducing their occurrence probability and/or impact; other risks to be accepted; however, some risks declared as "red flag" (obstacle to or even total failure of further progress)
- Interdependencies between technical parameters and economic/financial performance from sponsor's but also lender's perspective
- Debt-to-equity-ratio ↑ → Profitability of an investment for the sponsors ↑
- **Leverage effect as long as conditions remain acceptable for lenders**

Conclusion

Debt and Equity Financing:

- When earnings on debt > interest rate, returns on equity rise as debt increases
- The larger debt-to-equity-ratio, the larger expected return to investors
- Debt-to-equity-ratio only changing allocation of cash flows between debt and equity, but not total cash flows to the firm
- BUT risk grows as well! Investors in levered equity requiring higher expected return to compensate for increase in risk

Risk Assessment:

- Risk Identification
- Risk Evaluation
- Development of Mitigation Strategy
- Re-evaluation of (Residual) Risks

Mitigation measures reducing risk's occurrence probability and/or impact; other risks to be accepted

Interdependencies between technical parameters (risks) and economic/financial performance from sponsor's and lender's perspective