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Earth Air Tunnel: Design basics

Weather data

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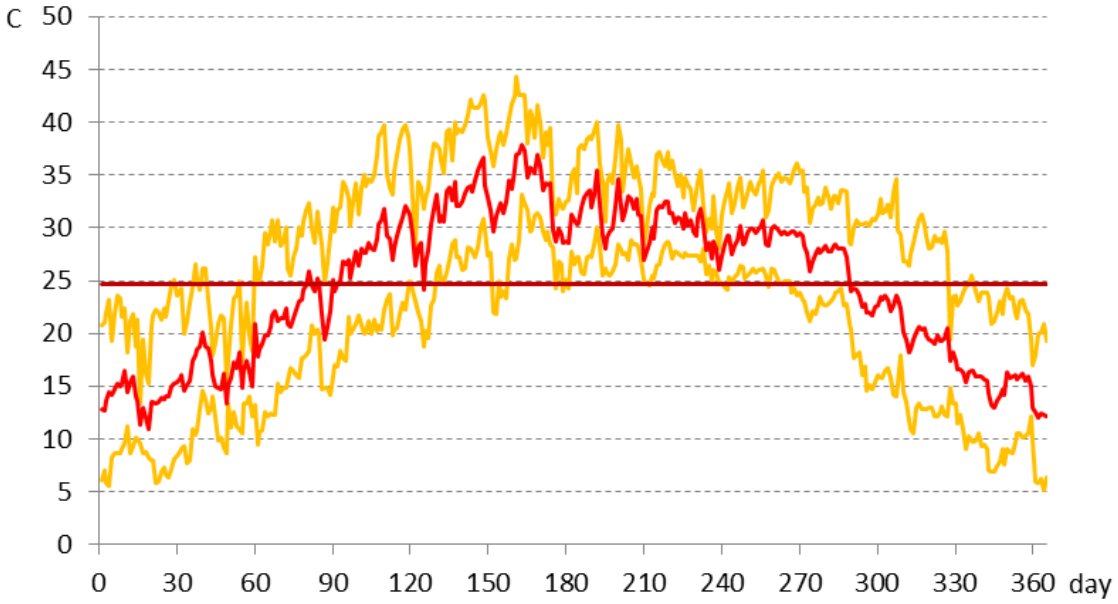
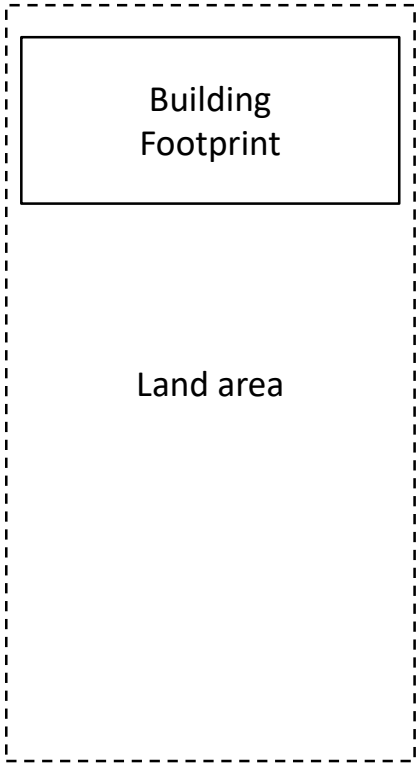
New Delhi weather data



- Annual mean: 24.7 °C
- Daily mean (hottest): 37.0 °C
- Daily max (hottest): 44.3 °C
- Annual half amplitude (hottest): 37.0 – 24.7 = 12.3 °C
- Daily half amplitude (hottest): 44.3 – 37.0 = 7.3 °C

Building data



Building

- Length: 50 m
- Width: 22 m
- Height: 3 m
- Footprint: 1100 m2
- Land area: 5000 m2
- Air change: 6 ach
- Air flow: 20’000 m3/h

Daily dampening

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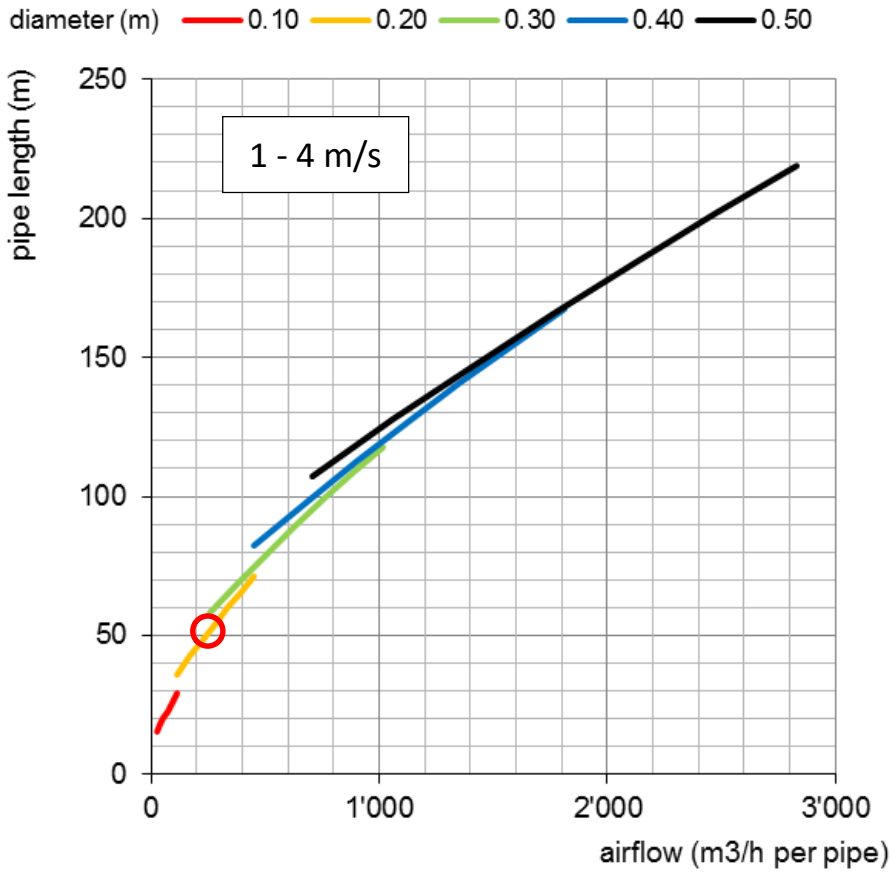
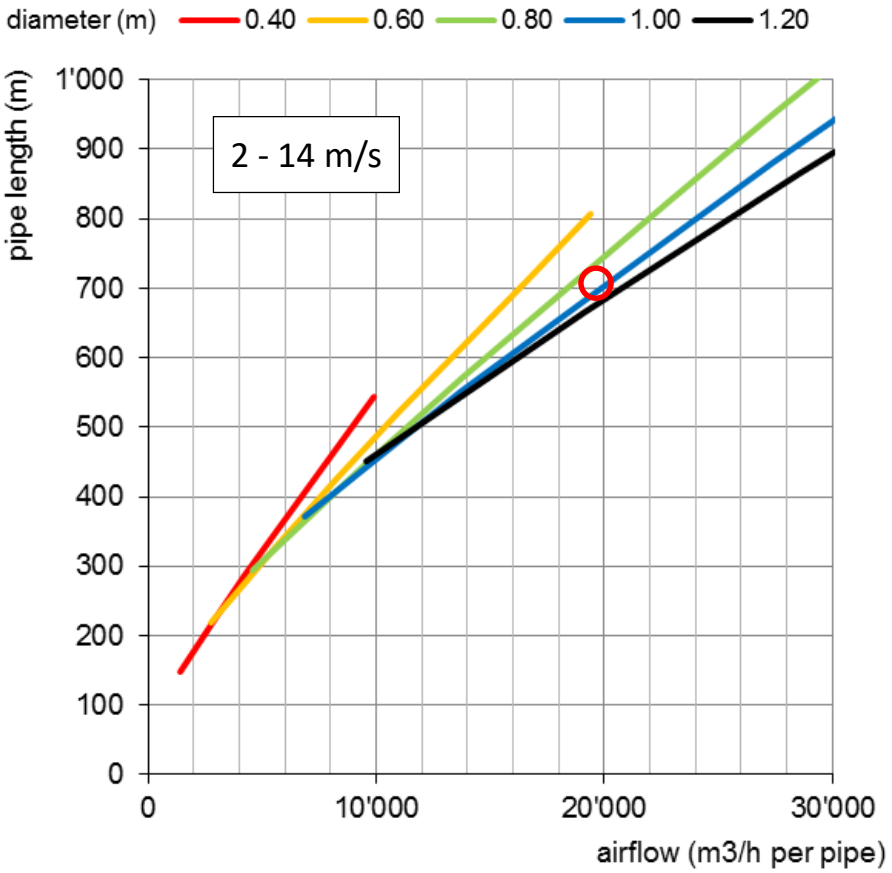
Soil around pipe: ~ 20 cm





Option 1 (length constraint):

- Pipe: 50 m (diameter 20 cm) => 250 m3/h
- No pipes: 80 => total length: 4000 m
- Velocity: 2.2 m/s

Option 2 (pipe in zig-zag):

- Pipe: 700 m (diameter 100 cm) => 20’000 m3/h
- No pipes: 1 => total length: 700 m
- Velocity: 7.1 m/s

Daily dampening

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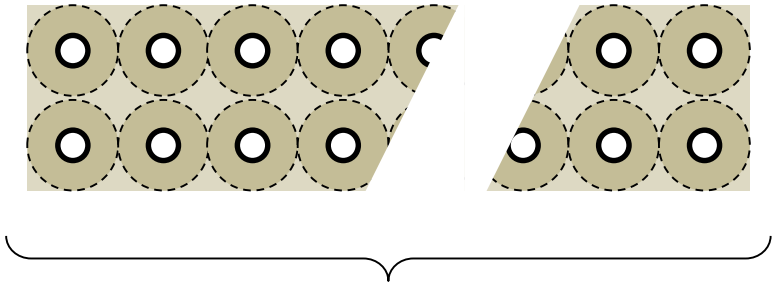
Size

Option 1:

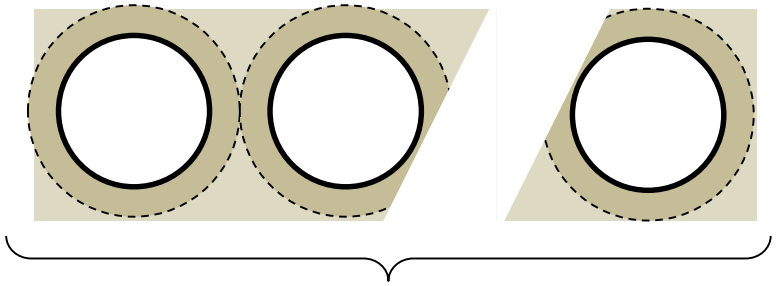
- Width per pipe: 0.2 + 2 x 0.2 = 0.6 m
- Area (monolayer): 0.6 x 4000 = 2’400 m2
- Layers under building: 2’400/1’100 ~ 2



2 x 40 pipes, one way

Option 2:

- Width per pipe: 1.0 + 2 x 0.2 = 1.4 m
- Area (monolayer): 1.4 x 700 = 980 m2
- Layers under building: 1



1 pipe, 7 x back-and-forth

Daily dampening

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Expected peak performance

Inlet:

- Daily mean: 37.0 °C
- Daily half amplitude: 7.3 °C
- Daily max: 37.0 + 7.3 = 44.3 °C

Outlet

- Daily mean: 37.0 °C
- Daily half-amplitude: 15% x 7.3 °C = 1.1 °C
- Daily max: 37.0 + 1.1 = 38.1 °C

Peak performance:

- Temp. drop: 43.4 – 38.1 = 6.2 °C
- Cooling: 20’000 m3/h x 6.2 °C x 0.3 = 37.2 kW

Daily dampening

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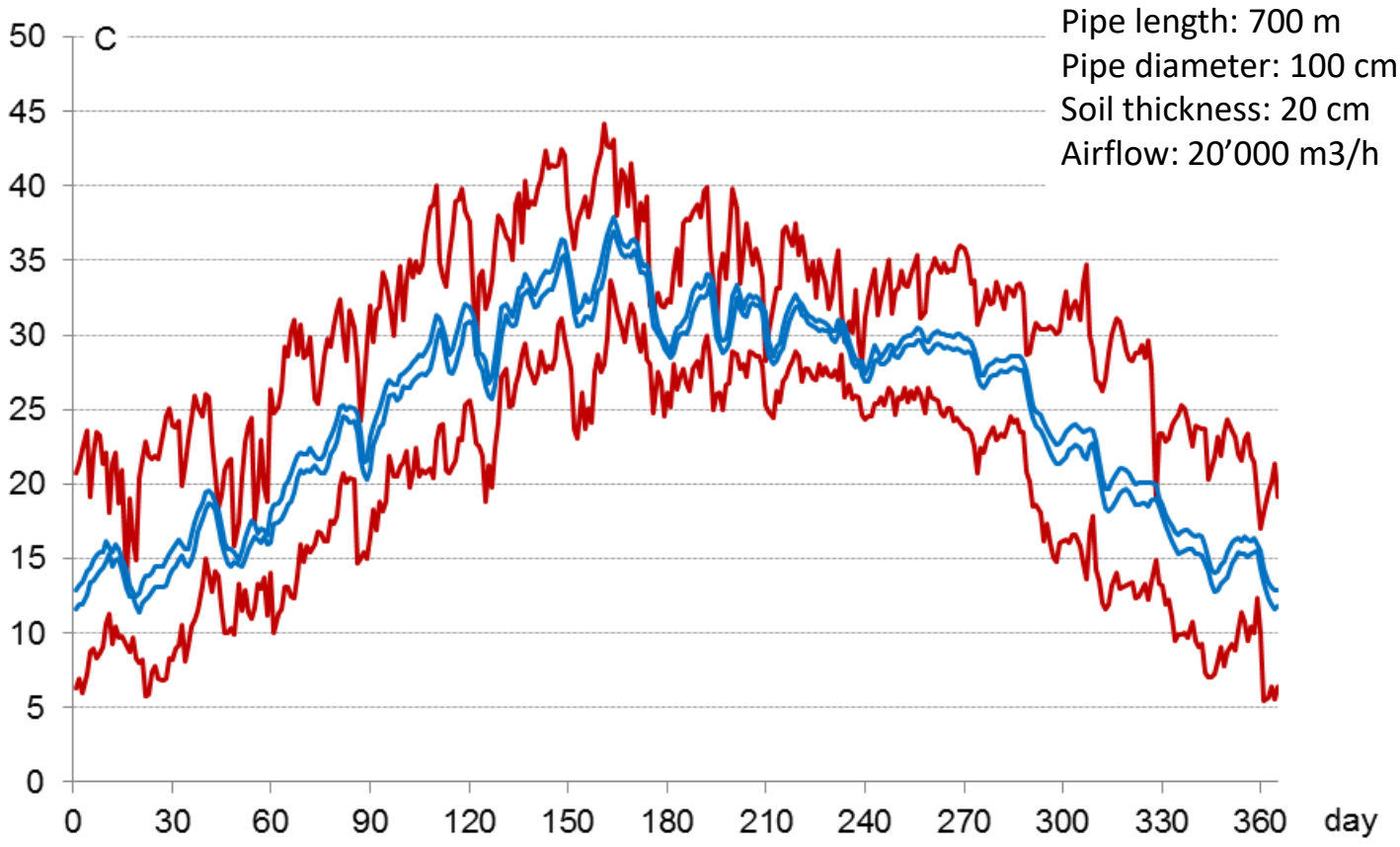
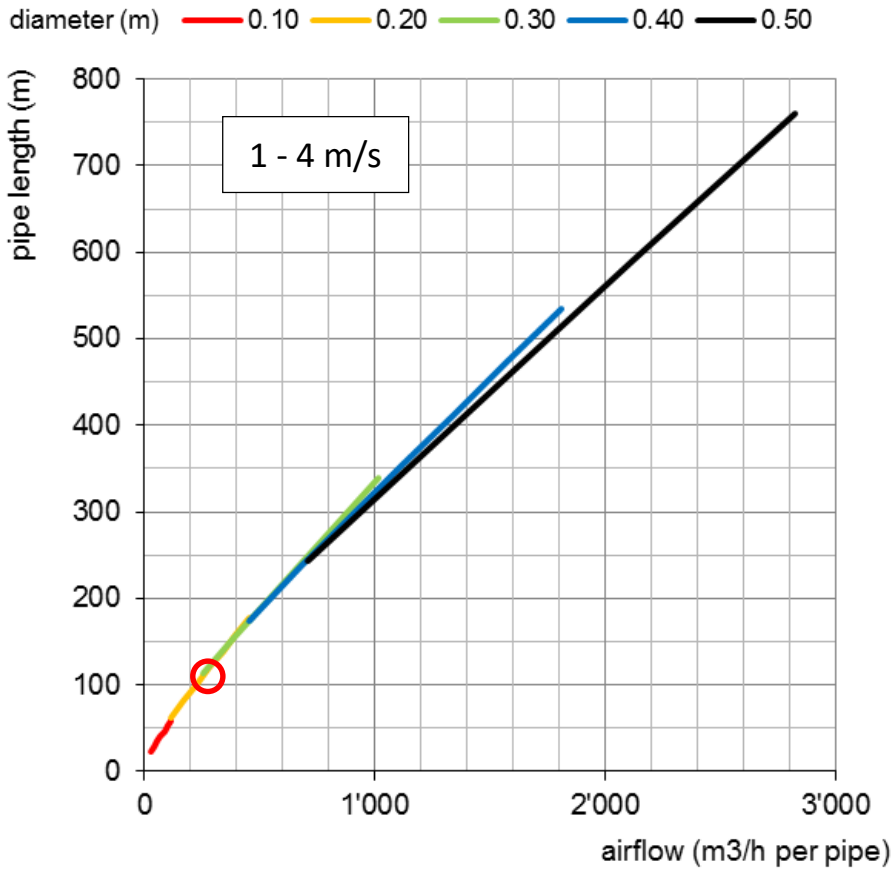
Expected dynamic (analytical model, EP.Basic)

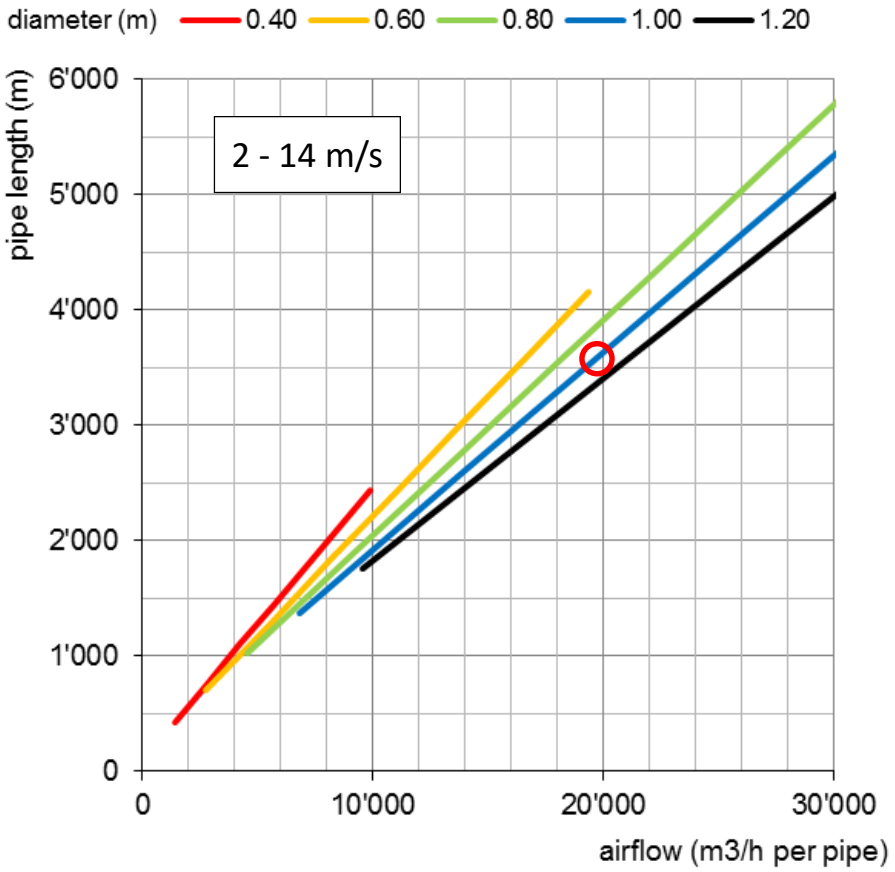


Pipe length: 700 m
Pipe diameter: 100 cm
Soil thickness: 20 cm
Airflow: 20’000 m3/h

Annual dampening

Soil around pipe: ~ 260 cm





Option 1:

- Pipe: 100 m (diameter 20 cm) => 250 m3/h
- No pipes: 80 => total length: 8’000 m
- Velocity: 2.2 m/s

Option 2 (pipe in zig-zag):

- Pipe: 3’500 m (diameter 100 cm) => 20’000 m3/h
- No pipes: 1 => total length: 3’500 m
- Velocity: 7.1 m/s

Annual dampening

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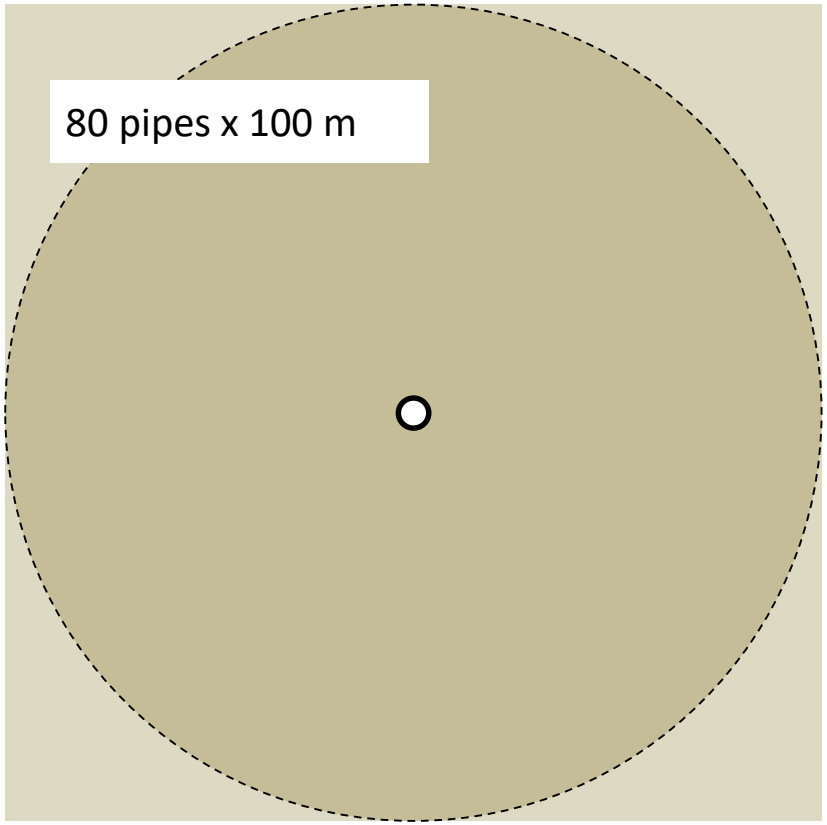
Size

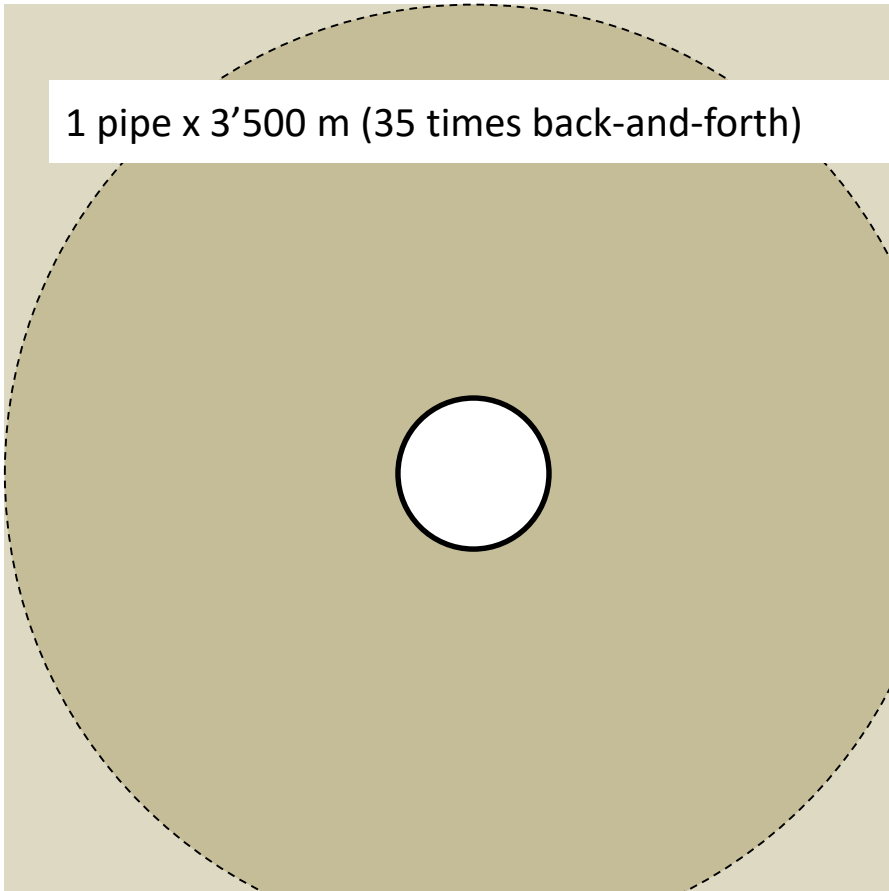
Option 1:

- Width per pipe: 0.2 + 2 x 2.6 = 5.4 m
- Total area: 8’000 m x 5.4 m = 43’200 m2 !!
- Total width: 43’200 m2 / 100 m = 430 m !!



Option 2:

- Width per pipe: 1.0 + 2 x 2.6 = 6.2 m
- Total area: 3’500 x 6.2 m = 21’700 m2 !!
- Total width: 21’700 m2 / 100 m = 217 m !!



Annual dampening

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Downsizing of length

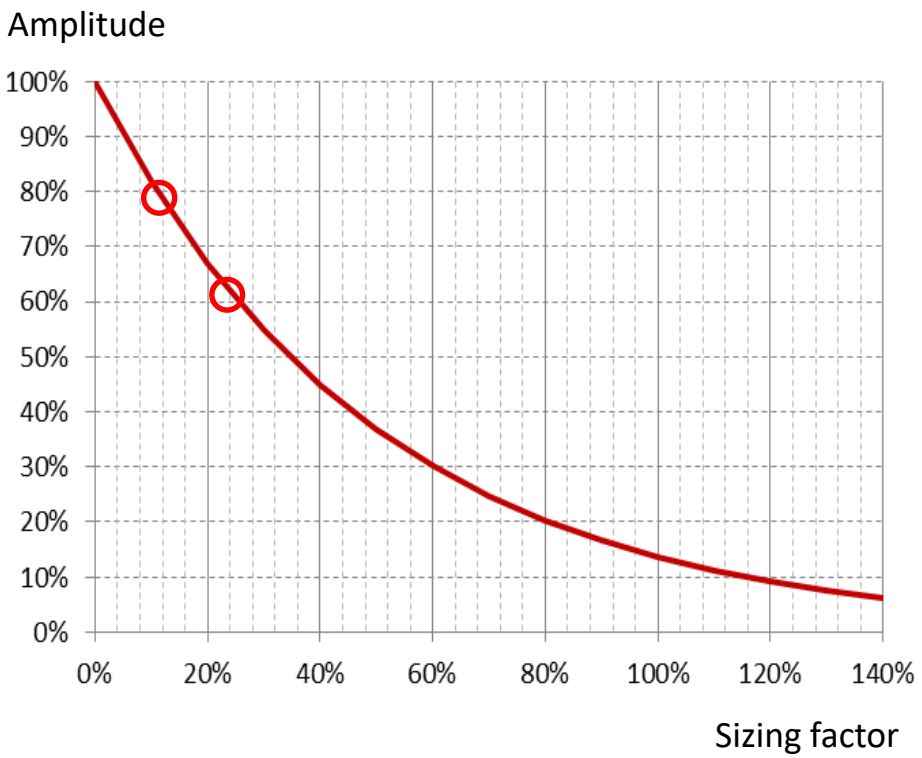
Option 1:

- Length possible: (5000 m2 / 43’200 m2) x 100 m/pipe = 12 m/pipe
- Complicated / unfeasible configuration !!

- Length nomograph annual: 100 m/pipe
- Sizing factor annual: 12/100 = 12%
- Amplitude annual: 80% !!

- Length nomograph daily: 50 m/pipe
- Sizing factor daily: 12/50 = 24%
- Amplitude daily: 60% !!

⇒ Unfeasible + bad results
⇒ Start with longer pipe length, then downsize



Annual dampening

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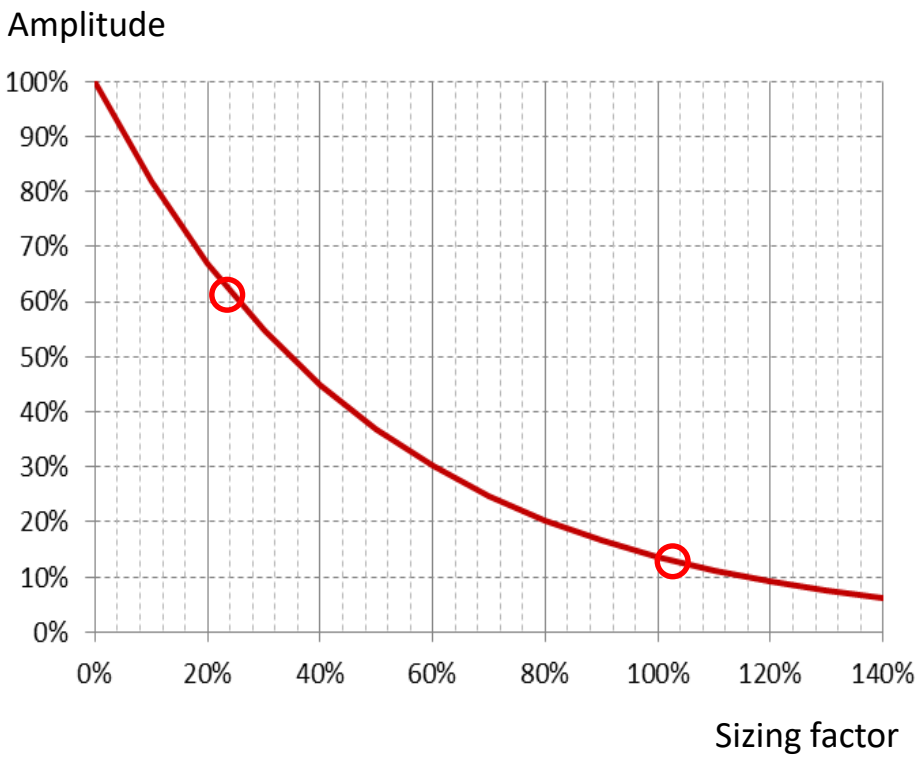
Downsizing of length

Option 2:

- Length possible: (5'000 m2 / 21'700 m2) x 3'500 m = 800 m
- 8 x back-and-forth on site length

- Length nomograph annual: 3'500 m
- Sizing factor annual: 800/3'500 = 23%
- Amplitude annual: 60%

- Length required daily: 700 m
- Sizing factor daily: 800/700 = 114%
- Amplitude daily: 12%



Annual dampening

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Expected performance

Option 2

Inlet:

- Annual mean: 24.7 °C
- Annual half amplitude: 12.3 °C
- Daily half amplitude: 7.3 °C
- Daily max: 24.7 + 12.3 + 7.3 = 44.3 °C

Outlet

- Annual mean: 24.7 °C
- Annual half-amplitude: 60% x 12.3 °C = 7.4 °C
- Daily half-amplitude: 12% x 7.3 °C = 0.8 °C
- Daily max. (hottest): 24.7 +7.4 + 0.8 = 32.9 °C

Performance:

- Temp. drop: 44.3 – 32.9 = 11.4 °C
- Cooling: 20’000 m3/h x 11.4 °C x 0.3 = 68.4 kW

Annual dampening

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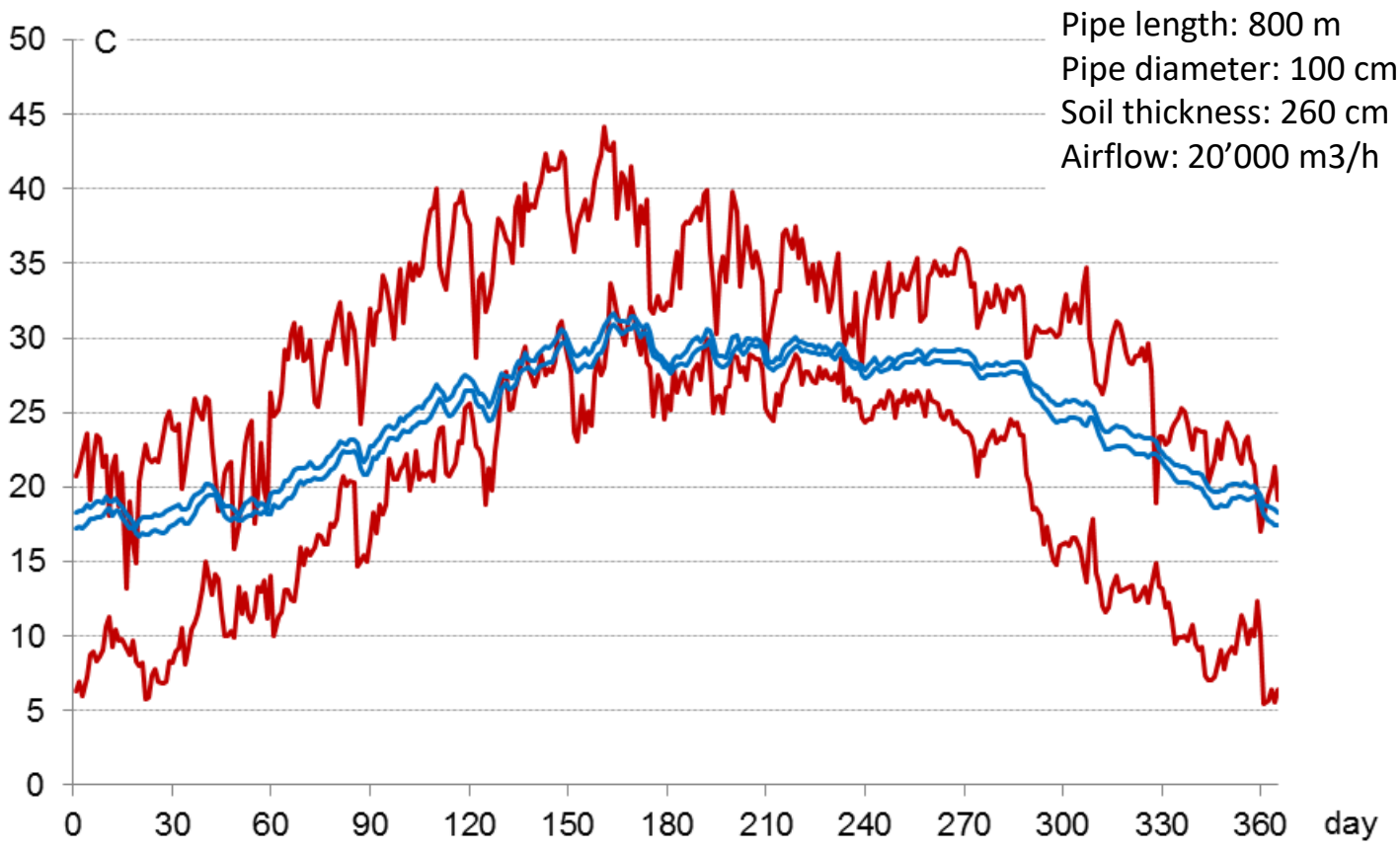
Expected dynamic (analytical model, EP.Basic)



Pipe length: 800 m
Pipe diameter: 100 cm
Soil thickness: 260 cm
Airflow: 20’000 m3/h

Perturbation from upper surface not taken into account!!