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FLAT BOTTOM OR VACUUM INSULATED TANKS?

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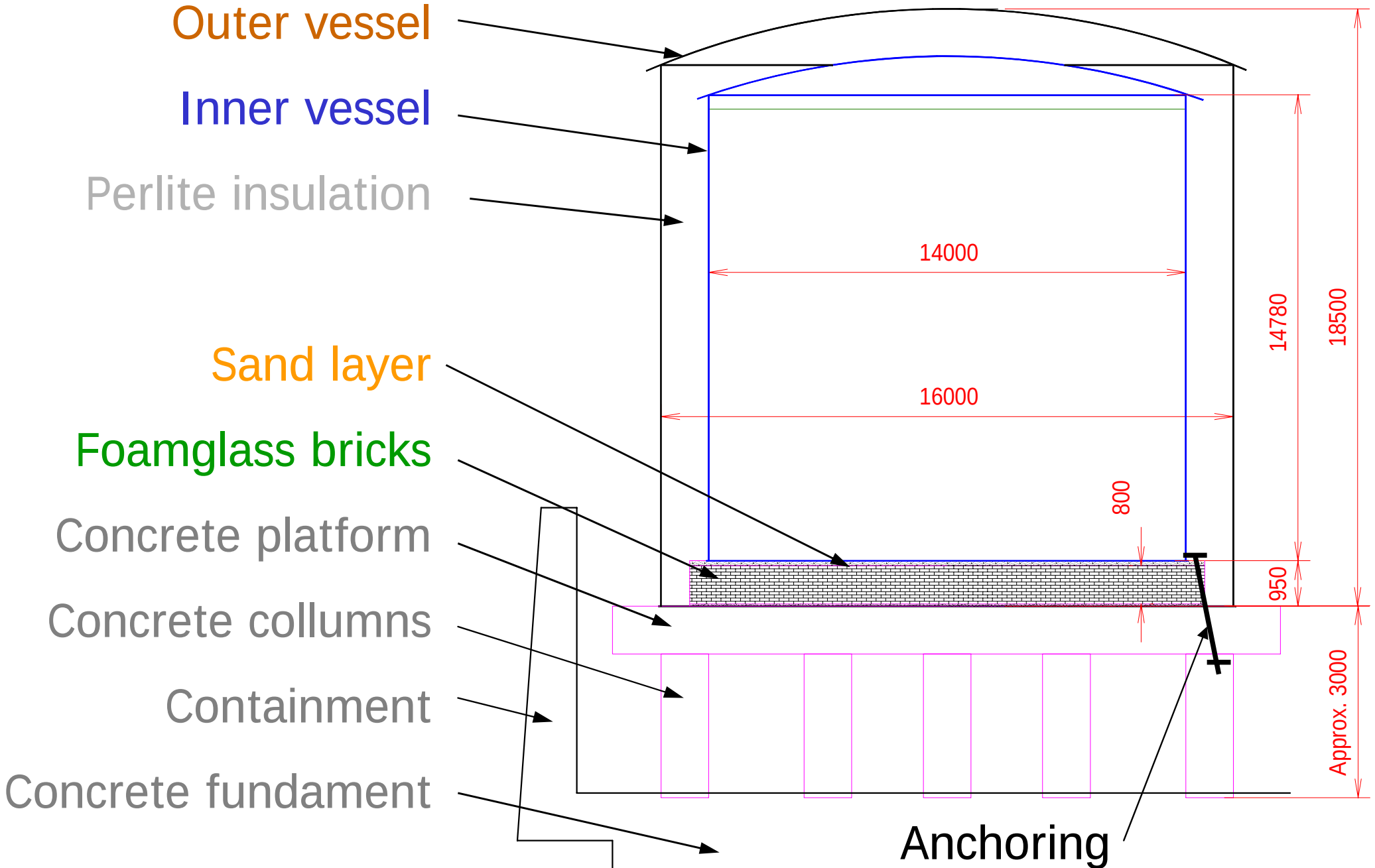
Dilemma of Liquefied Cryogenic Gas Storage Projects

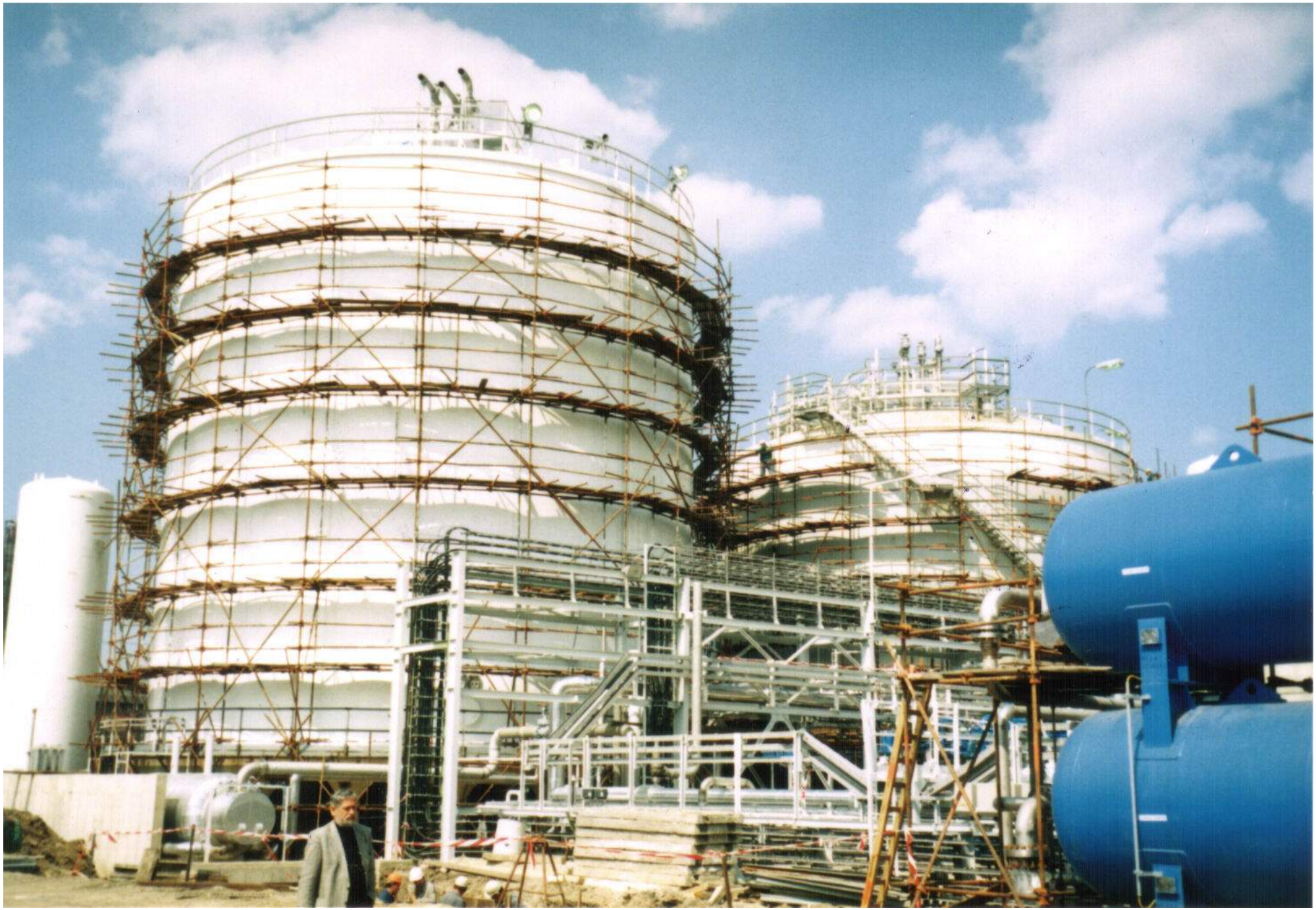
- There is no doubt, that for storage of quantities less than 250 m3, **vacuum insulated tanks** are the best option

- There is no doubt, that for storage of quantities larger than 50 000 m3 **flat bottom tanks** are the best option

- What about the **intermediate** region?

Design of a Flat Bottom Tank



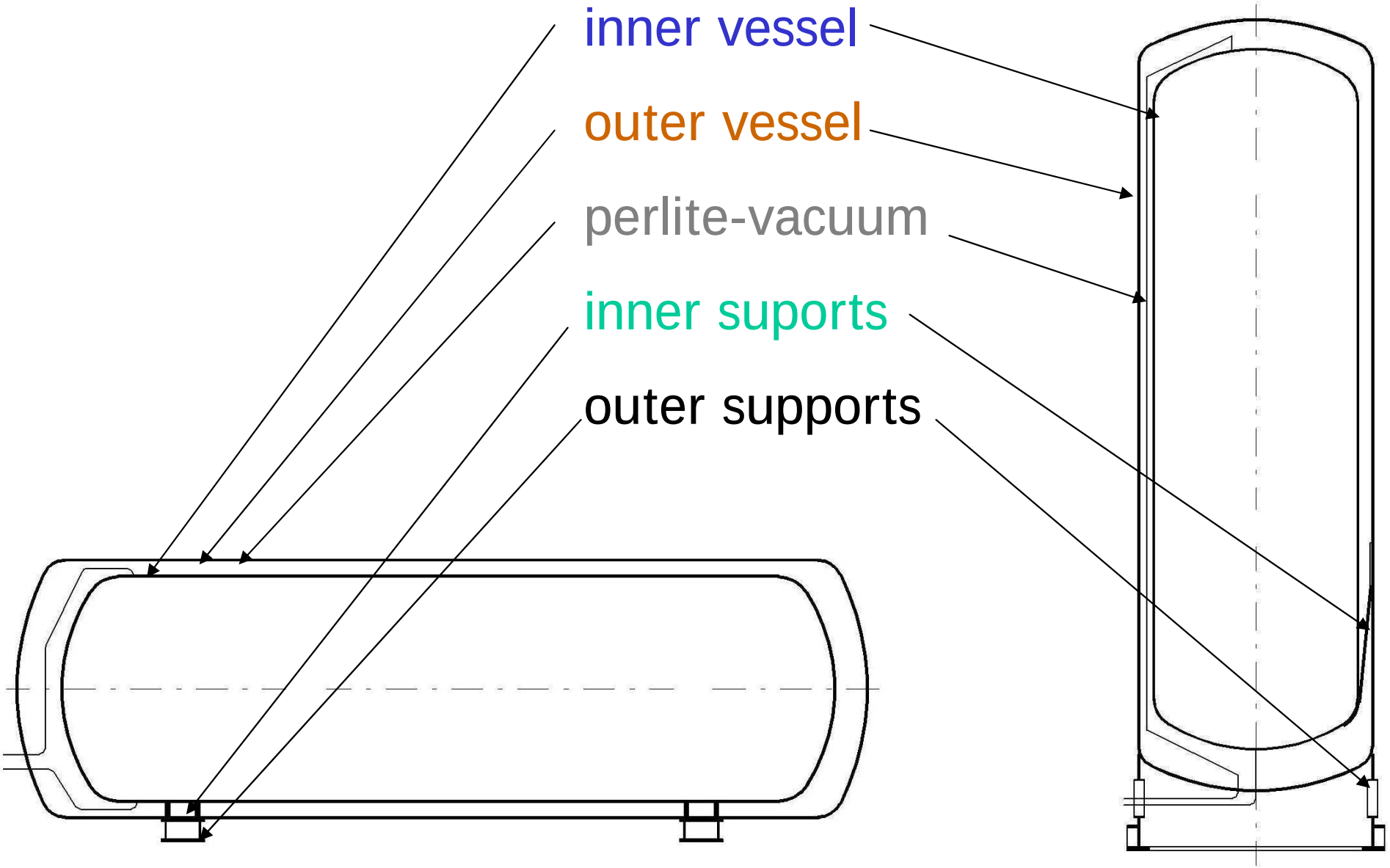


Flat bottom tanks during construction

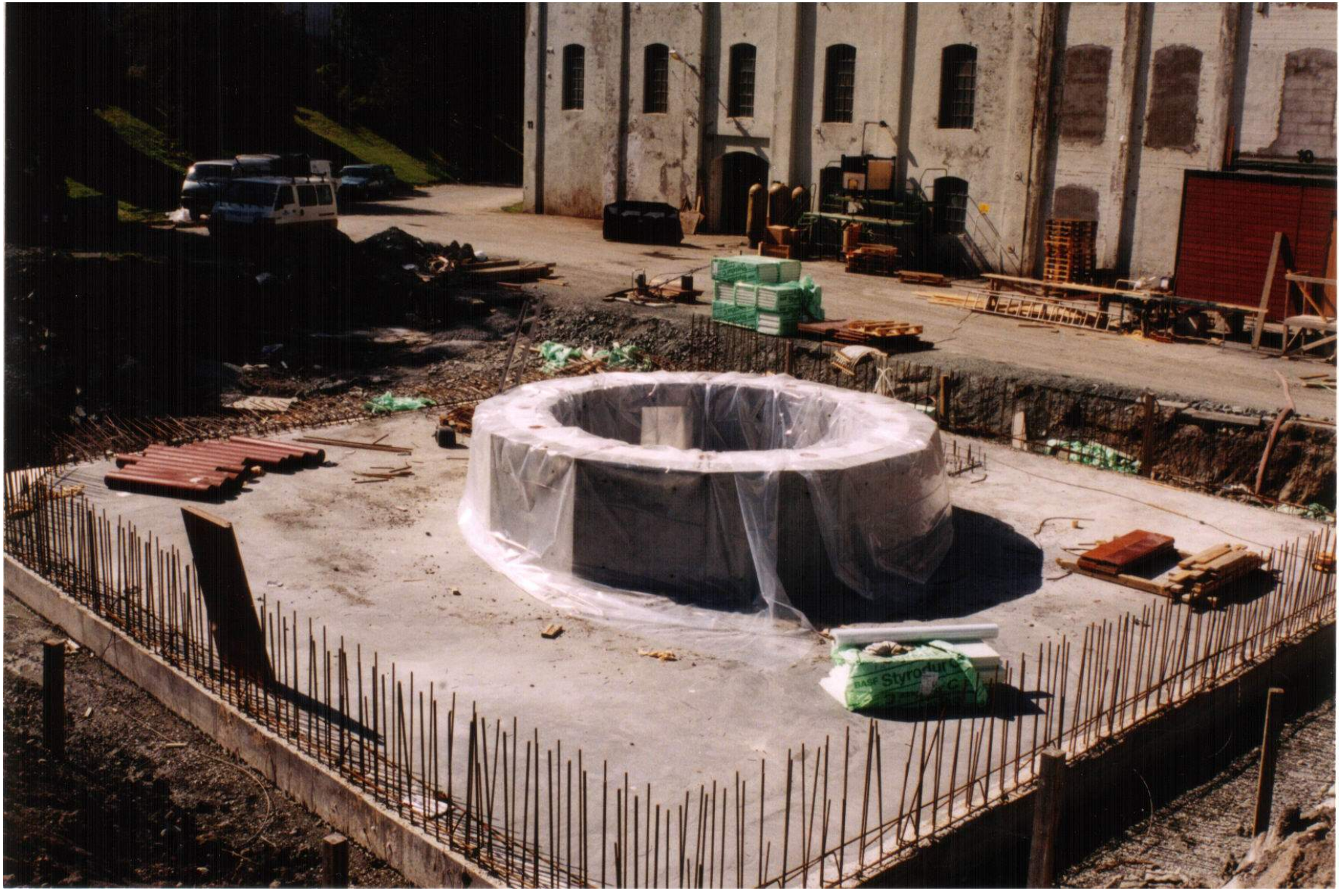
1800 m3

2200 m3

Vacuum insulated tank design



Vertical tank foundation with a containment (in process)



Erection of a vertical Vacuum Insulated tank

(212 m3 LNG,

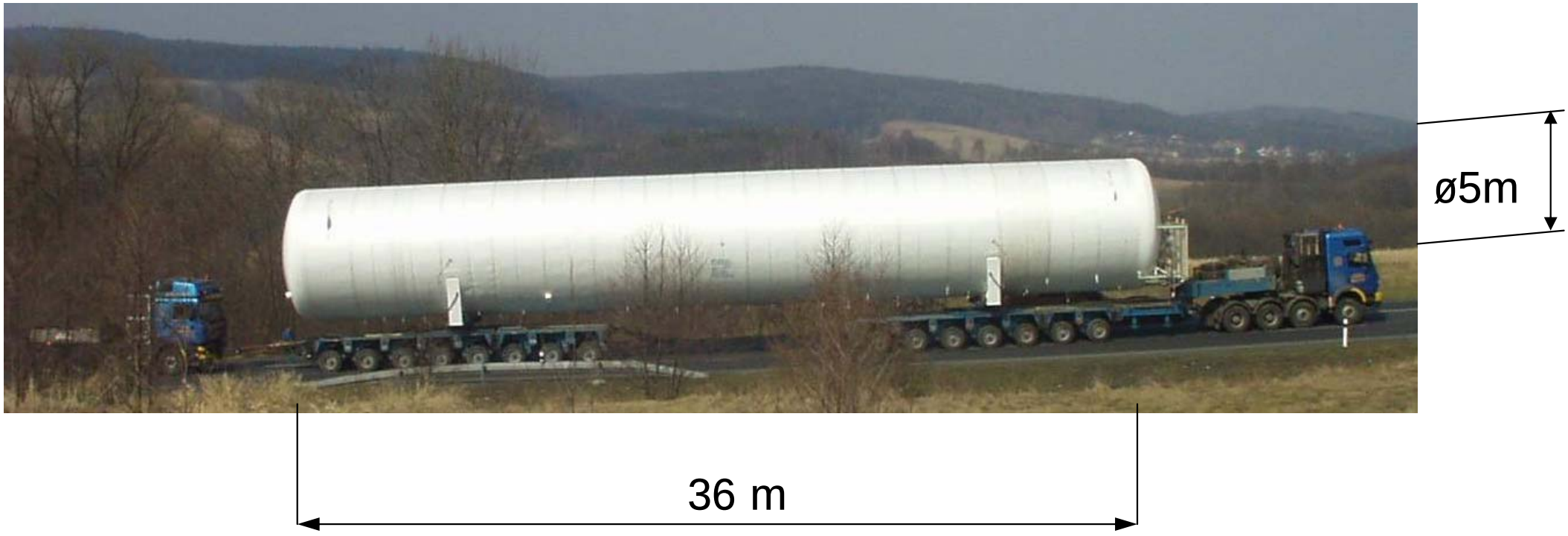
Statoil,Norway

Large Vacuum Insulated tanks

HT500 (LNG, Norway, 3 pieces in 2003)

volume: 500 000 liters

weight: 130 000 kg




STORAGE TA to NORWAY


RESQK


Naturgas Vest, Sunndalsora, Norway
Storage capacity 1500 m3 of LNG, Vaporization 3000 Nm3/h

Comparison of Flat Bottom and Vacuum Insulated tanks (Qualitative)

- Project lay-out
- Manufacturing and Construction
- Process design
- Pressure dynamics
- Risk with catastrophic accidents

Project lay-out

	Flat bottom	*Vacuum insulated*
Number of units	one	more
Containment volume needed	the whole storage volume	single tank volume
Ground area needed	small	vertical: marginally larger horizontal: much larger
Design of concrete foundations and containment	expensive	lower cost

Manufacturing and Construction

	Flat bottom	*Vacuum insulated*
Method of manufacturing	on site with shop preparation	shop manufactured
Lead time of shop work	several weeks	several weeks
Lead time of on site construction	several months	several days
Possibility of sequential building-up and commissioning (two or three stages, e.g.)	no	yes
Easy to move in case of change of market environment	no	yes

Process design

	Flat bottom	*Vacuum insulated*
Typical max. pressure (bar)	0,05	8
Need of discharge pump	yes	no
Net daily evaporation rate due to heat leak	0.1 to 0.2 % / day	0.06 to 0.08 % / day
Operators' access for inspection and maintenance	difficult (all on the roof)	easy (ground level)

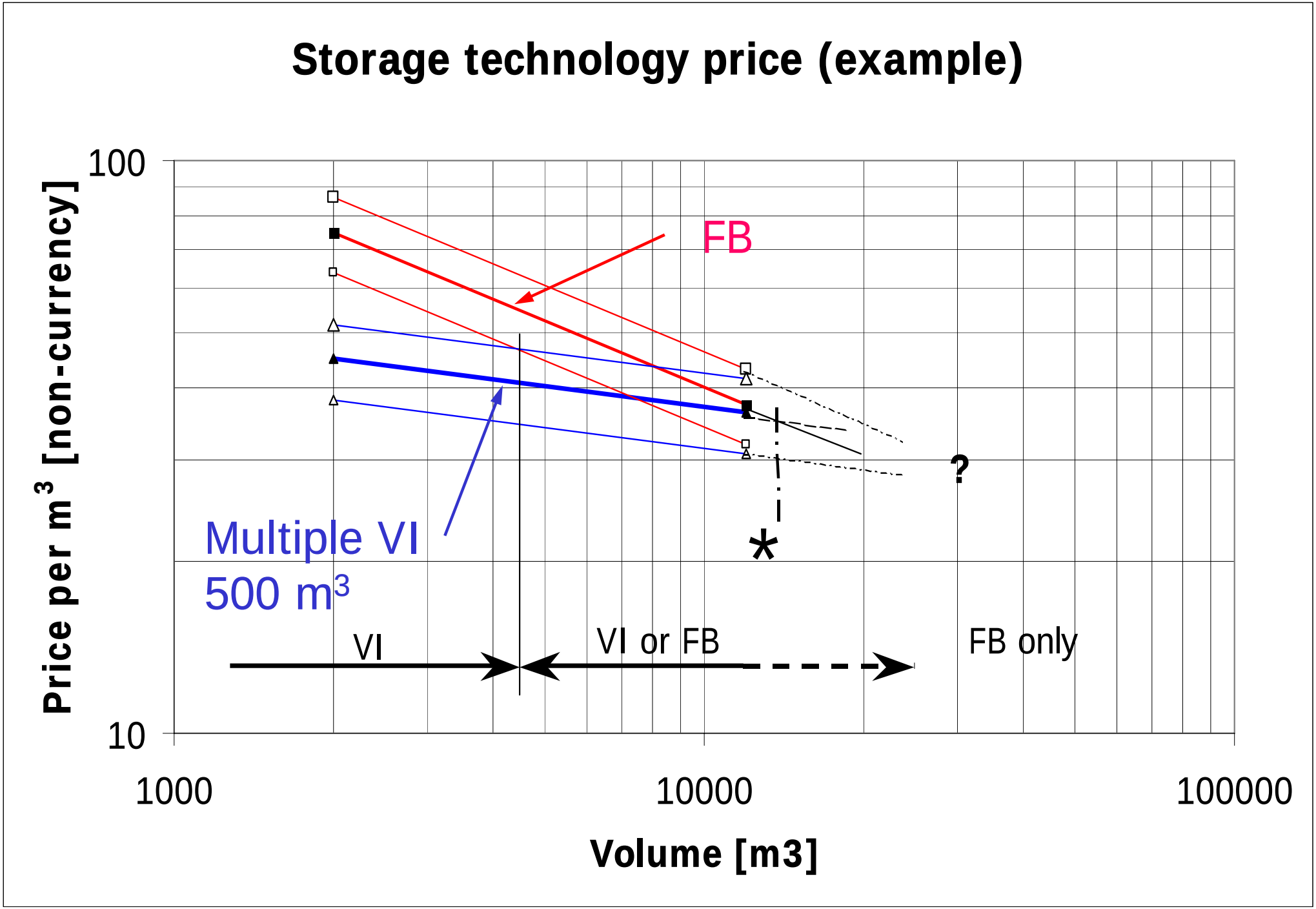
Pressure dynamics

	Flat bottom	*Vacuum insulated*
Need of pressure control according to atmospheric pressure	yes	no
Danger of roll over (spontaneous shrug down of stratified liquid with risky vapor generation and pressure growth)	yes	none
Maximum boil-off generation at roll-over	0.04 to 0.24 % / hour	-
Need of boil-off compressors (sized to maximum)	yes	no
Consequent need of temperature and concentration profile continuous control	yes	no

Risk with catastrophic accidents

	Flat bottom	*Vacuum insulated*
Resistance to earthquake – measures needed	**difficult**	**easy**
Catastrophic events – war, terrorism, airplane fall, industrial catastrophy	**risk of total damage**	**single or several tanks**
Possibility of partial operation after a case of failure or accident	**no**	**yes**

Economic Comparison



Conclusion

- Progress in manufacturing of large Vacuum Insulated tanks makes possible design of sizes 500 m^3 and larger.
- Multiple use of these tanks is a realistic alternative to Flat Bottom tanks.
- This alternative should be always taken into account when projecting storages with total volume up to 15 000 m3.