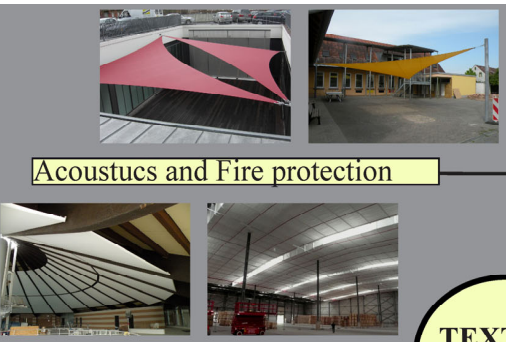
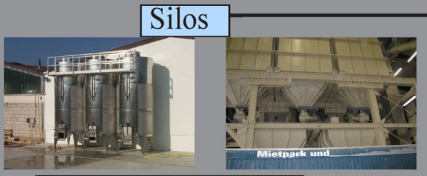


# DWA Conform Static Dimensioning of Gas Storages

An attempt to compare different guidelines for the statical analysis of biogas storages





**METAL-structures**

**TEXTILE-structures**

**SOLID-structures**

**TIMBER-structures**

**COMPLEX structures**

**SPECIAL structures**

more than 3000 projects processed in 30 Years

**STATIK RYKLIN**

Dipl.-Ing (FH)  
Master Membrane Structures  
Architect M.Sc.

Consultancy

Design

Optimisation

Submission

Building physics

Statics

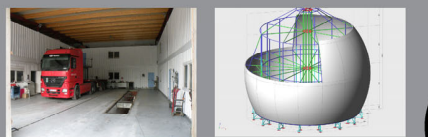
Dynamics

Execution

Verification

Education

Seecontainer/Container/Scaffolds



Advertising/Glas Facades

Factory buildings



# Biogas storages – in general



# DWA-M 377 → Published in 2023

- in general:

# defines load values

- for cones shaped:

# mast skew →  $l/200$

# mast dislocated →  $d/300$

www.dwa.de



DWA-Regelwerk

## Merkblatt DWA-M 377

Biogas – Membranspeichersysteme über Behältern

März 2023

Von der DWA lizenziert für ID: ~s44d9e9a-3b24-e71ee-a2bz-000e2b274a1b5~ | IP: 80.146.41.221 | 18.04.2025 07:00



# cone shaped - model

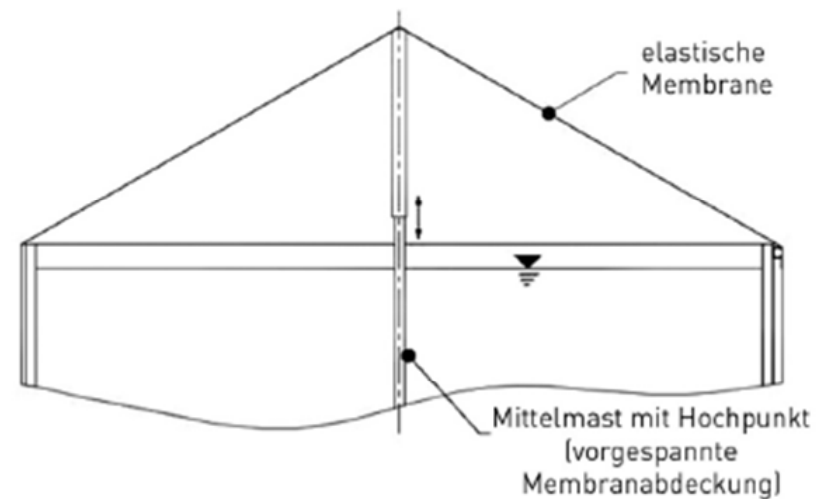
- cone geometry used for calculation:

$d=40\text{m}$   $h=5\text{m}$   $f=5,3\text{m}$

height of mast 10,3m

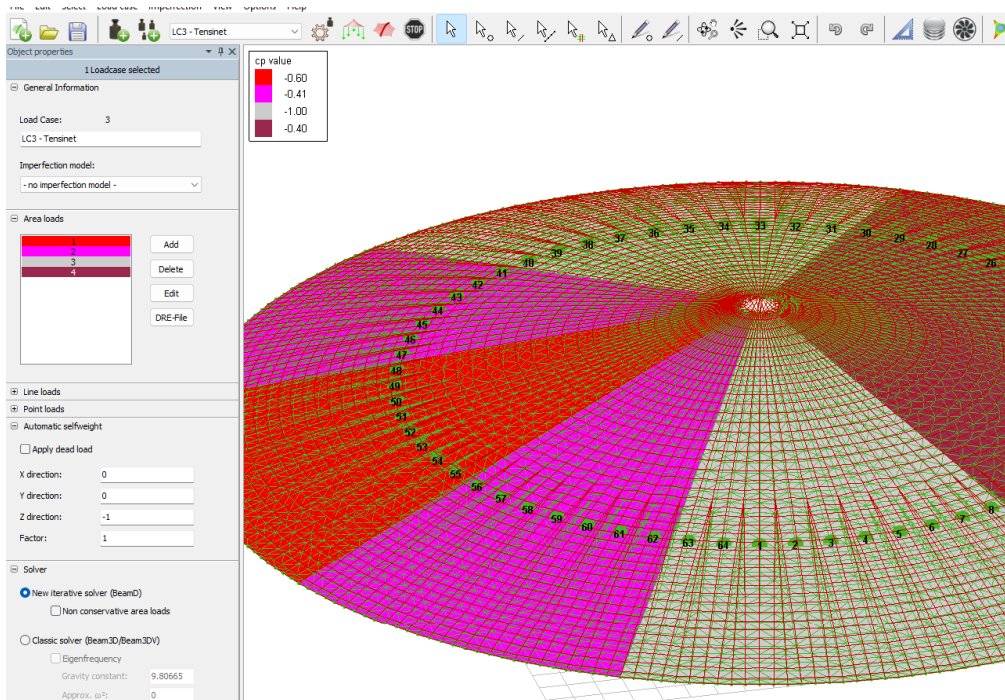
- membran with belts (x64) and mast
- inner pressure

DWA-M 377

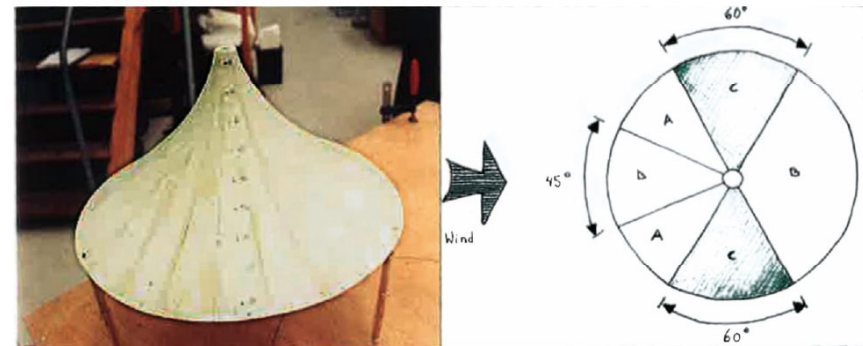


# cone shaped – Easy model

## Loadzones in Easy



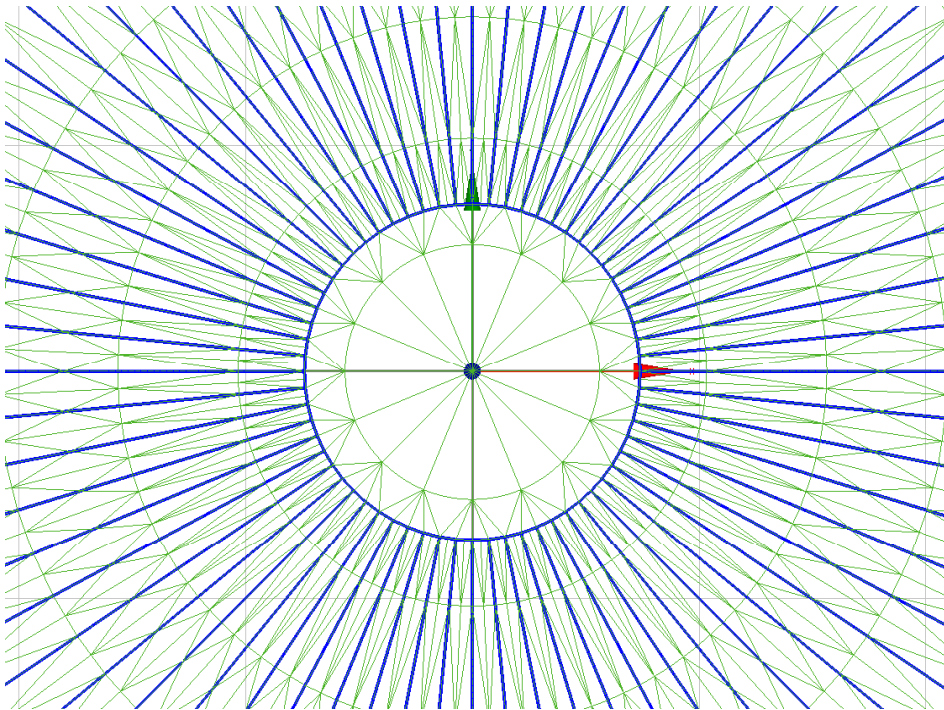
## Wind loads according to Tensinet guide



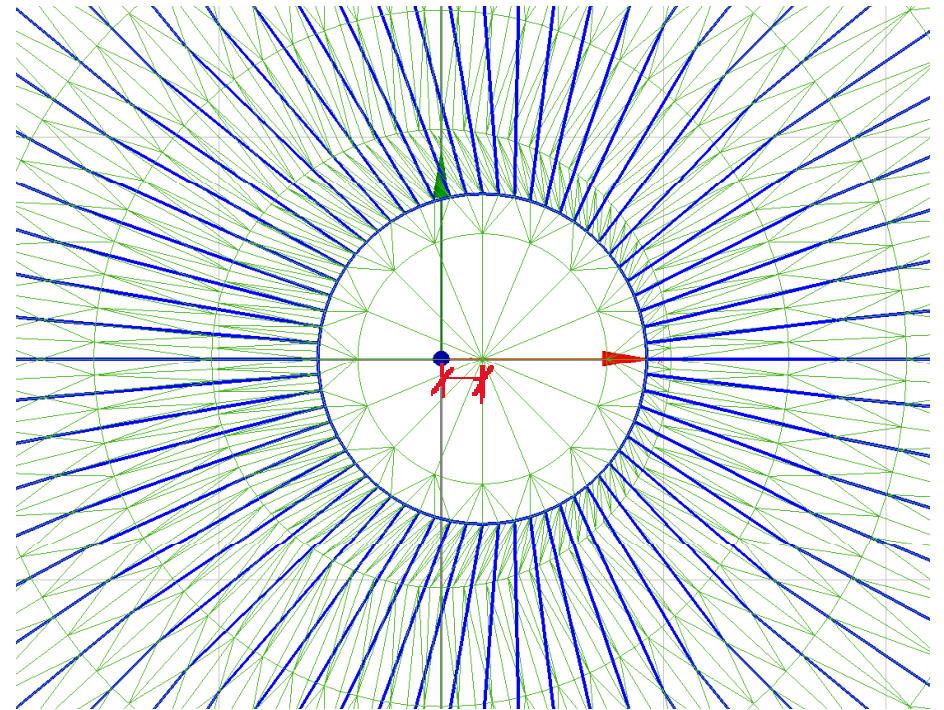
Bereich	A	B	C	D
$c_{pe}$ -Wert	-0,41	-0,7	-1,0	+0,75/-0,6

# cone shaped – Easy model

symmetrical model



unsymmetrical model

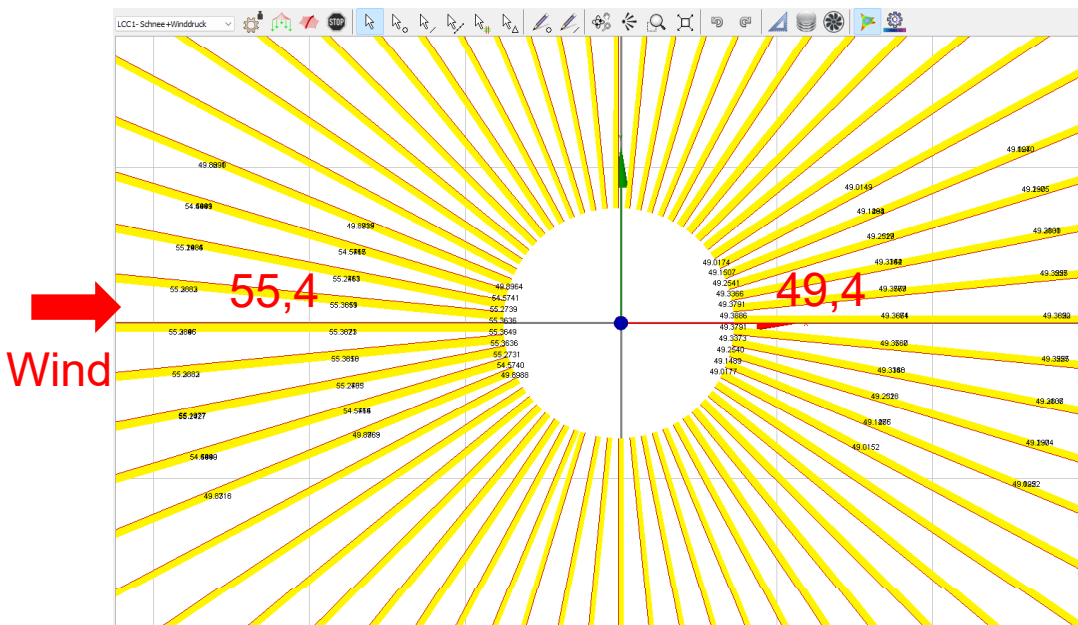


# cone shaped – results: snow+wind pressure

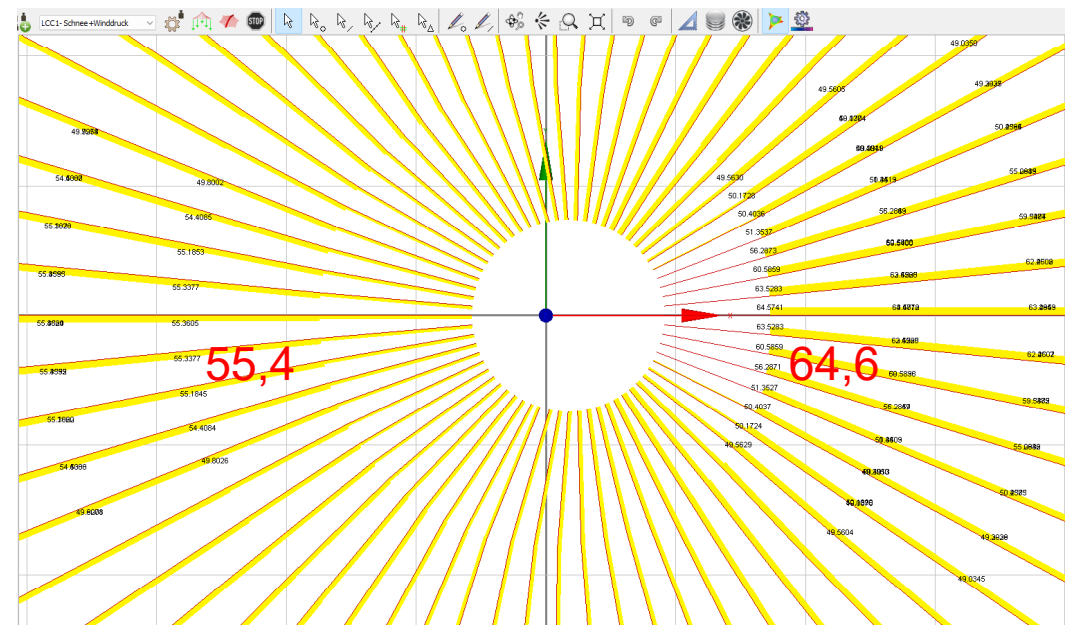
Parameters

Load Case	Factor
<input checked="" type="checkbox"/> LC1 - Eigengewicht	1.3500
<input type="checkbox"/> LC3 - Tensinet	1.0000
<input type="checkbox"/> LC4 - Schnee geteilt X- x1,0	1.0000
<input checked="" type="checkbox"/> LC2 - Schnee	1.5000
<input type="checkbox"/> LC5 - Innendruck	1.0000
<input checked="" type="checkbox"/> LC6 - Tensinet Druck	0.9000
<input type="checkbox"/> LC4 - Schnee geteilt X+ x1,0	1.0000

symmetrical



unsymmetrical

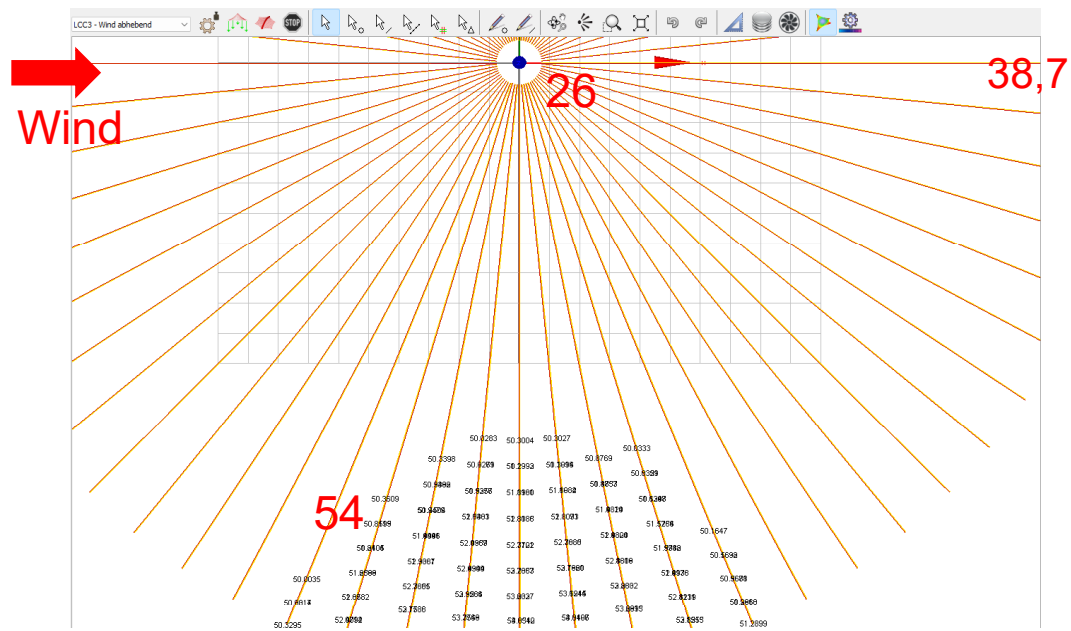


# cone shaped – results: wind suction

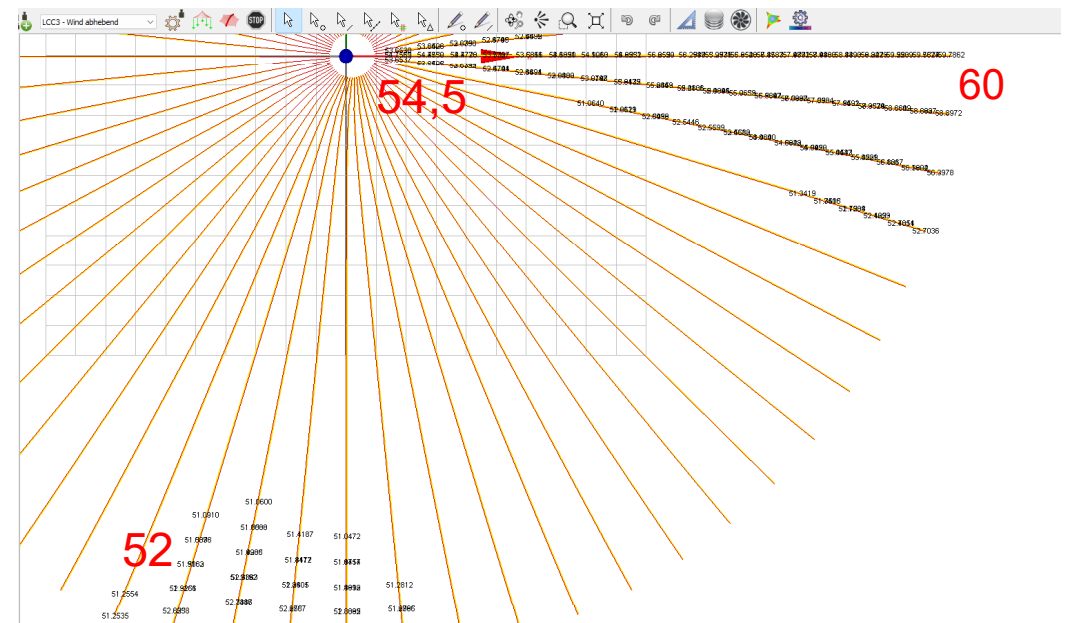
Parameters

Load Case	Factor
<input checked="" type="checkbox"/> LC1 - Eigengewicht	1.0000
<input checked="" type="checkbox"/> LC3 - Tensinet	1.5000
<input type="checkbox"/> LC4 - Schnee geteilt X- x1,0	1.0000
<input type="checkbox"/> LC2 - Schnee	1.0000
<input checked="" type="checkbox"/> LC5 - Innendruck	1.3500
<input type="checkbox"/> LC6 - Tensinet Druck	1.0000
<input type="checkbox"/> LC4 - Schnee geteilt X+ x1,0	1.0000

symmetrical

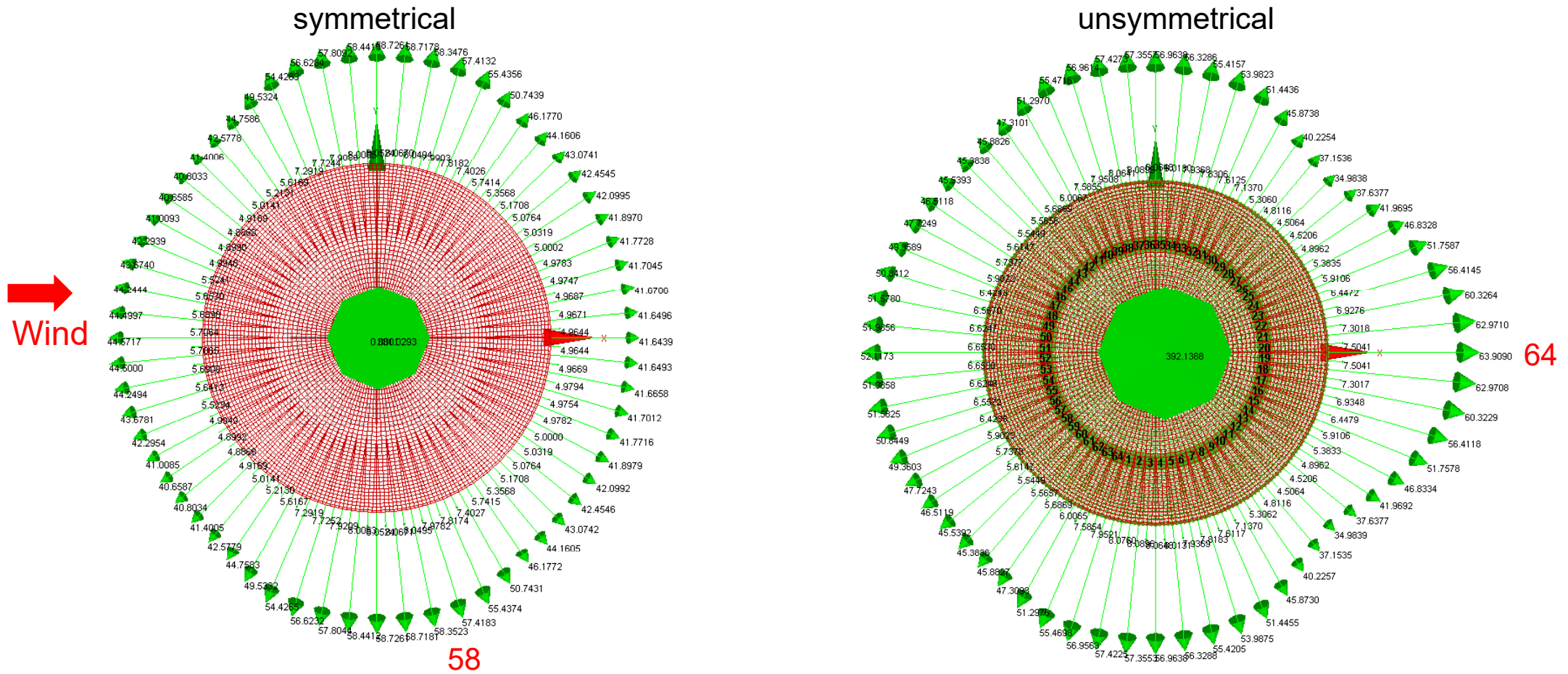


unsymmetrical



# cone shaped – conclusion: wind suction

- Higher peak forces



# calotte - models

- geometry of models:

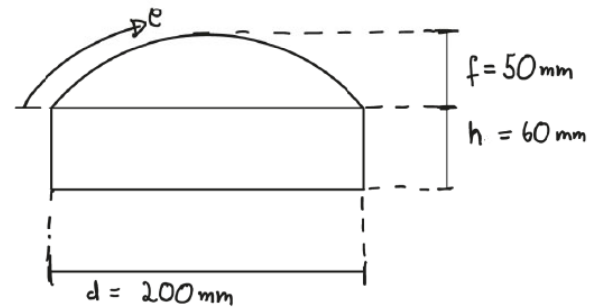
hemisphere

$d=20m$   $h=5m$   $f=10m$

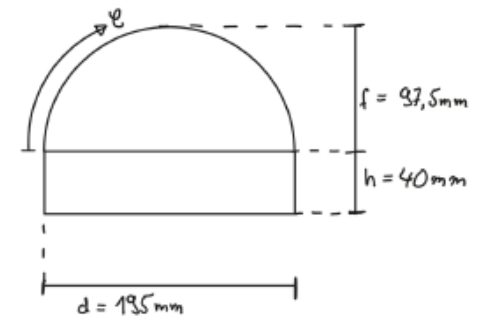
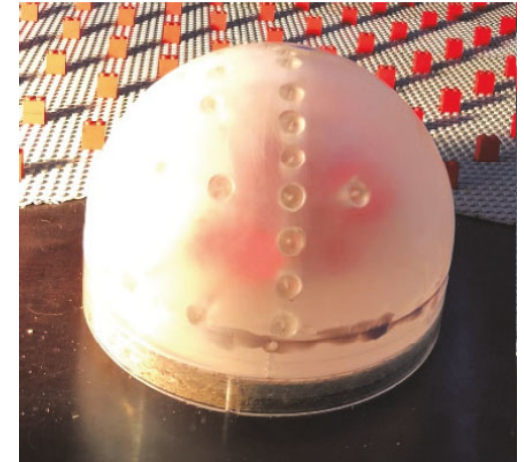
$\frac{1}{4}$  calotte

$d=20m$   $h=5m$   $f=5m$

$\frac{1}{4}$  calotte

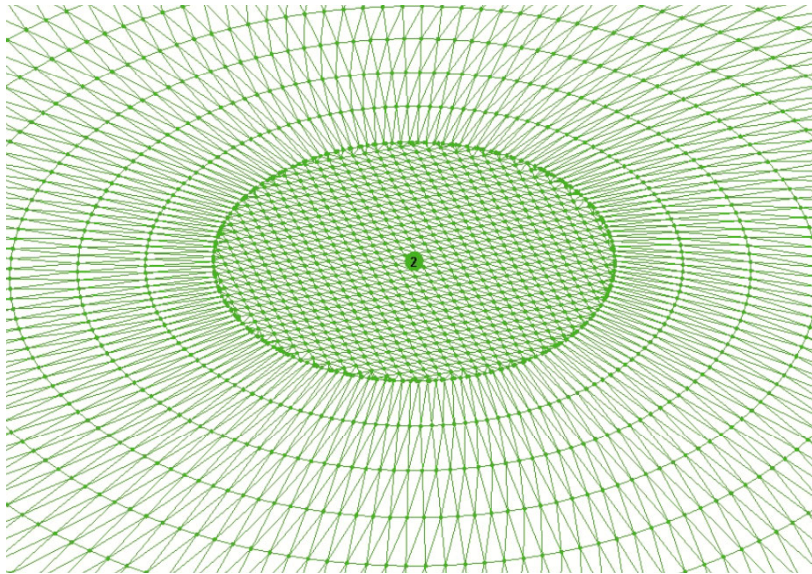


hemisphere

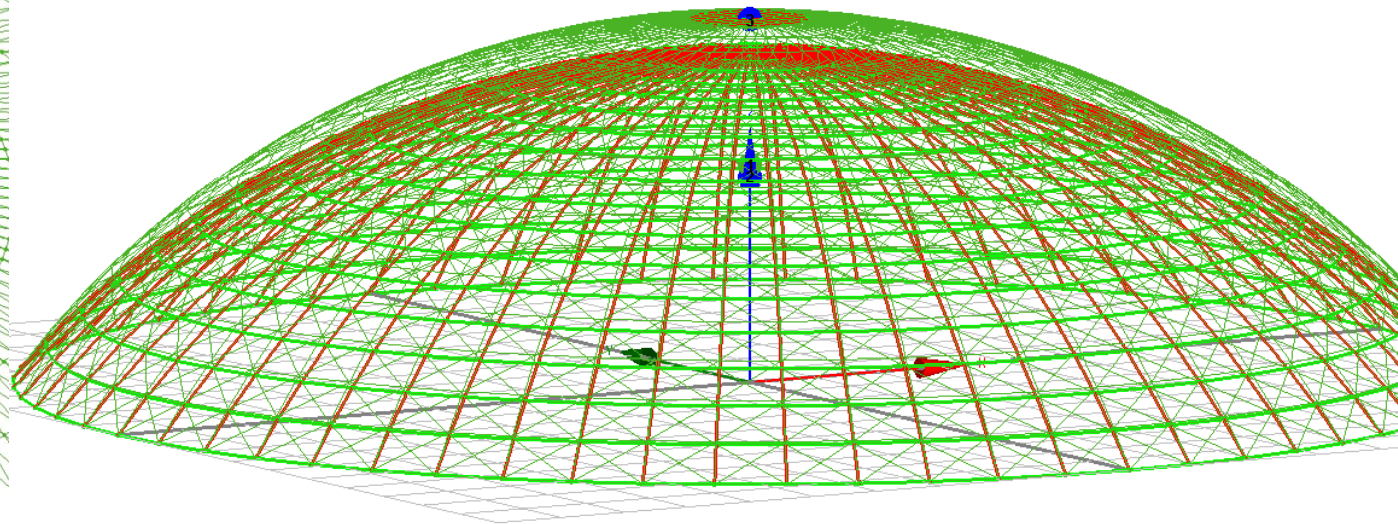


# calculations via Easy – some impressions

polcap at rooftop  
“top cover” 4x stiffness



2 chambers and polcap



# calculations via Easy – some impressions

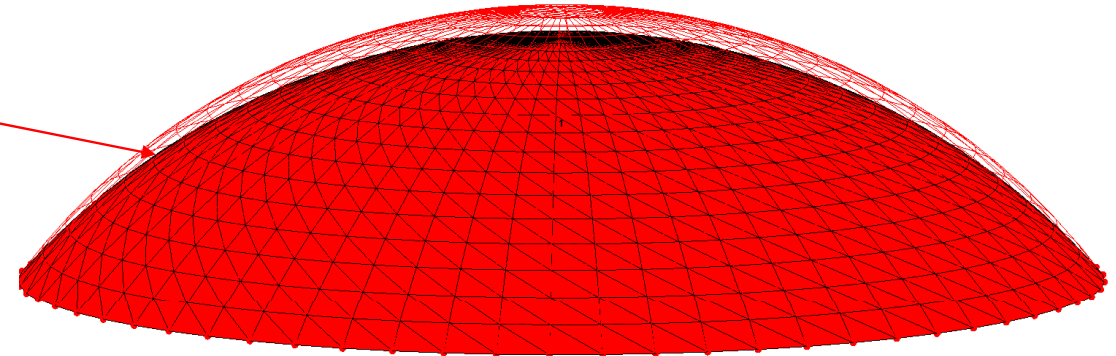
The screenshot displays the Easy software interface. On the left, the 'Object properties' panel shows '1 Loadcase selected' and 'LC1 - Eigengewicht'. The 'Solver' section is set to 'New iterative solver (BeamD)'. A 'Legacy Settings' dialog box is open, with 'BEAMD' selected. The 'Messages' window at the bottom shows 'Model loaded: I:\LI\OneDrive...'. A table in the 'Volume' section is highlighted with a red box:

C...	Type	Value
1	V(P+Po) constant (tech...	9621.010
2	V(P+Po) constant (tech...	75608.22

Below this table, the text 'inner pressure' is written in red. To the right, the 'BEAMD Settings' dialog box is open, showing a list of parameters and their values. The 'DREIC' entry is highlighted with a red box:

Use	Key	Value	File extension	I/K
	INI	EASY	.INI	
	KOOR	..EASY_BM	.KOO	
	ELDEF	..EASY_BM	.ELQ	
	ELQUER	..EASY_BM	.ELQ	
	ELVER	LOADGEN	.ELV	
	ELKRD	..EASY_BM	.ELK	
	ELXCE	..EASY_BM	.ELX	
	MATER	..EASY_BM	.MAT	
	FEDER	..EASY_BM	.FED	
	BEAM	..EASY_BM	.BEA	
	RELAT	..EASY_BM	.REL	
	ELLOK	..EASY_BM	.ELL	
	LAST	LOADGEN	.LAS	
	ELAST	LOADGEN	.ELA	
	ANGLE	..EASY_BM	.ANG	
	KODEF	..EASY_BM	.KOD	
	ROLL	..EASY_BM	.ROL	
	INPUT	VOLUME	.INP	
	DREI	..CHAMBERS	.DRE	
	INPUTL	LOAD	.INP	
	DREIV	PUTZV	.DRE	
	DREIS	PUTZS	.DRE	
	DREIC	..V..SPHERE_INNER_Schritt4	.DRE	
	REPORT	LOADGEN1	.REP	
	POLYGON	DATEN	.POL	
	LASTE	LOADINC	.LAS	
	AKOOR	BEAMD	.KOO	
	ELKRDA	BEAMD	.ELK	
	LASTA	BEAMD	.LAS	
	ELLOKA	BEAMD	.ELL	
	ELVERA	BEAMD	.ELV	

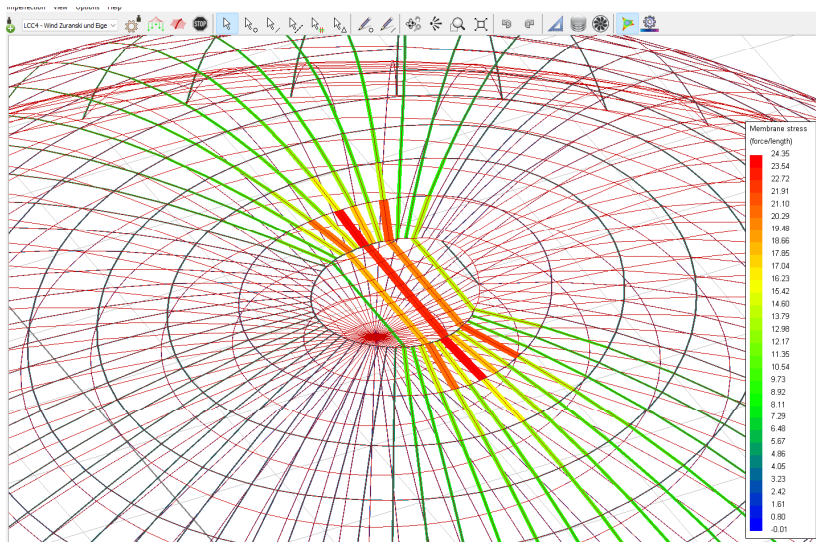
surface of inner membran



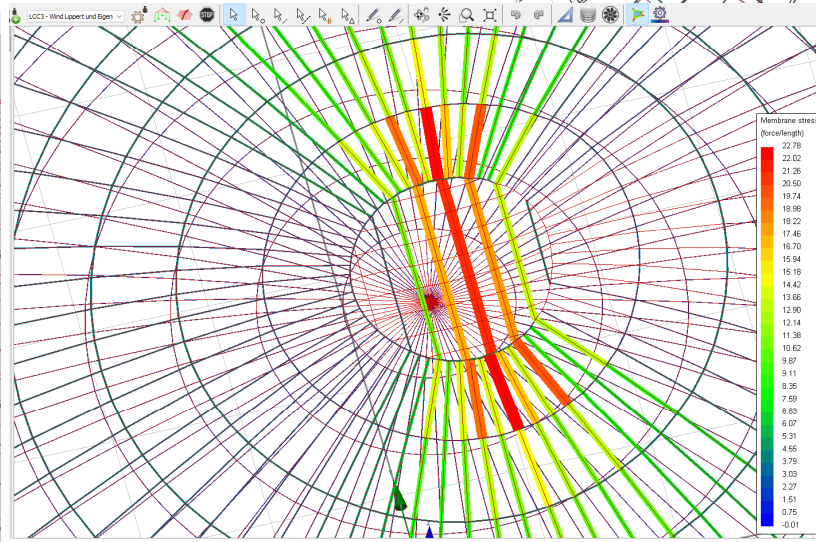
# results – ¼ calotte stress

- wind x1,5 and selfweight x1,35
- DIN 4134 → stress: 15,24

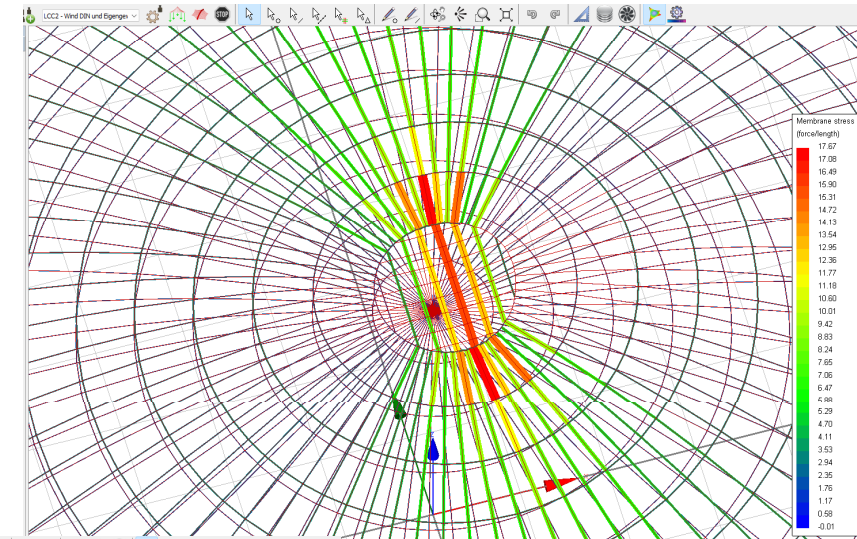
Zuranski – stress: 24,35 →60%



Lippert – stress: 22,76  
→ 49%



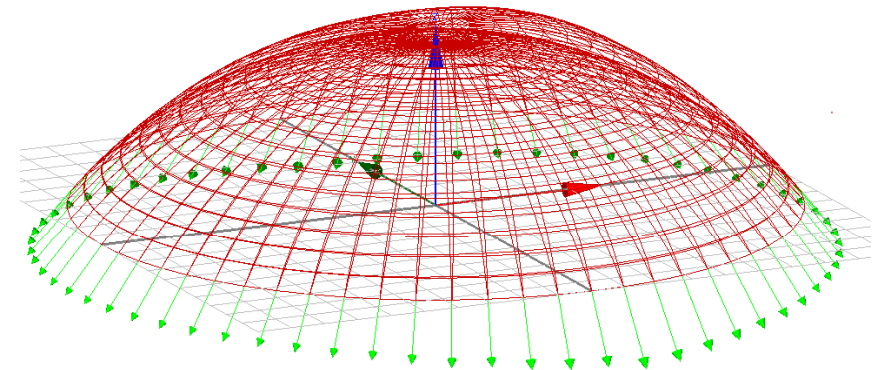
DIN EN – stress: 17,67 → 16%



# results – ¼ calotte resulting forces

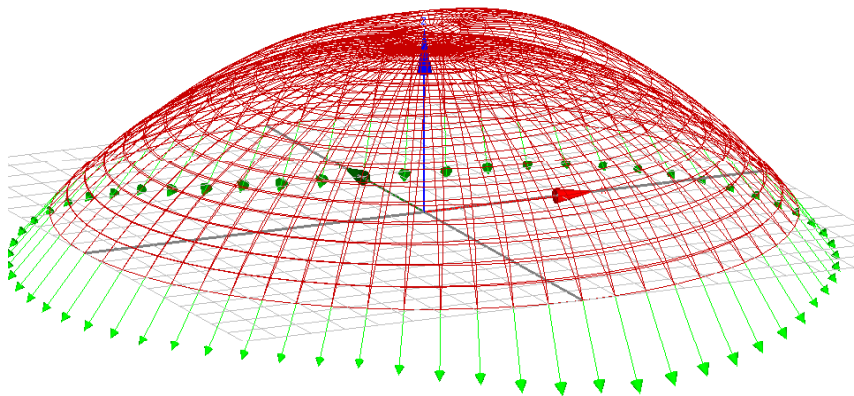
- wind and selfweight
- DIN 4134 → 10,61

DIN EN – resulting forces



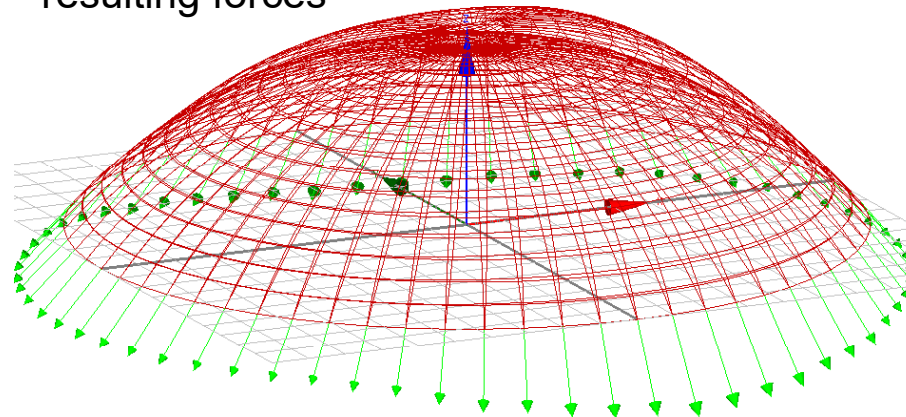
6 → -43%

Zuranski – resulting forces



7 → -34%

Lippert –  
resulting forces

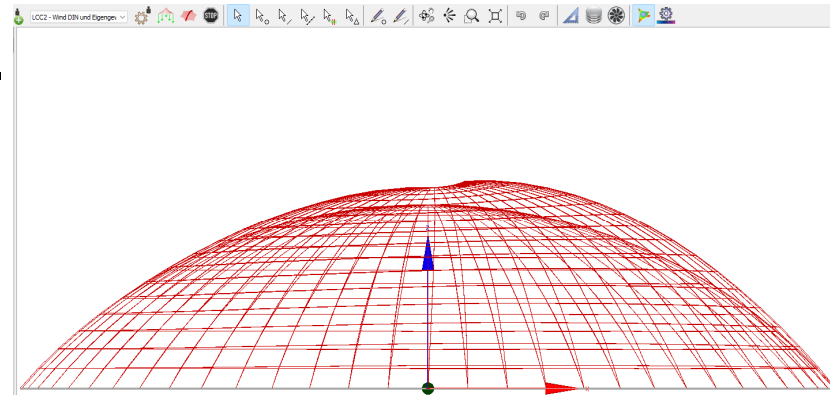


6,8 → -36%

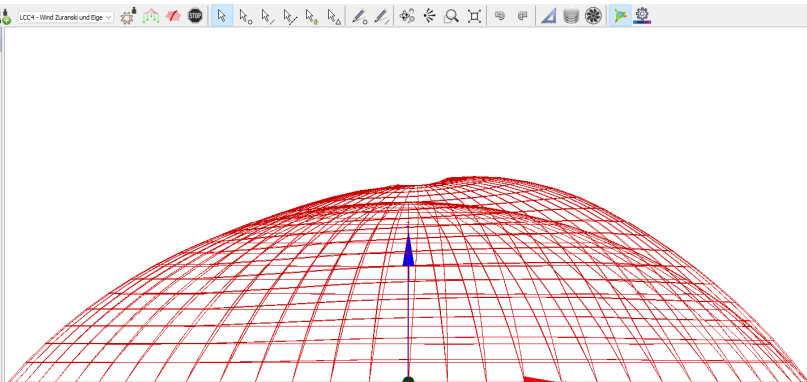
# results – ¼ calotte deformation

- wind x1,5 and selfweight x1,35

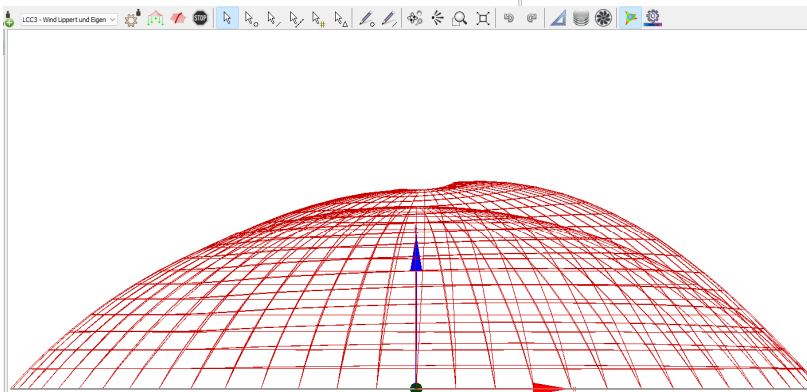
DIN EN – deformation x1



Zuranski – deformation x1



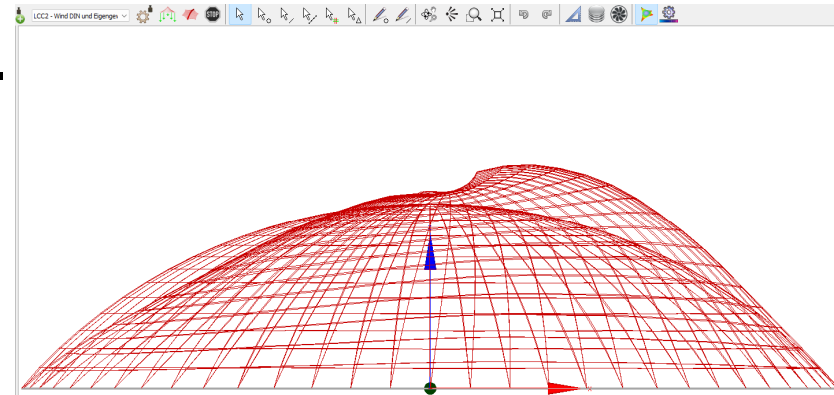
Lippert – deformation x1



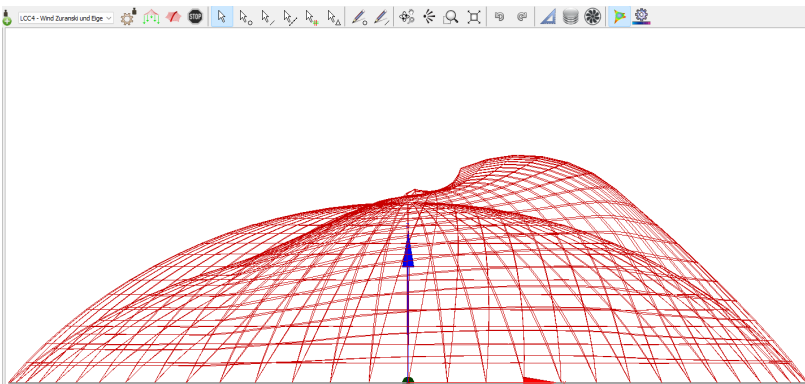
# results – ¼ calotte deformation

- wind x1,5 and selfweight x1,35

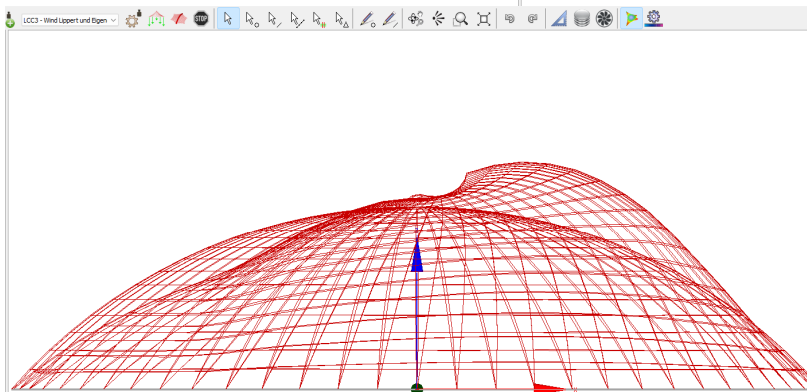
DIN EN – deformation x3



Zuranski – deformation x3



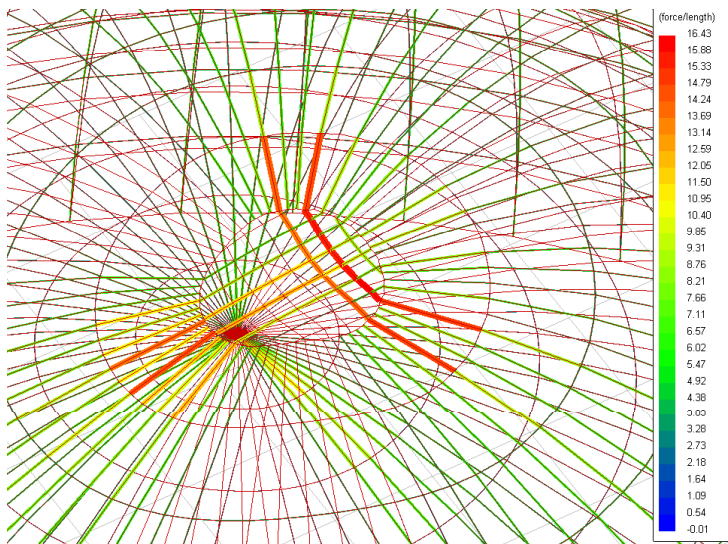
Lippert – deformation x3



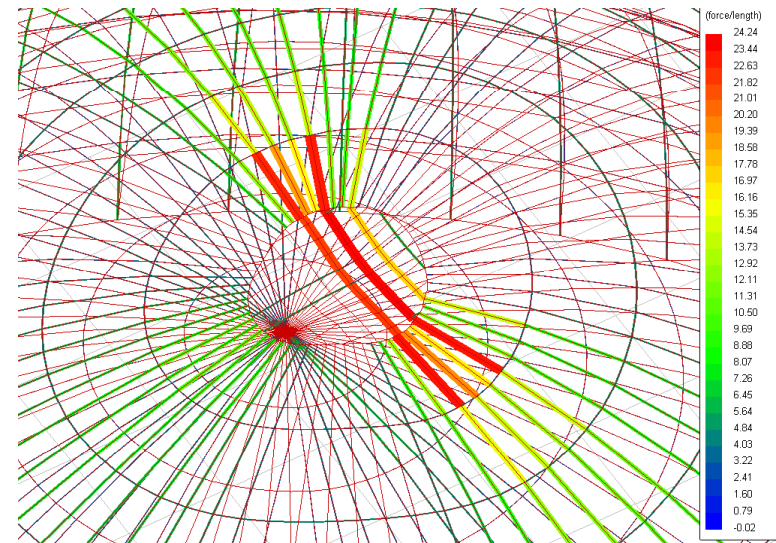
# results – hemisphere stress

- wind x1,5 and selfweight x1,35
- DIN 4134 -> stress: 12,19

Lippert – stress: 16,43 → 35%



DIN EN – stress: 24,24 → 99%

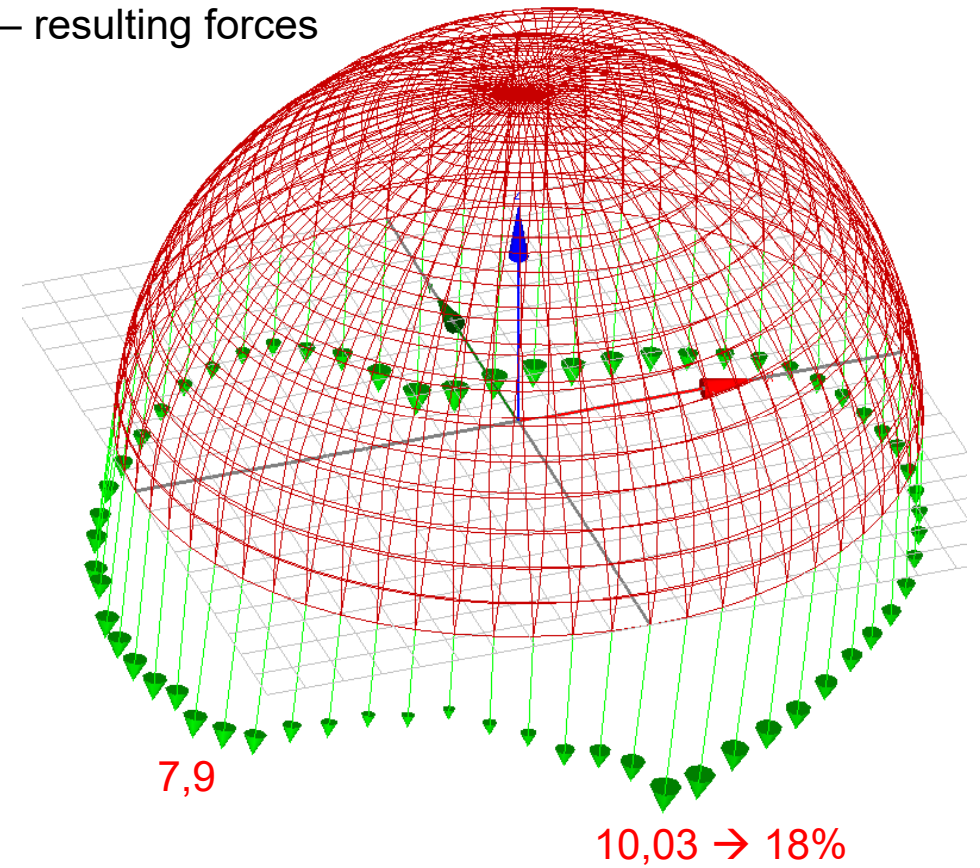
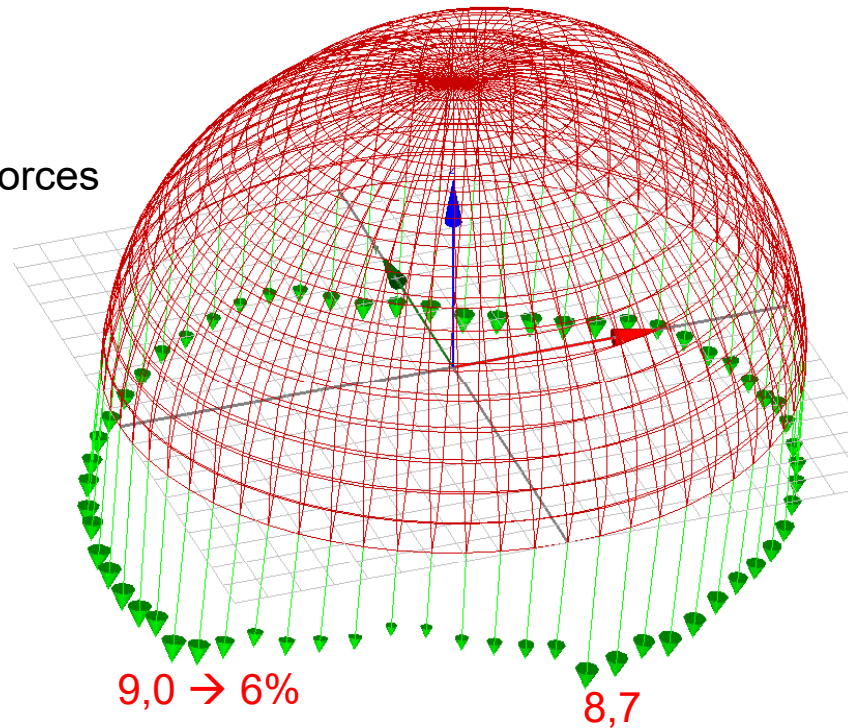


# results – hemisphere resulting forces

- wind and selfweight
- DIN 4134 → 8,5

DIN EN – resulting forces

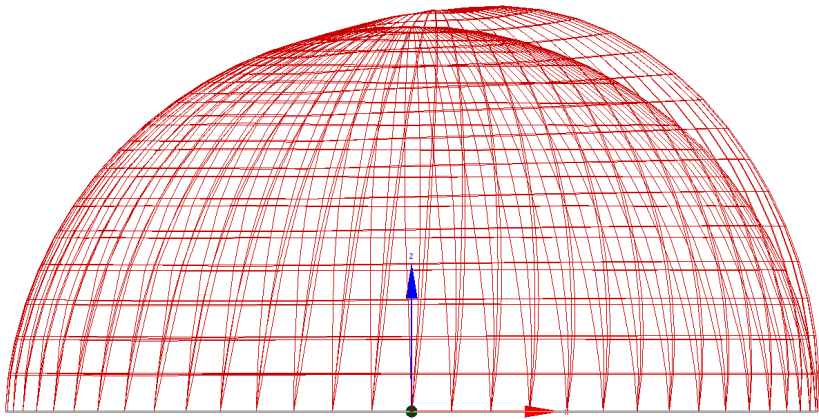
Lippert –  
resulting forces



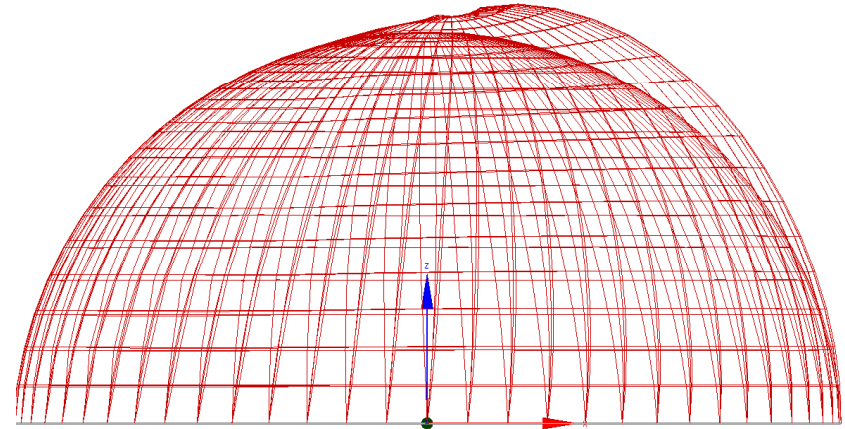
# results – hemisphere deformation

- wind x1,5 and selfweight x1,35

Lippert – deformation x1



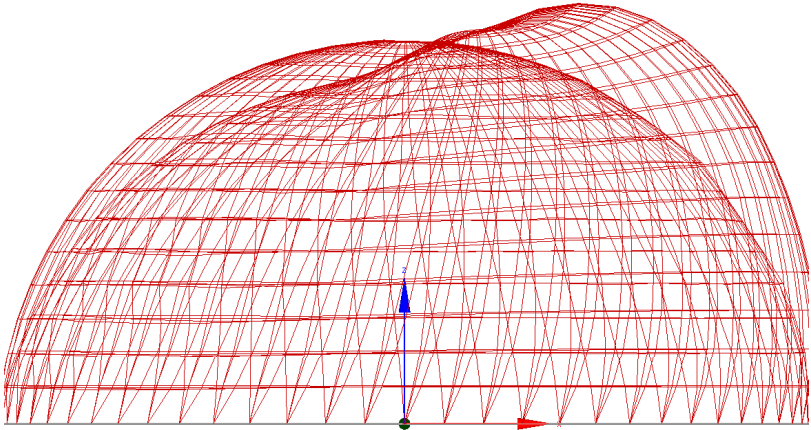
DIN EN – deformation x1



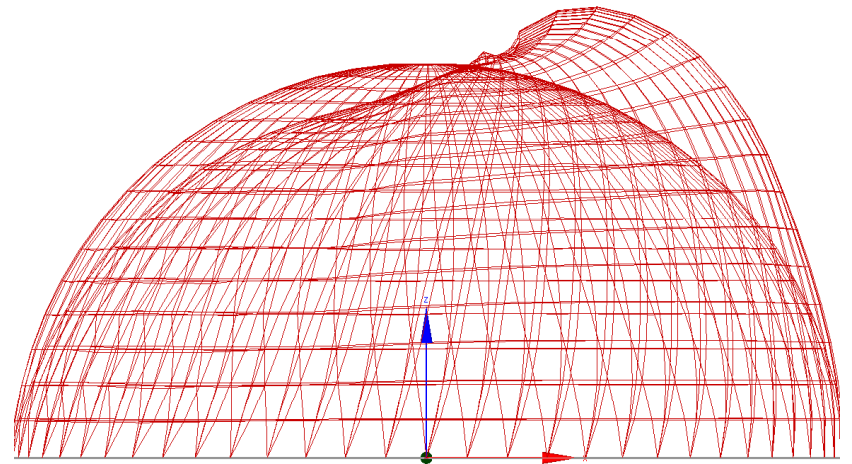
# results – hemisphere deformation

- wind x1,5 and selfweight x1,35

Lippert – deformation x3



DIN EN – deformation x3



## results – what is missing

- temperatur differences
- fluctuating pressure/volume
- different filling level of biogas
- design resistance values of material

# conclusion

- more precise statical analysis for biogas storages
- compare results with practical expiarence

Questions?