for more detailed economical calculations → Petroleum Economics Trygve - Strøm (TPG5110)

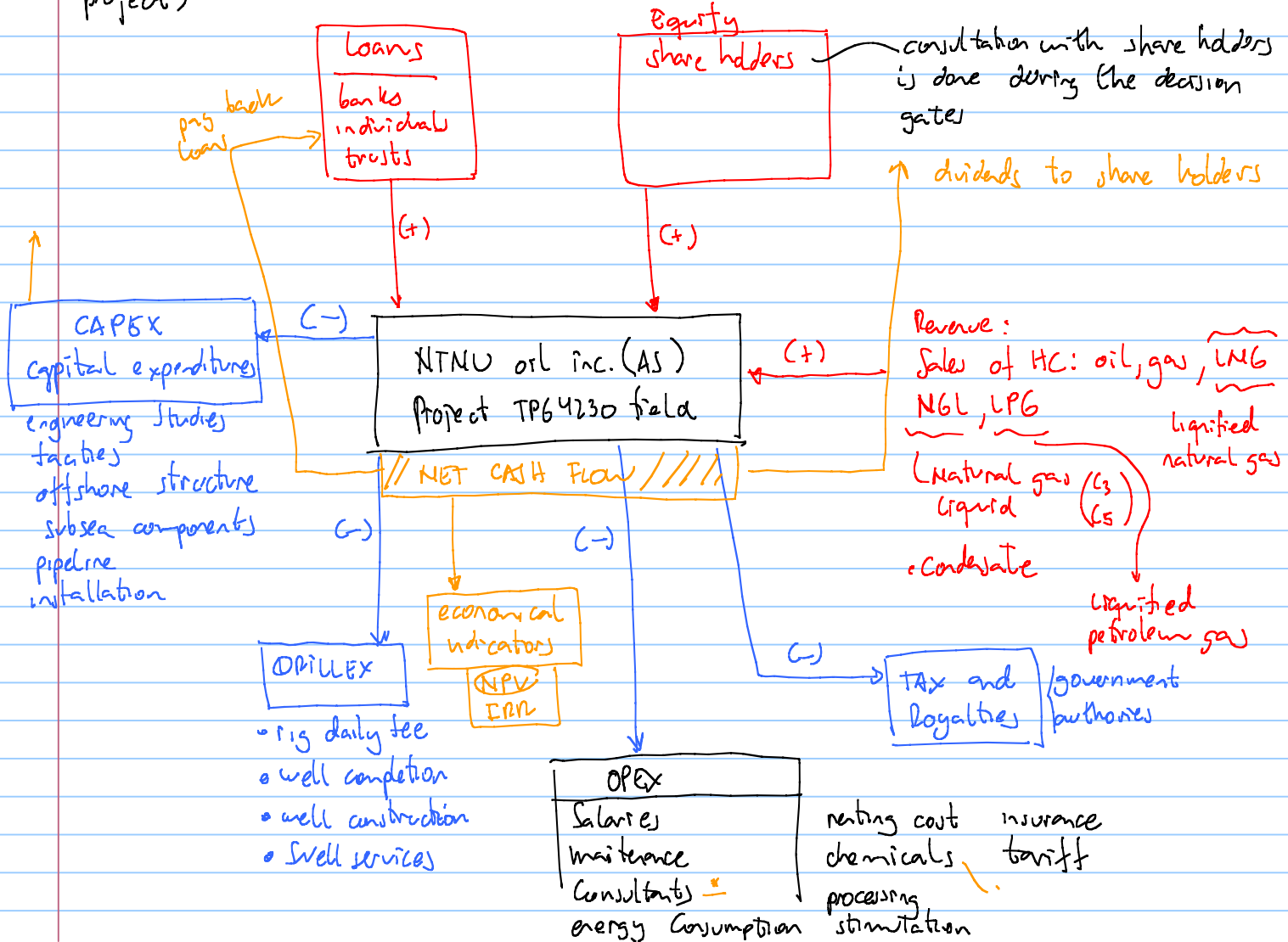
TRR [MMstb]	count	relative freq %
31	1	0.1
38	22	2.2
44	56	5.6
51	99	9.9
57	151	15.1
64	154	15.4
70	136	13.6
76	108	10.8
83	103	10.3
89	59	5.9
96	43	4.3
102	31	3.1
109	23	2.3
115	10	1
121	0	0
128	4	0.4

if I sum from bottom up → probability that my TRR is equal or lower than 51

probability that my TRR is equal or higher than ←

//

Cash flow and economic indicators of the project (Fred development project)



Cash flow with time

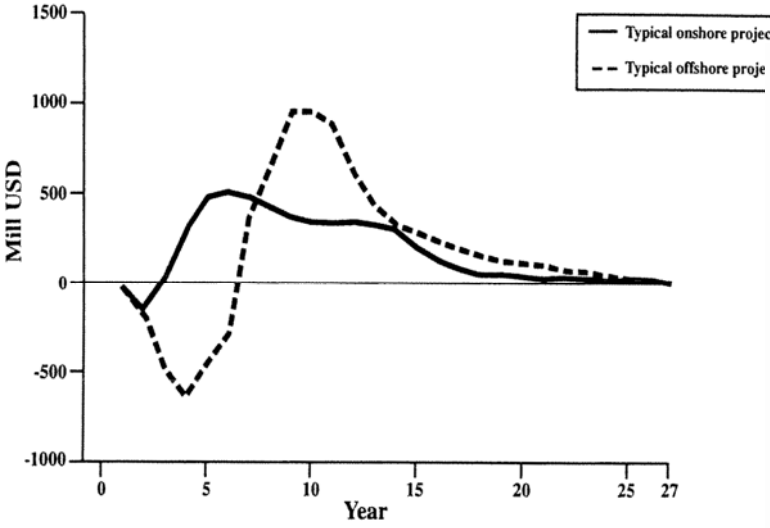
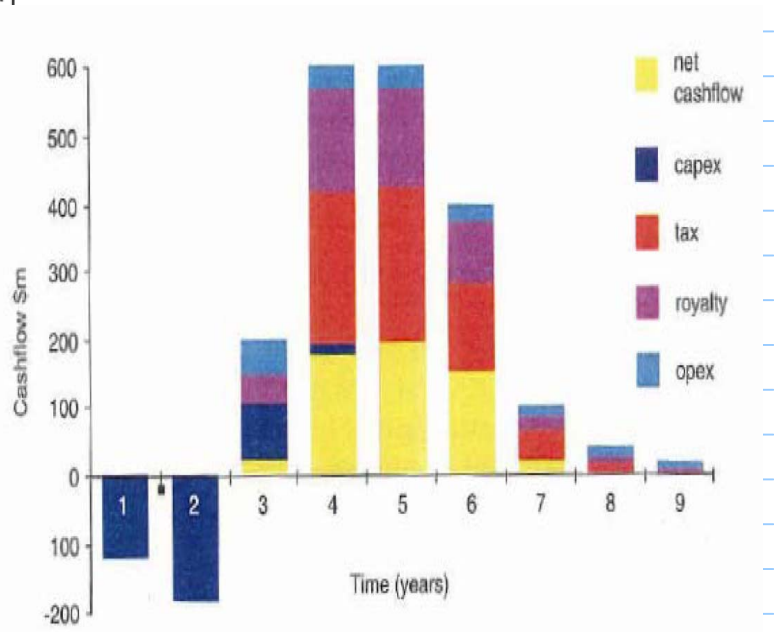


Fig. 9. Typical before tax cash flow profiles for offshore and onshore projects.



Cash flow is calculated on a yearly basis.

Year	CAPEX	OPEX	DRILLEX	TAX AND ROYALTIES	EXPENSES	Revenue	Cash flow	PV of cashflow
0	−	0	−	0	−	0	−	
1	−	0	−	0	−	0	−	
2	0	−	0	−	−	+	+	
3	0	−	0	−	−	+	+	

$\Sigma(\quad)$ NPV

Present value: the current worth of a future sum of money

present value, future value

$V_P = V_F \frac{1}{(1+i)^n}$

n is the year were the future value is spent or gained

i interest, discount rate ~

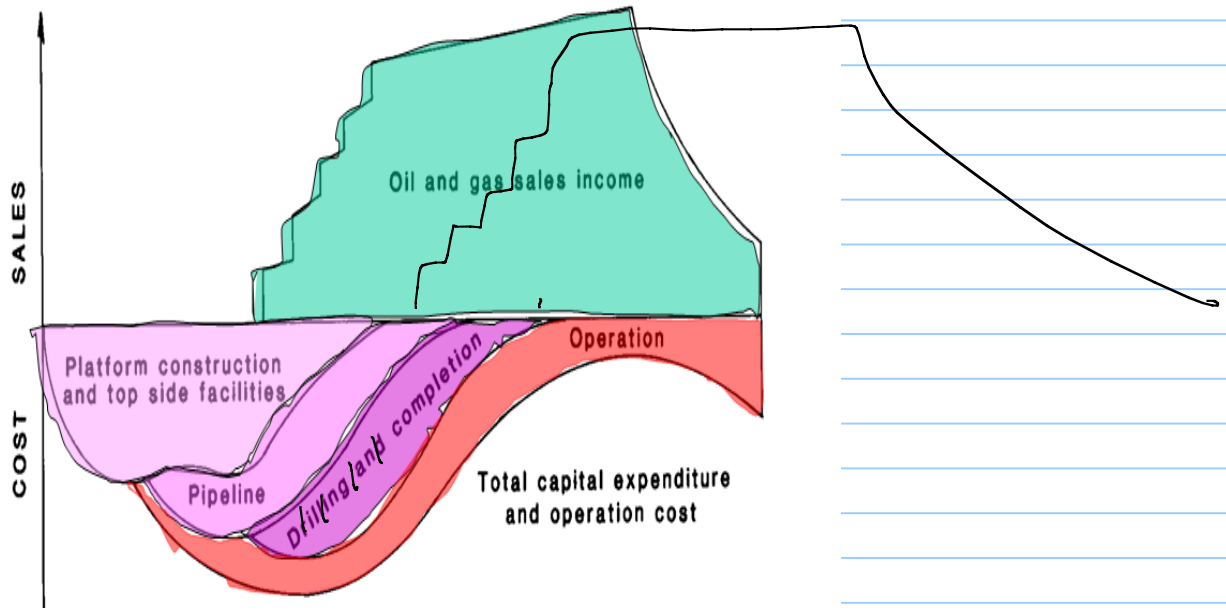
$(1+i)$ compound factor

$\left(\frac{1}{1+i}\right)$ ~ discount factor

Net present value — main economical indicator of the project

has to be (+)

Revenue and Cost Profiles



The Ultimate driver in E&P operations

$$NPV = \sum_{i=0}^{N} \frac{\text{OIL PRICE}(i) \times \text{OIL PROD}(i) - \text{CAPEX}(i) - \text{OPEX}(i) - \text{TAX}(i)}{(1+r)^{i}}$$

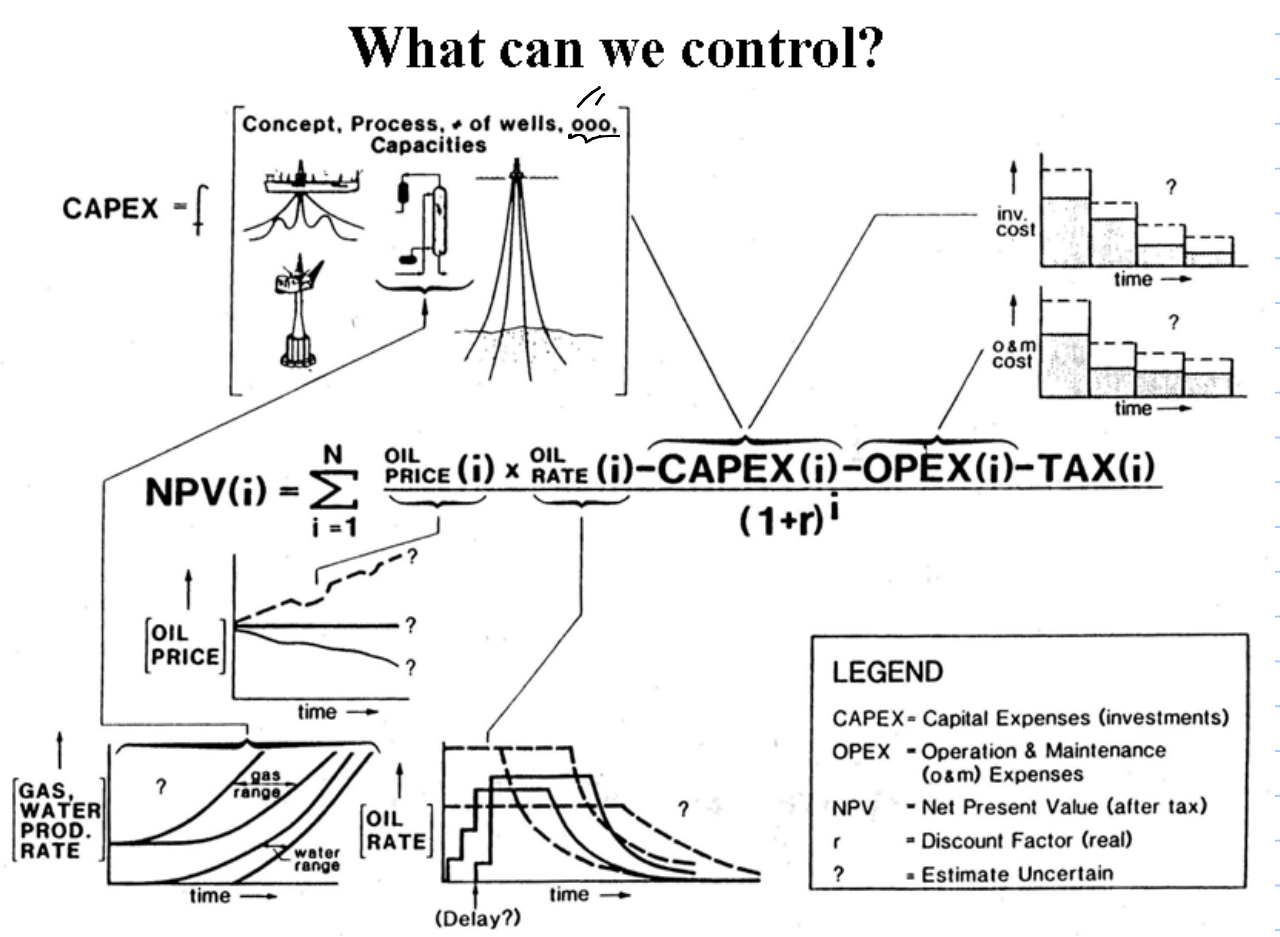
total number of years

+ gas prod(i) + gas price(i)

neglected in this course

year

interest, discount rate



to get accurate estimates of cost values (and production rates) we need the input from the following specialists:

petroleum engineer: Re reserves, location and Nr wells, production scheduling, fluids

Drilling engineer: Drilling and completion costs (DRILLEX)

facilities engineer (processing): production processing facilities, equipment required, transportation } size, cost

Operations and maintenance: maintenance costs, manpower requirements

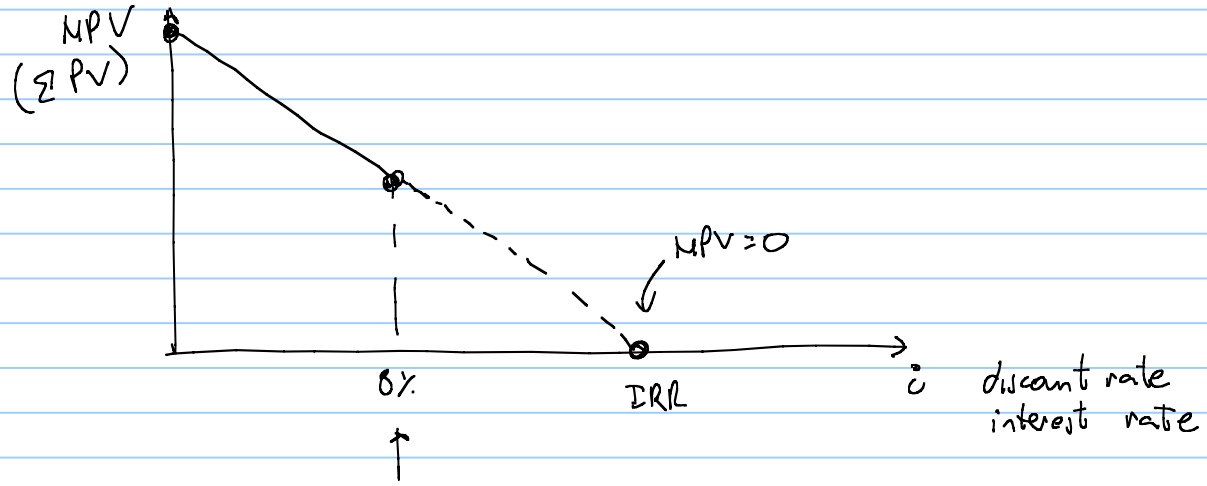
Offshore engineer: offshore structure, layout of the system

Project manager.

Human resources; Fiscal system expert (tax, royalties), corporate planner

Another indicator of economical health of the project. IRR

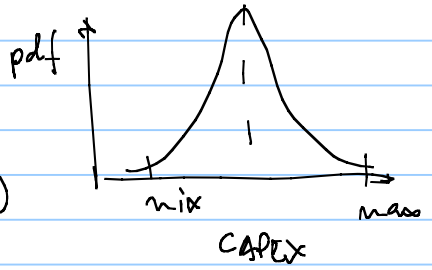
internal rate of return: the interest rate that makes the project NPV = 0

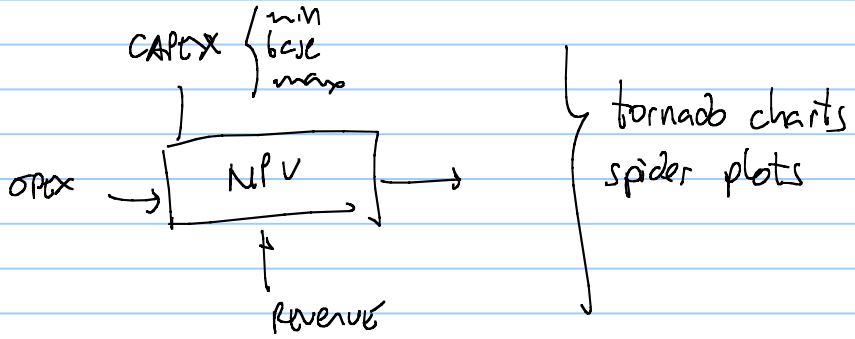


how do we quantify the effect of uncertainty in the NPV.

Sensitivity studies using the principle

of "Ceteris Paribus" ~ (all others same)





① Define a base case scenario base value for { oil price, CAPEX, OPEX, etc

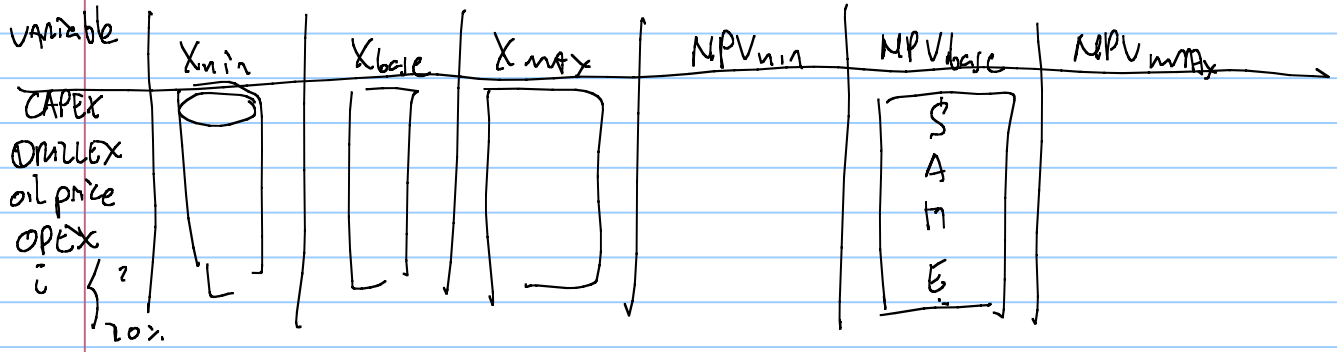
② Define a range for each variable. E.g. oil price { min, base, max

③ Calculate value of interest (economic indicator NPV) changing (one at a time) the variables (while keeping all other variables at their base value)

min price ⟶ calculate NPV

base oil price ⟶ NPV

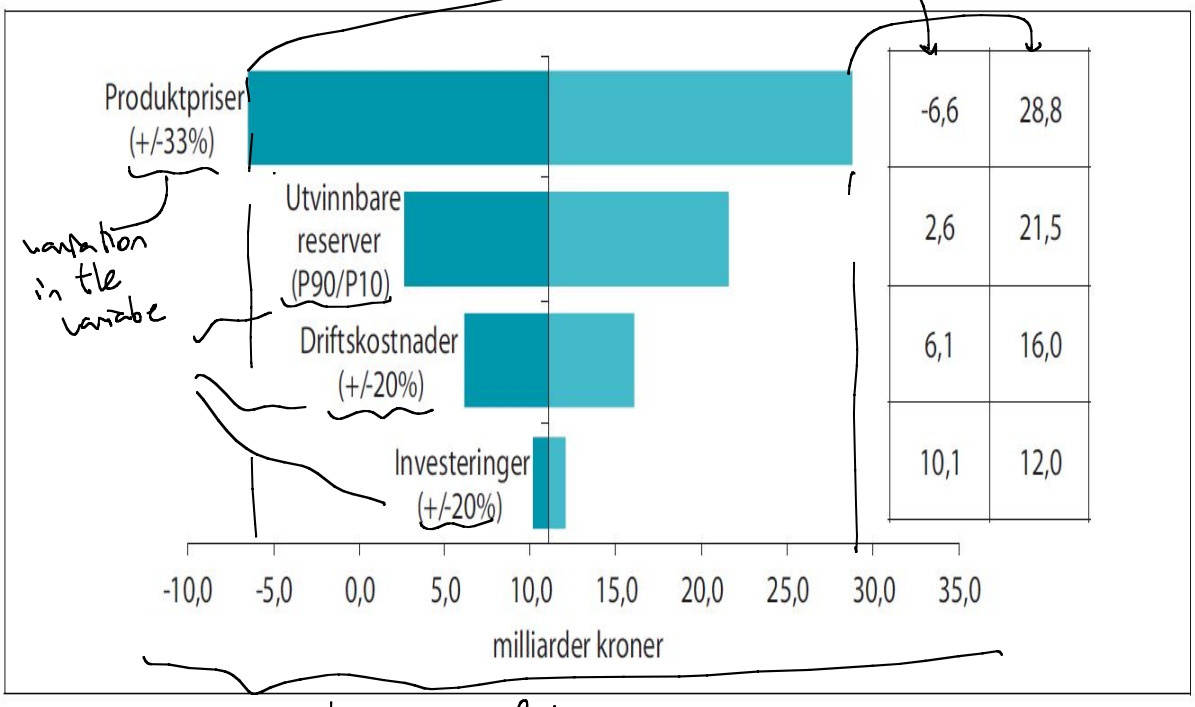
max oil price ⟶ NPV



apply normalization

	$X_{normalized}$	X_{min} normalized	X_{max} normalize	% NPV normalize
CAPEX	$\frac{X_{min} - X_{base}}{X_{base}} \cdot 100$	0%	$\frac{X_{max} - X_{base}}{X_{base}} \cdot 100$	$\frac{NPV_{min} - NPV_{base}}{NPV_{base}} \cdot 100$ ○
DRILLEX	"	0%	"	
oil price	"	0%	"	

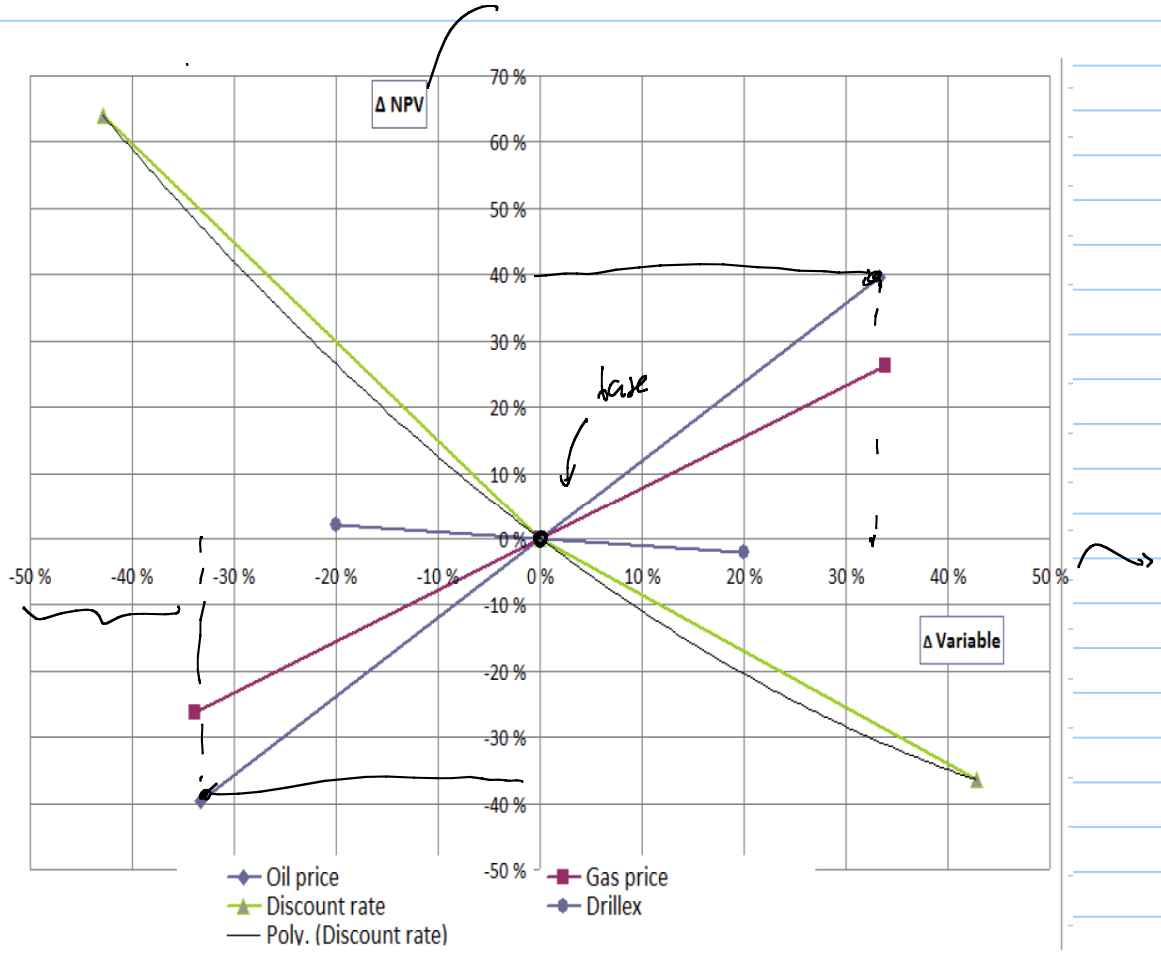
tornado chart

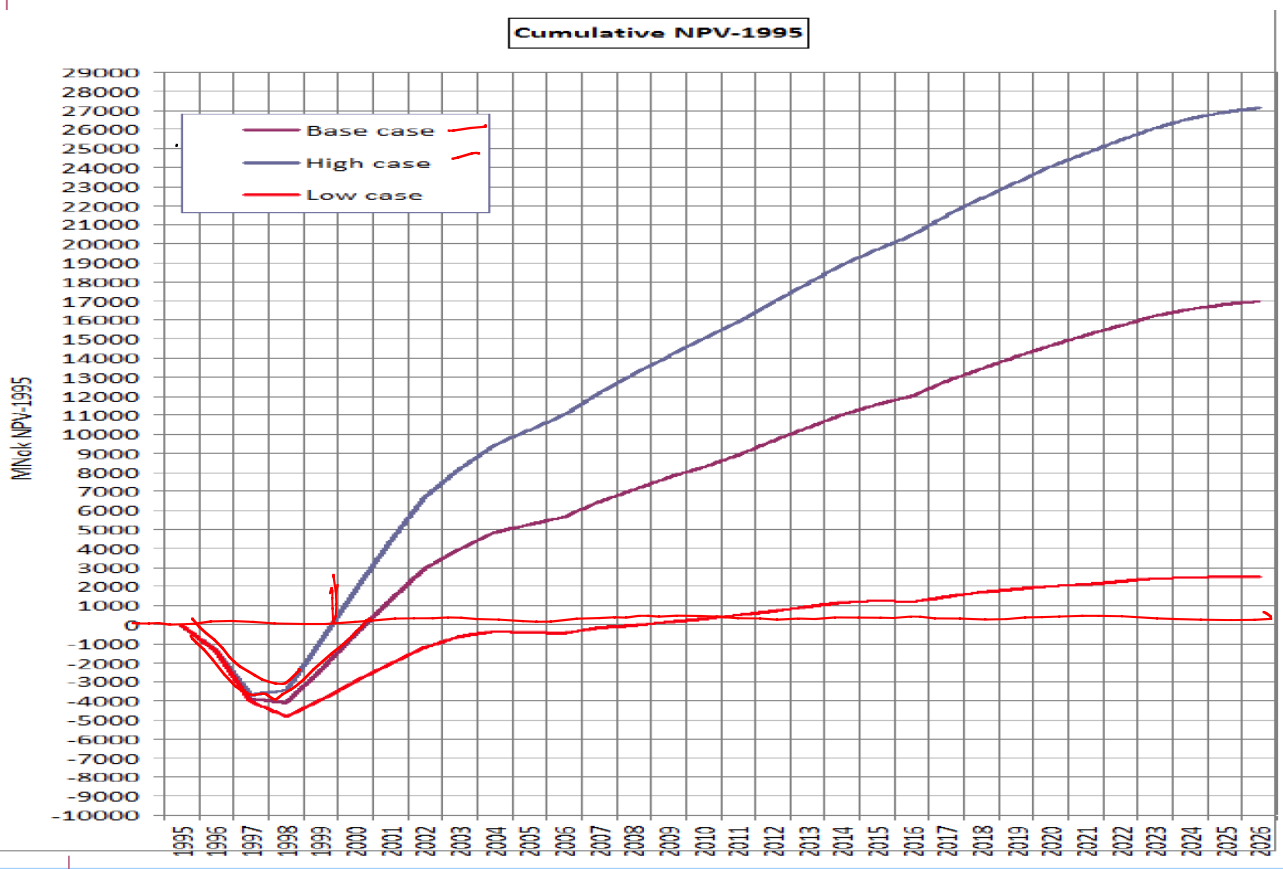


variation in the variable

variation in NPV

Spider plot


Δ NPV
70 %
60 %
50 %
40 %
30 %
20 %
10 %
0 %
-10 %
-20 %
-30 %
-40 %
-50 %
-50 %
-40 %
-30 %
-20 %
-10 %
0 %
10 %
20 %
30 %
40 %
50 %
Δ Variable
base
Oil price
Gas price
Discount rate
Drillex
Poly. (Discount rate)


Cumulative NPV-1995
MNok NPV-1995
Base case
High case
Low case
29000
28000
27000
26000
25000
24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
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-1000
-2000
-3000
-4000
-5000
-6000
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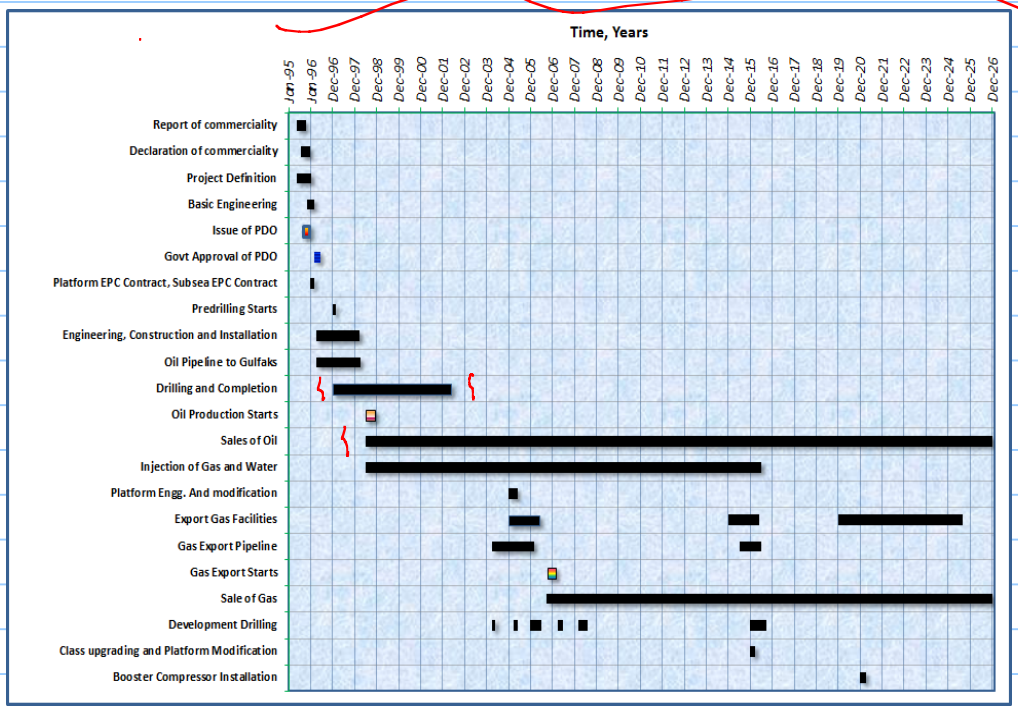
2026

Gantt diagrams Special chart diagram used in project management that shows timeline when and the duration of important events in the design and construction of the field



Henry Gantt (1861-1919), a mechanical engineer, management consultant, and industrial advisor developed Gantt charts in the 1910's. Not as commonplace as they are today, Gantt charts were innovative and new during the 1920's, where Gant charts were used on large construction projects like the Hoover Dam started in 1931 and the Eisenhower National Defense Interstate Highway System started in 1956.

Henry Gantt

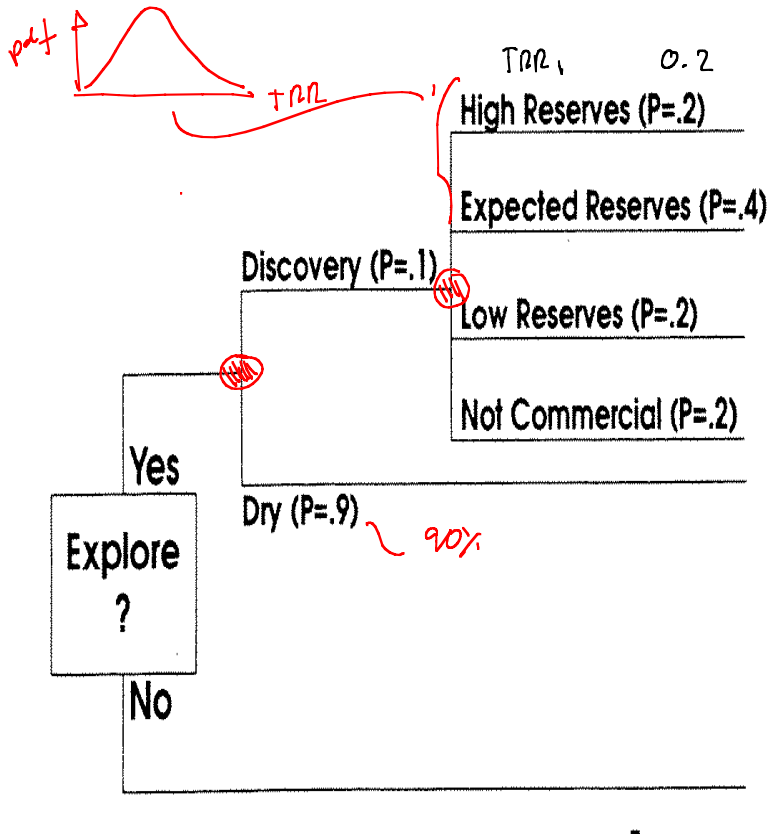
Every time we, in our project management careers, go through the rigmarole of our projects, trying to meet and beat our own-set goals, a silent word of gratitude goes to the heavens for Henry Gantt for conceiving this intuitive diagram for charting project timelines, for the Gannt Diagram allows us to excel in this chosen career.

https://www.smartsheet.com/blog/gantt-chart-excel ← useful for exercise.

How to deal with uncertainty in desicions or with integer variables
- decisions
- development options
  - platform
  - subsea to beach
  - FPSO

Decision trees allow to deal with integer variables (not continuous)

- ~ decision nodes
- ~ chance nodes
- ~ end node



multiplication of all probabilities (chance nodes) of that particular branch

i	Prob$_i$	NPV$_i$	Prob$_i$ x NPV$_i$	
1	0.02	A	(.02) A	$\Sigma P(i)\,NPV(i)$
2	0.04	B	(.04) B	
3	0.02	C	0.02 C	
4	0.02	D	(.02) D	EMV
5	0.90	E	(.90) E	
6	1.00	0	0	=

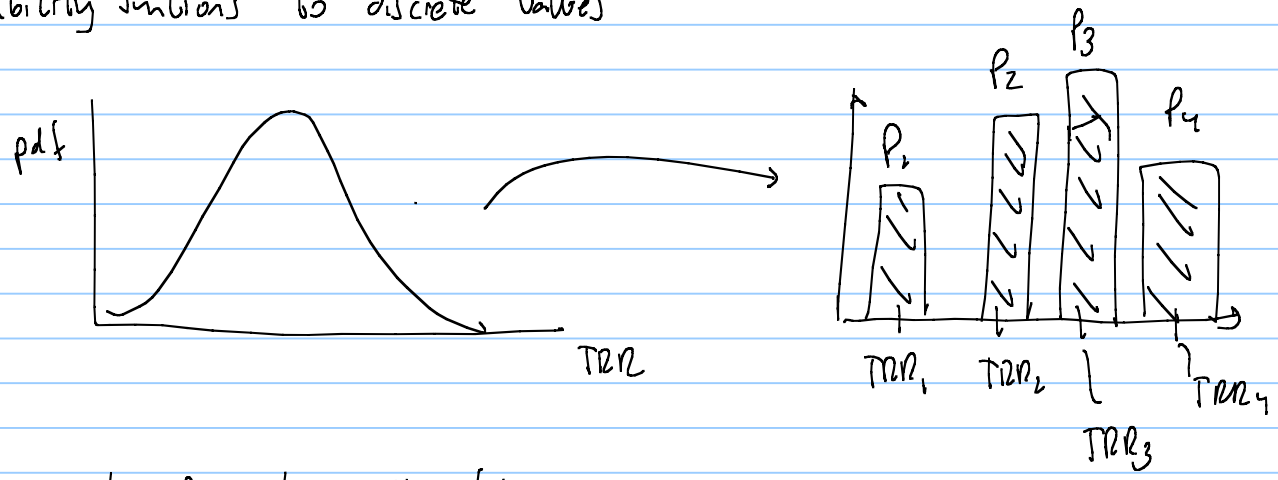
NPV

A > B > C > D

E negative (!)

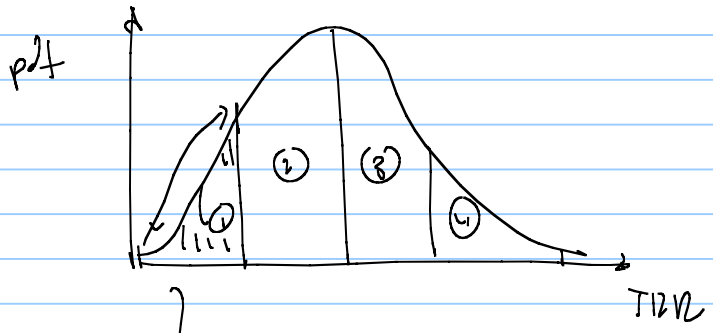
- Weighted AVG. NPV ('Yes-Branch') $= \sum_{i=1}^{5} (\text{Prob}_i) \times \text{NPV}_i = G$
- NPV ('No-Branch') =0
- IF G>0, Explore !
- A-E; Shows the spread in NPV-Outcome for this venture

In decision trees we sometimes have to convert continuous probability functions to discrete values



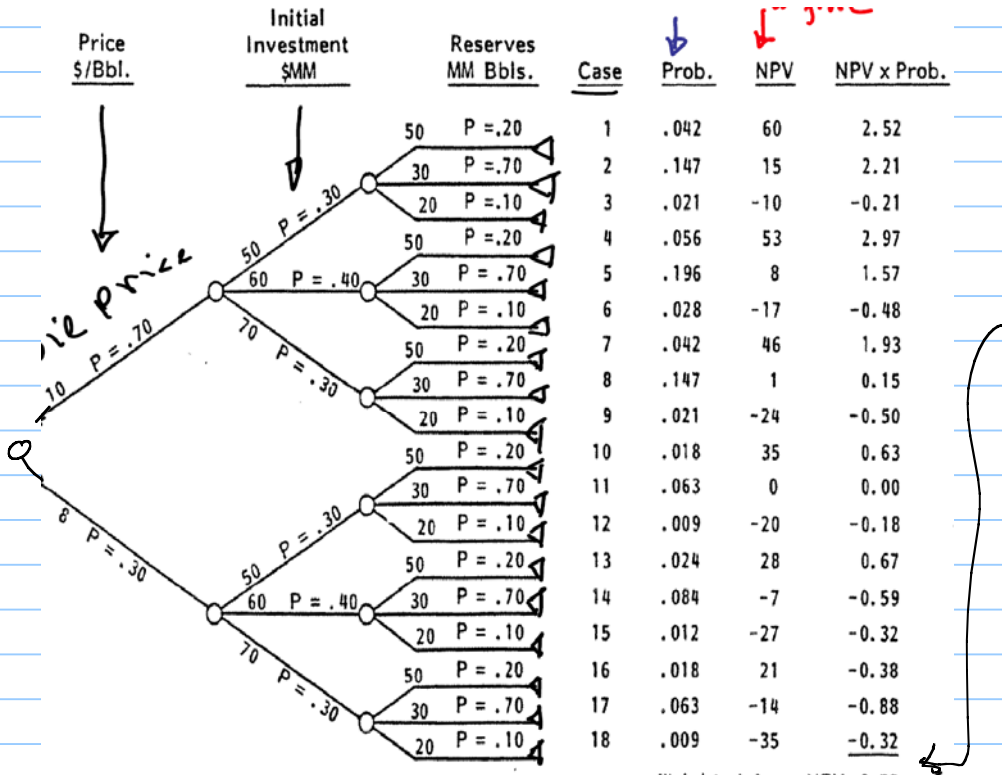
one way to do it is the following:

divide the pdf in sections



area under the curve provides the probability of the section

for the value TRR1 calculate the most probable value in the section (mode of each section)



Case	Prob.	NPV	NPV x Prob.
1	.042	60	2.52
2	.147	15	2.21
3	.021	-10	-0.21
4	.056	53	2.97
5	.196	8	1.57
6	.028	-17	-0.48
7	.042	46	1.93
8	.147	1	0.15
9	.021	-24	-0.50
10	.018	35	0.63
11	.063	0	0.00
12	.009	-20	-0.18
13	.024	28	0.67
14	.084	-7	-0.59
15	.012	-27	-0.32
16	.018	21	-0.38
17	.063	-14	-0.88
18	.009	-35	-0.32
Weighted Avg. NPV			9.55

MEV mean expected value