

Cooling Tower Siting

Siting factors

- Recirculation & interference
 - Types of Tower
 - Wind direction
- Air inlet space requirements
 - Walls / Enclosures / Existing structures
 - Available plan area
- Existing basins / supporting steels
- Installation and maintenance access
- Piping and pump requirements
- Noise
- Visible plume



Siting factors

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- **Installation and maintenance access**

- **Piping and pump requirements**

- **Noise restrictions**

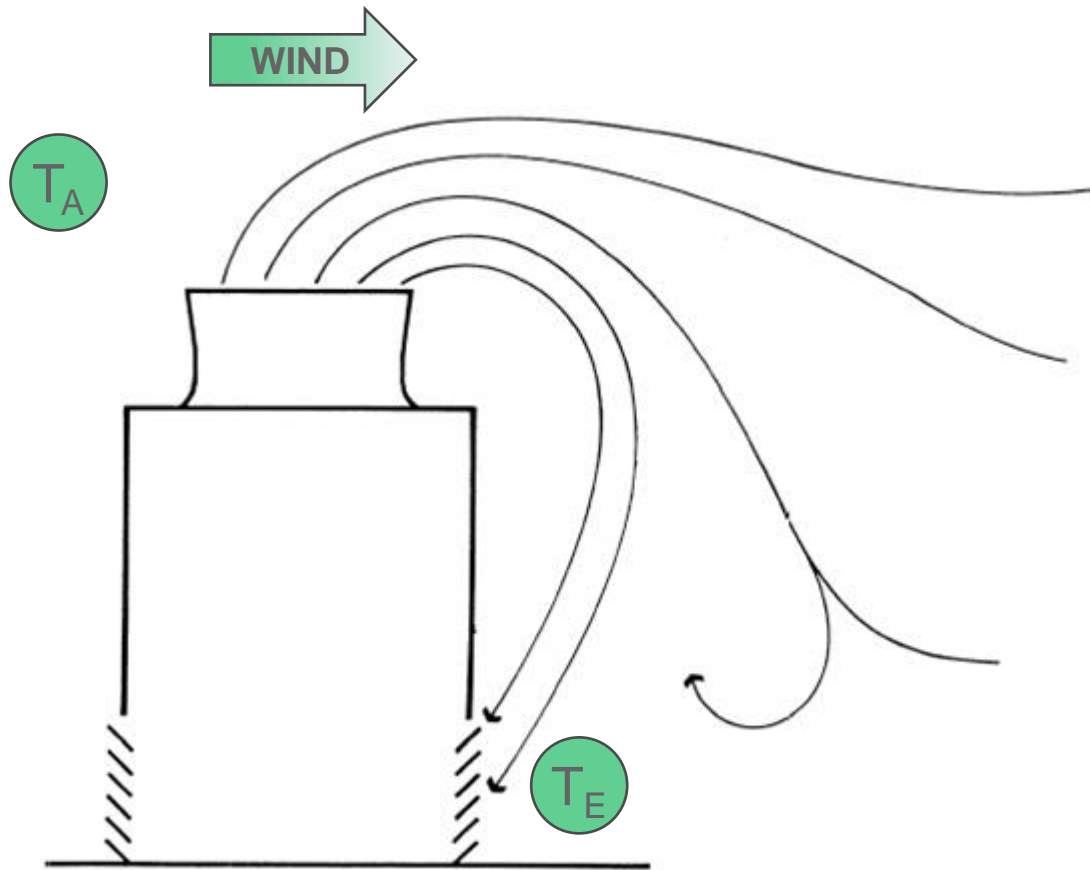
- **Visible plume**

Covered in separate presentations

- Recirculation & Interference

Recirculation

It is wet bulb at the tower air inlet which matters



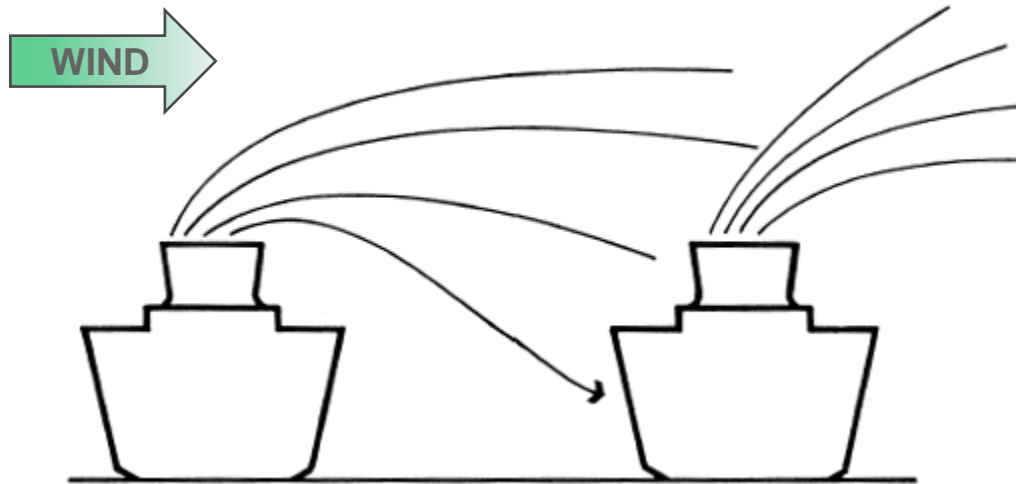
T_A – Ambient wet bulb is a general number which could apply anywhere in the site vicinity

T_E – Entering wet bulb is the temperature entering the tower, taking into consideration location specific factors, such as saturated air from the tower discharge, being induced back into the air inlets

Pay attention to what data the client has given you

Interference

It is wet bulb at the tower air inlet which matters



Local heat sources up wind of the cooling tower can elevate the wet bulb temperature of the air entering the tower, thereby affecting its performance. This could be an existing cooling tower, or another source of heat. This phenomenon is called “interference”.

Pay attention to what data the client has given you, this may tell you what considerations they have already taken

Recirculation

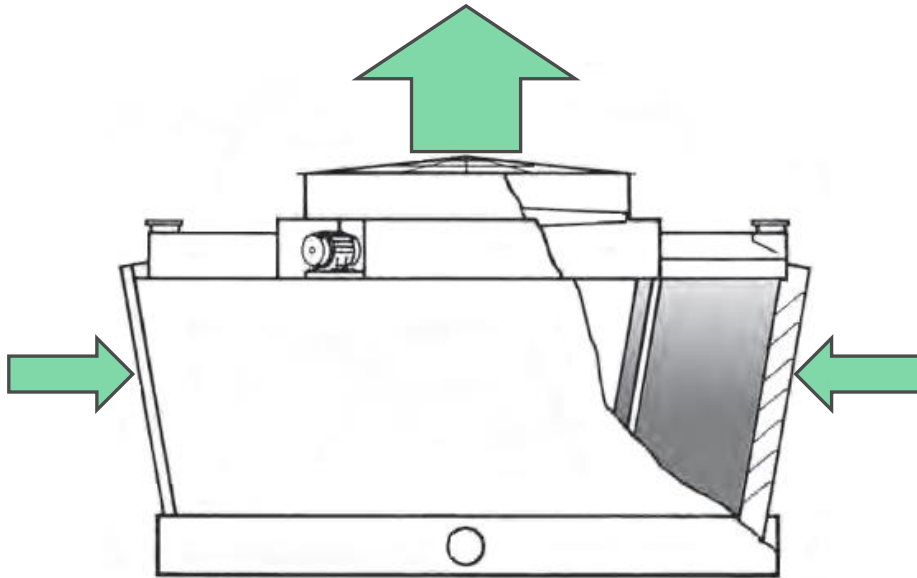
Factors that determine the amount of recirculation:

- **Discharge velocity** – recirculation is reduced by higher discharge velocities, which propel the discharge air away from the tower. The discharge air is warmer than the ambient air, so it will rise away from the tower naturally, once it is beyond the influence of air currents in the vicinity of the tower.
- **Air inlet velocity** – recirculation is increased by higher air inlet velocities, which create a low pressure area around the air inlet. This can draw the discharge air back into the tower inlet.
- **Tower orientation** – a long multi-cell tower installation will recirculate less when installed with the multiple fans in line with the prevailing wind direction. In this orientation, the separate tower plumes concentrate together into one plume of higher buoyancy. Also, a cooling tower which discharges horizontally should be oriented to discharge in the downwind direction of the prevailing wind, to prevent discharge air being drawn back to the air inlet side of the tower.
- **Enclosures & surrounding structures** – enclosures or surrounding buildings can encourage recirculation, especially if the tower is completely surrounded. This forces the incoming air to pass near the discharge air, increasing the risk of mixing. Also when combined with wind, low pressure areas form below the edges of non-streamlined obstacles.

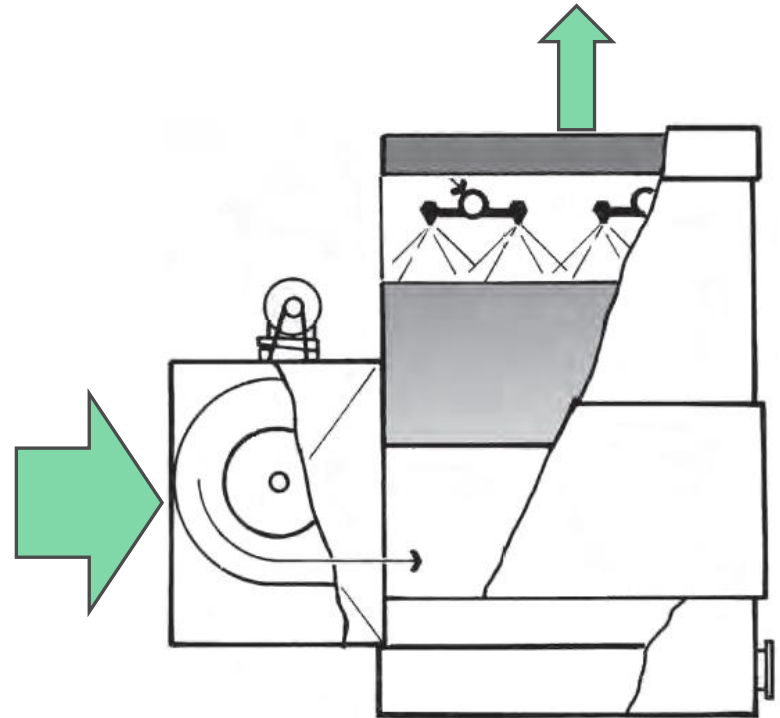
Almost all towers will recirculate some amount, some of the time

Recirculation – Types of Tower

- **Induced Draught** – Discharge air is propelled out of the tower at approx. 10m/s, while fresh air is drawn into the intakes at less than 3.5m/s. This velocity relationship gives reasonable assurance that the tower will be subjected to very little self-imposed recirculation. However, external influences could still cause recirculation.



- **Forced Draught** – Velocity relationships are reversed, so intake velocity is more like 10m/s, discharge less than 3.5m/s. The high intake velocity causes a low pressure area around the air intake, which can draw the low velocity discharge air back into the tower.

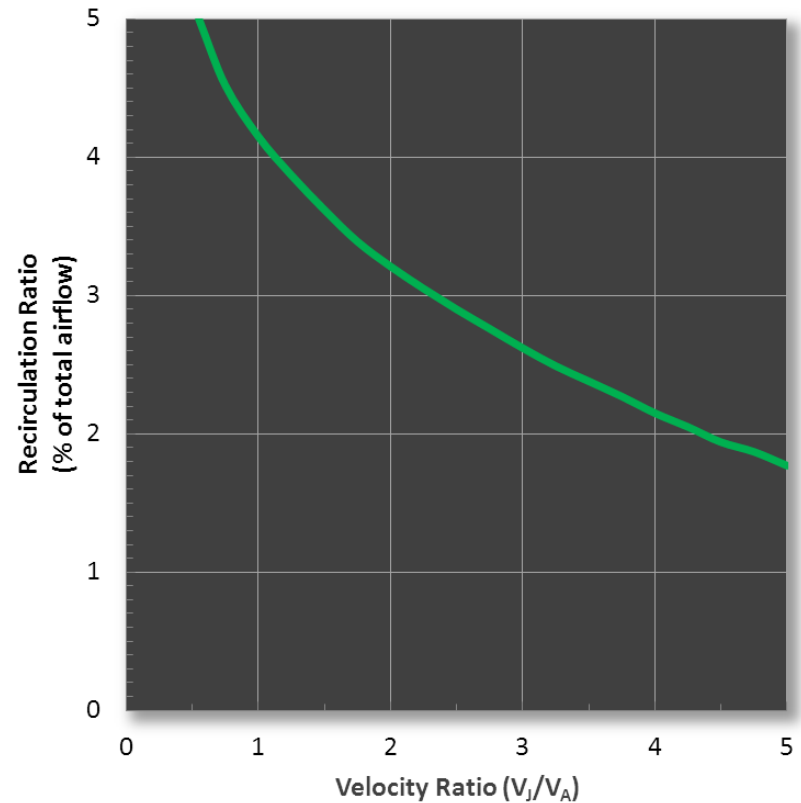
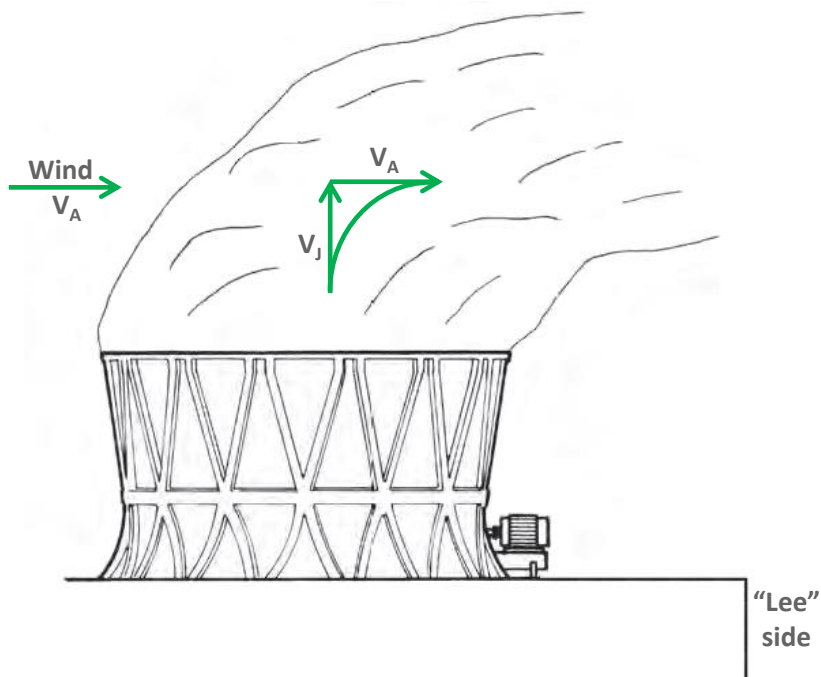


If recirculation is a major concern, consider the type of cooling tower you propose as the solution

Recirculation – Effects of Wind

Wind, depending on its speed and direction (prevailing wind direction vs. air inlet face orientation), tends to magnify a cooling tower's potential to recirculate:

- Creates low pressure area on “lee” side of cooling tower
- Bends the exiting plume

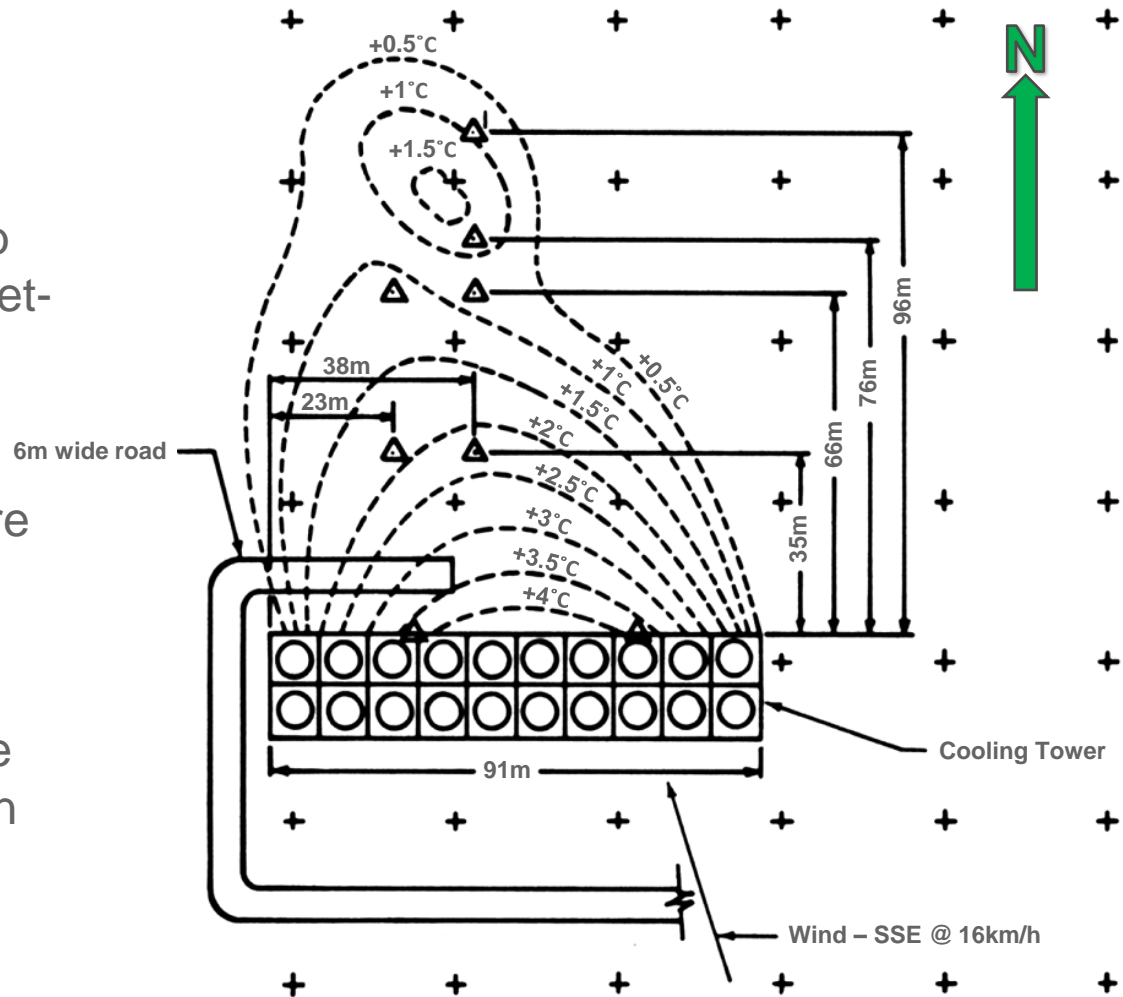


For a fixed tower air discharge velocity, an increase in wind results in an exponential increase in recirculation potential

Scale of recirculation's effect on entering wet bulb

Lines of constant temperature difference show downwind wet-bulb increase over ambient wet-bulb.

Effects of recirculation are exaggerated on larger multi-cell towers. On a single-cell packaged cooling tower, it would be unusual to see more than 1°C difference at the air inlet.

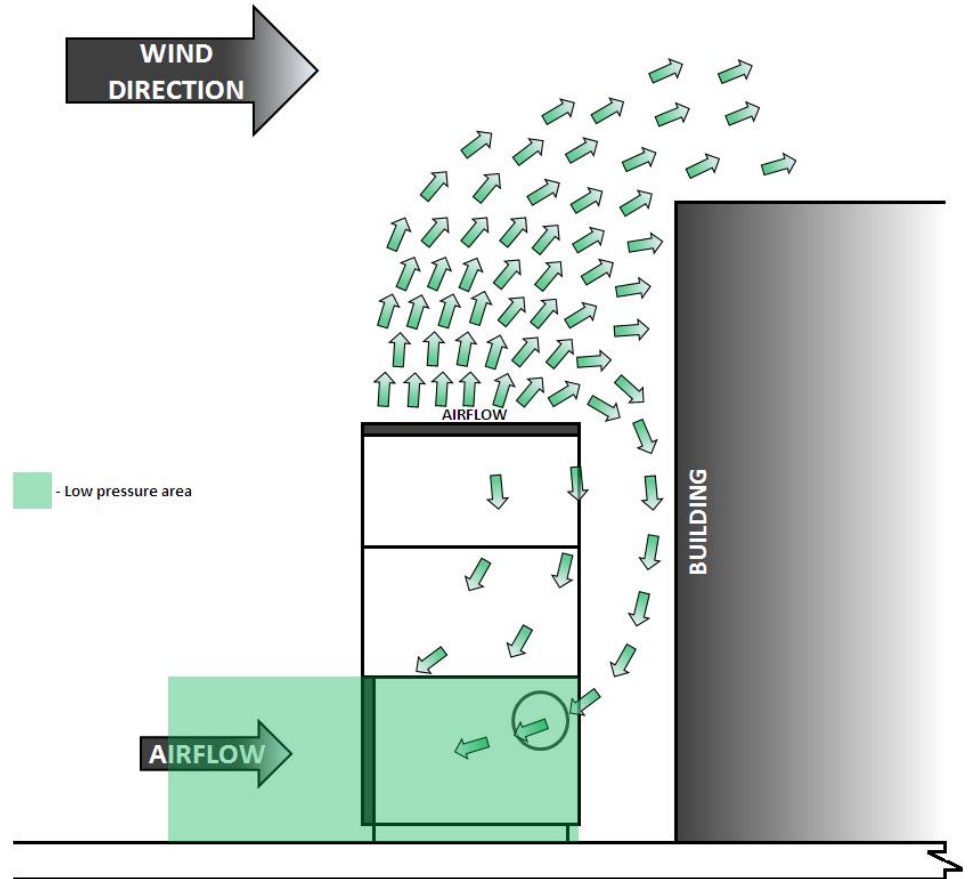


Although this is an extreme case, size of tower dramatically effects how much recirculation can occur

Siting's effect on recirculation – forced draught

When siting a cooling tower next to a building, wind direction and discharge elevation need to be considered to avoid recirculation.

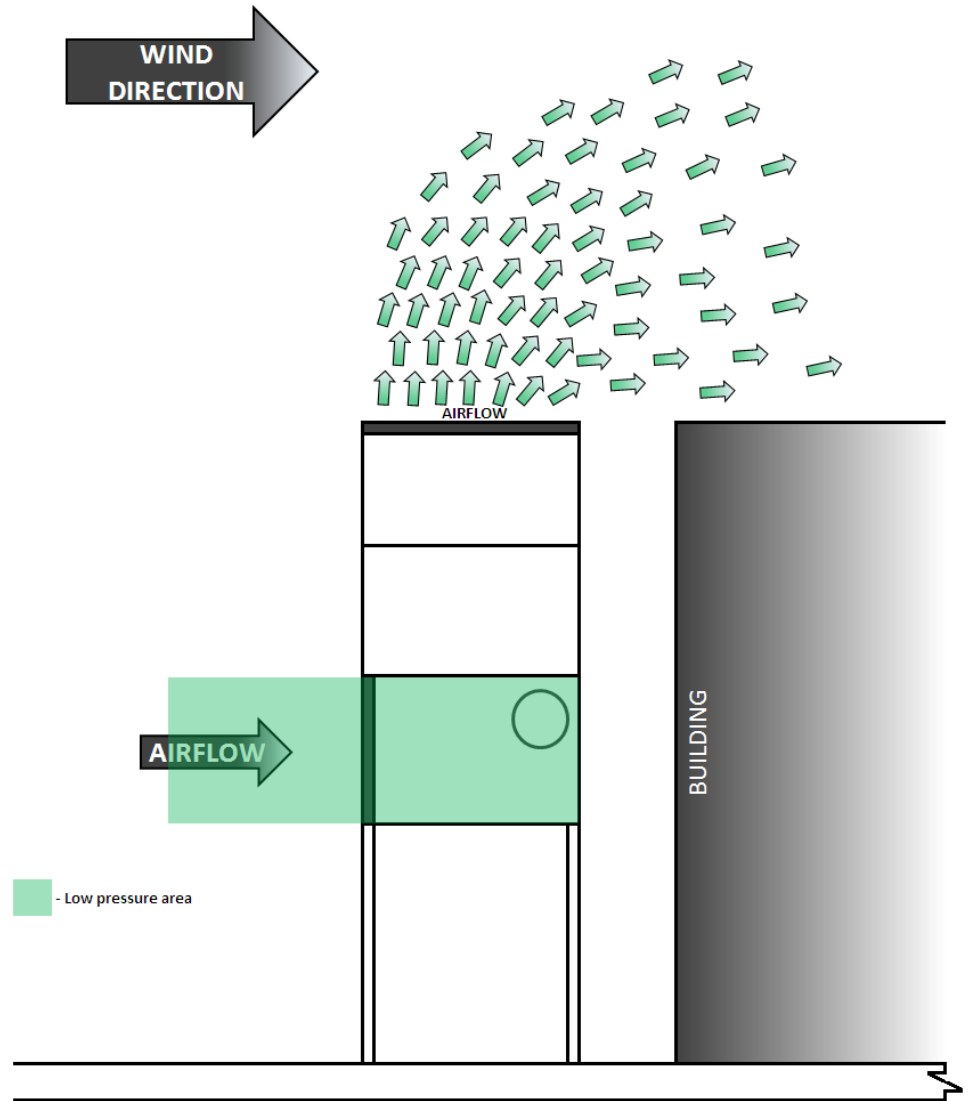
The higher building elevation, and low discharge velocity encourages the air back down towards the low pressure area around the air inlet, created by the high inlet velocity of a forced draught configuration.



This phenomenon is more common with forced draught towers due to the air inlet/discharge velocity relationship

Siting's effect on recirculation – forced draught

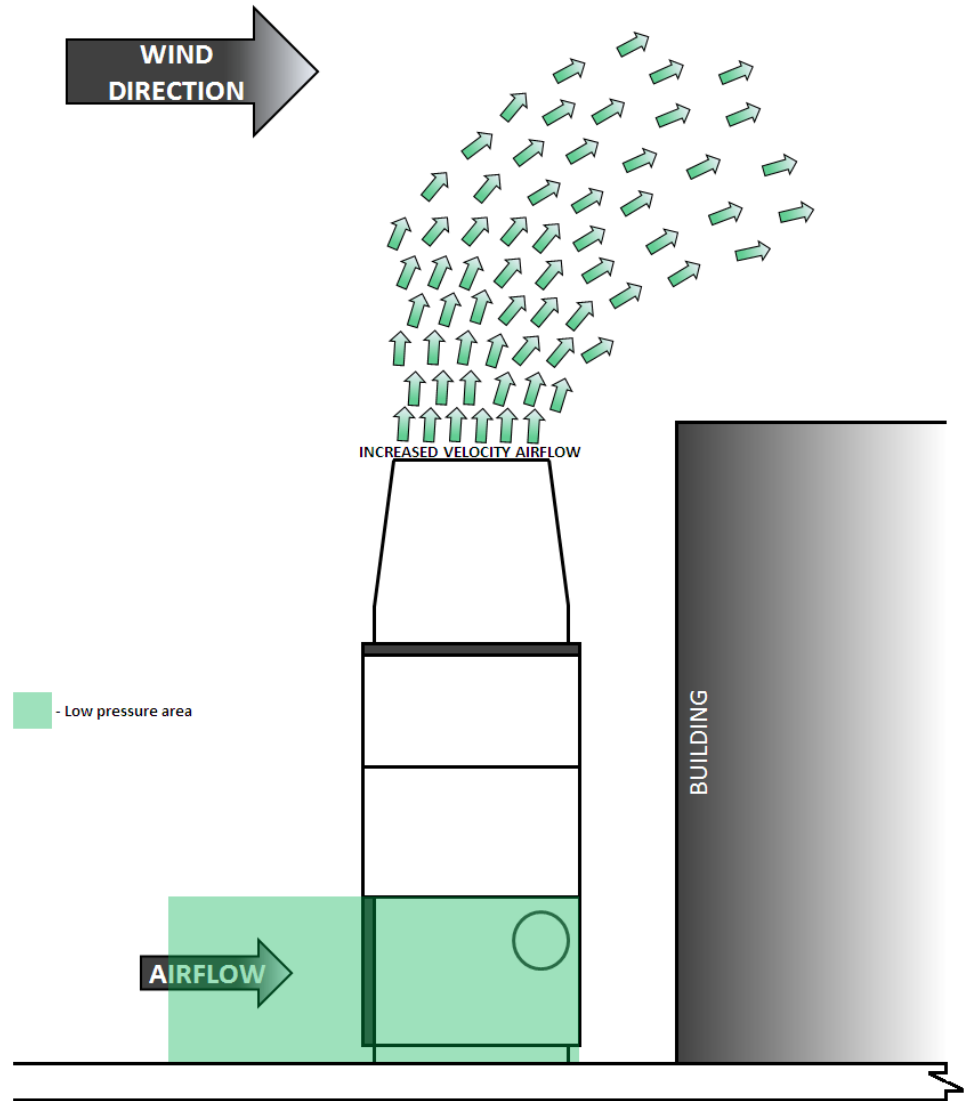
Solution – Raising the cooling tower on supporting steelwork so that the discharge elevation is level with the building. The wind carries the air directly over the building.



Ensure you also consider maintenance implications when raising a cooling tower above grade

Siting's effect on recirculation – forced draught

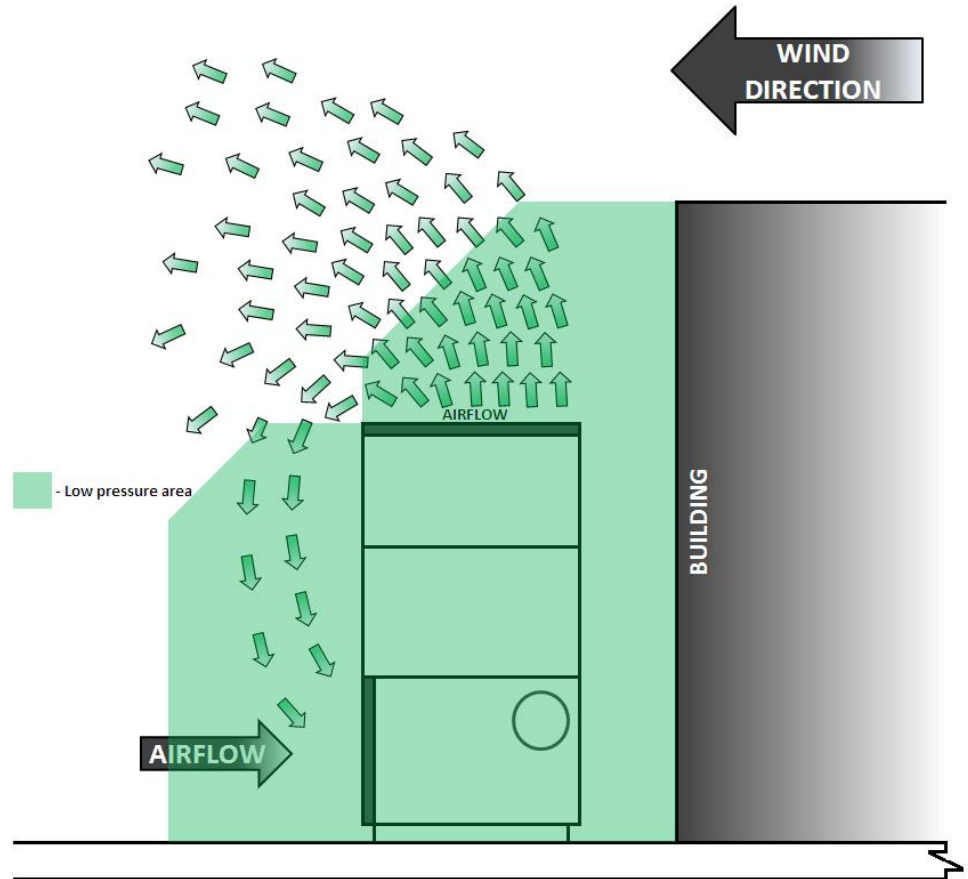
Alternative – Adding a tapered discharge duct increases the velocity and elevation of the exiting air, preventing it from being drawn back down into the tower inlet.



Siting's effect on recirculation – forced draught

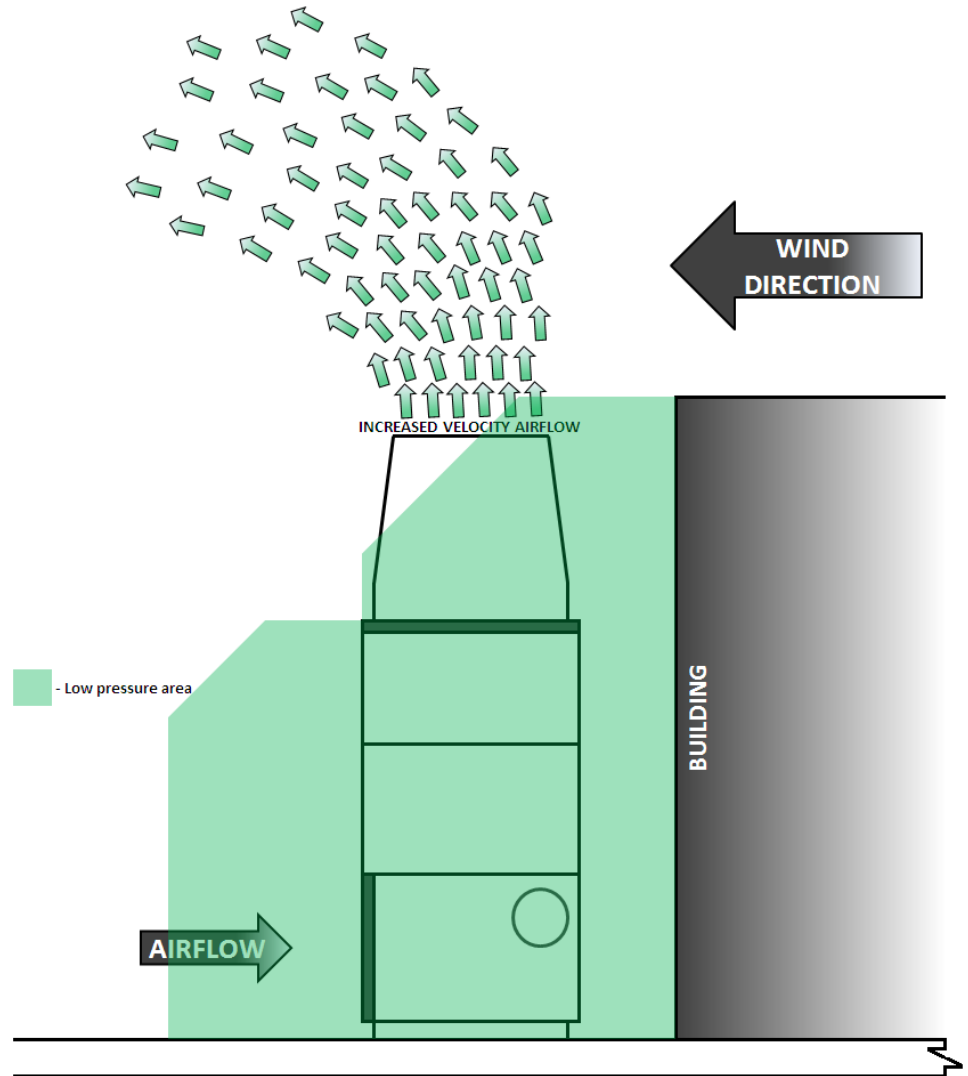
If the prevailing wind is coming over the building, a low pressure area is created where the wind drops off the edge of the building, and the cooling tower.

This, combined with the existing low pressure created by the high inlet velocity, will draw the discharge air down into the air inlet.



Siting's effect on recirculation – forced draught

Solution – Using a tapered discharge duct in this situation will increase the discharge velocity, and prevent the low pressure below from drawing the air back into the air inlet.

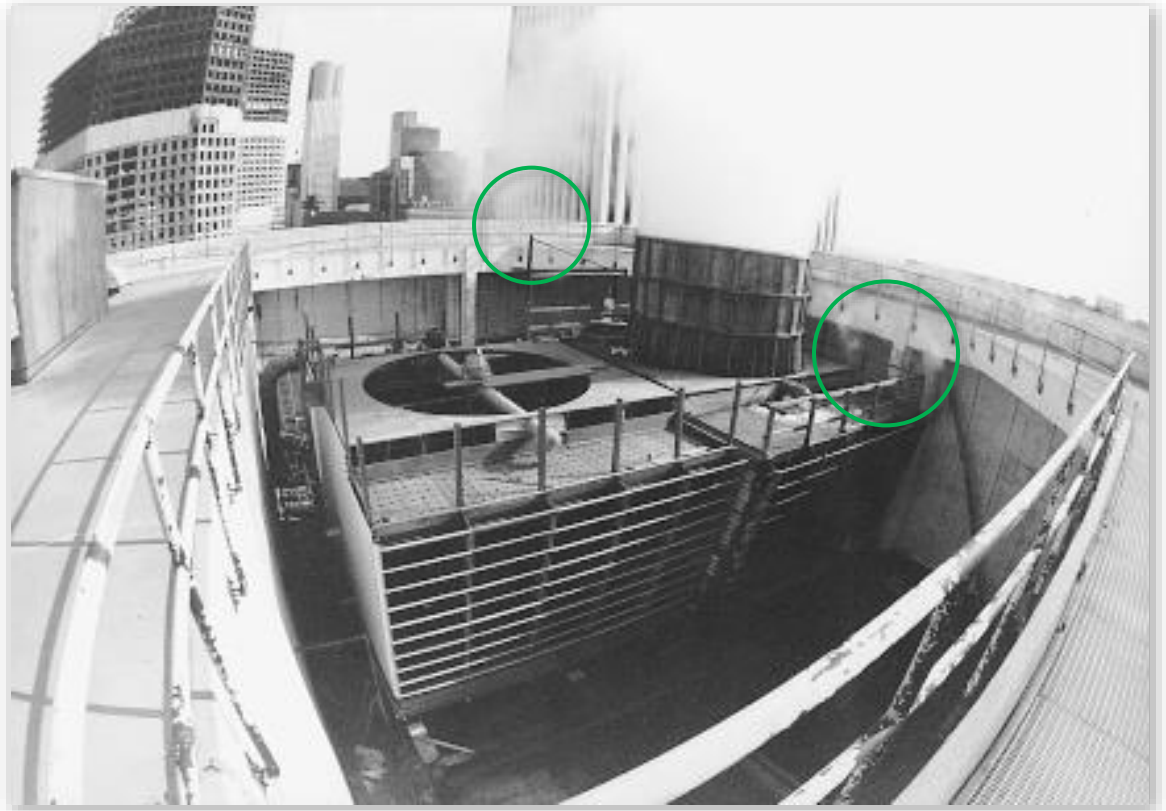


Make sure your customer understands the performance implications of their proposed tower location

Recirculation – induced draught

This induced draught cooling tower has been installed inside a “well”, surrounded on all 4 sides. This type of location will invite serious recirculation, because the incoming air has to pass right by the discharge air to get into the well.

A fan stack has been added to the cell on the right to try to increase the discharge elevation, but you can still see the warm discharge plume being drawn down towards the air inlets.

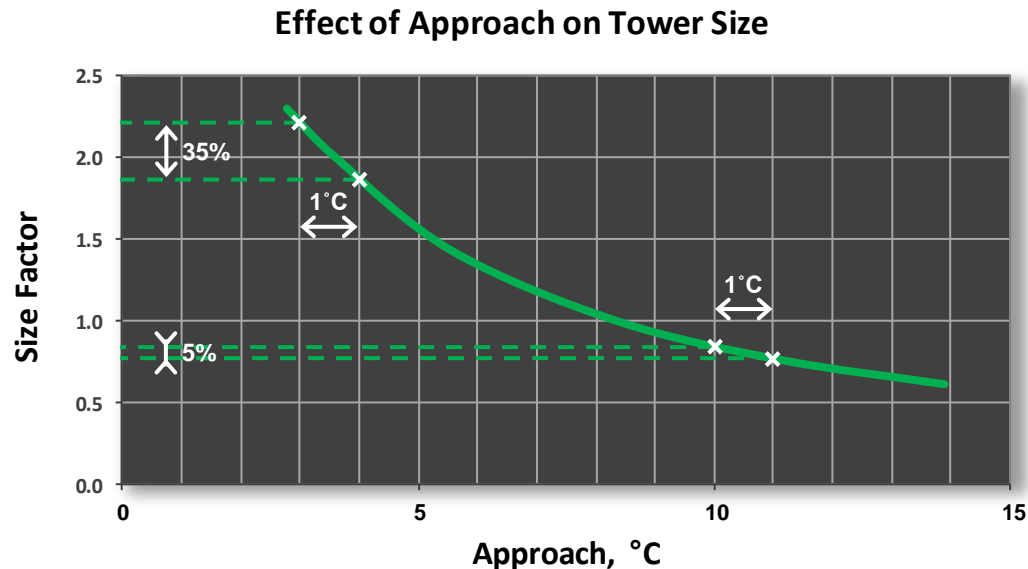


External influences can adversely affect induced draught towers too, they are not immune to recirculation

Incorporating recirculation into design wet bulb

If adjusting the siting of the tower is not possible, an estimation can be made in the tower design for recirculation or interference by increasing the design wet bulb.

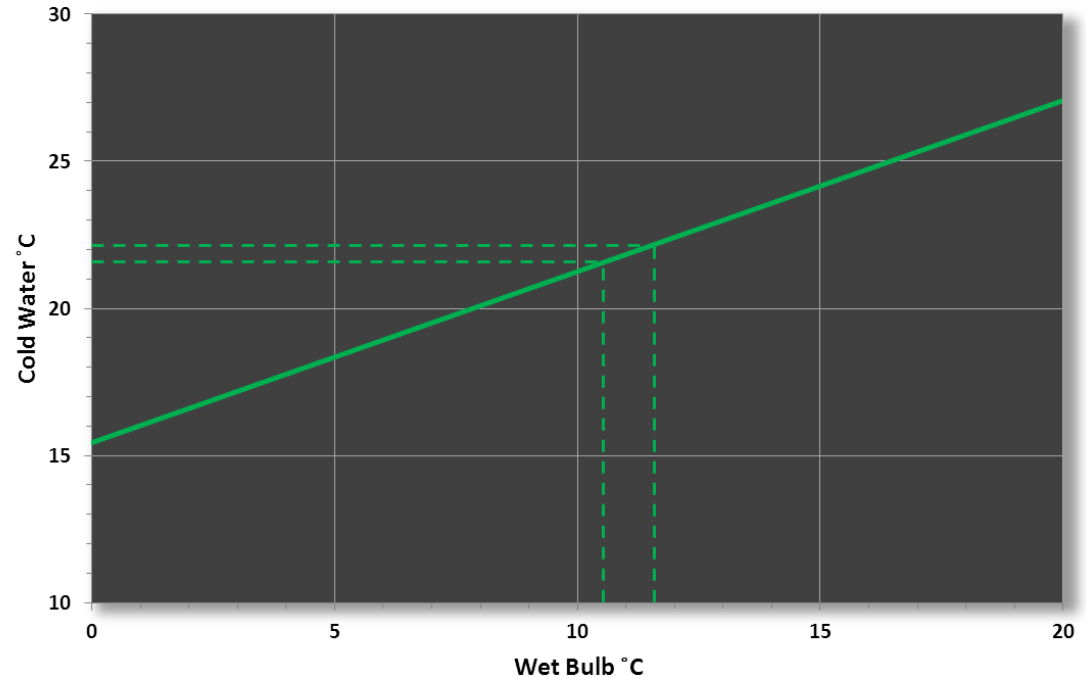
At higher approach temperatures, the effects of a 1°C increase in WB would not cause as much of an impact on tower size. But at low approaches, a 1°C increase could effect the tower size by 30-40%.



Best to have client specify design entering wet bulb, then they are taking responsibility for considering recirculation

Recirculation effect on process cold water temperature

- As a rule of thumb, a 1°C rise in wet bulb will result in a 0.5°C rise in cold water temperature.
- How critical this much of a rise in CWT is, will depend on the process the cooling tower is serving.
- For HVAC, a 0.5°C rise in CWT equates to approx. 2% chiller inefficiency



Example –

- 1000 ton water cooled chiller & cooling tower installation
- 450kW total installed motor power
- €0.15 / kWh

Difference in energy cost per year caused by 0.5°C higher CWT from tower - €7,884!

What seems like a minor siting issue could lead to significant increases in performance / running costs

Mistakes others have made



- Air Inlet Space Requirements

Air Inlet Space Requirements

Air Flow

Considering the following assumptions...

- Fixed heat load
- Fixed water flow
- Fixed wet bulb temperature

...the cold water temperature produced by a cooling tower is totally dependent upon the quantity of entering air.

Static Pressure

The measure of a system's resistance to a given flow of air. It results from changes in airflow direction and restrictions in the system (which increase air velocity), such as:

- Fill
- Drift Eliminators
- Piping
- Structure

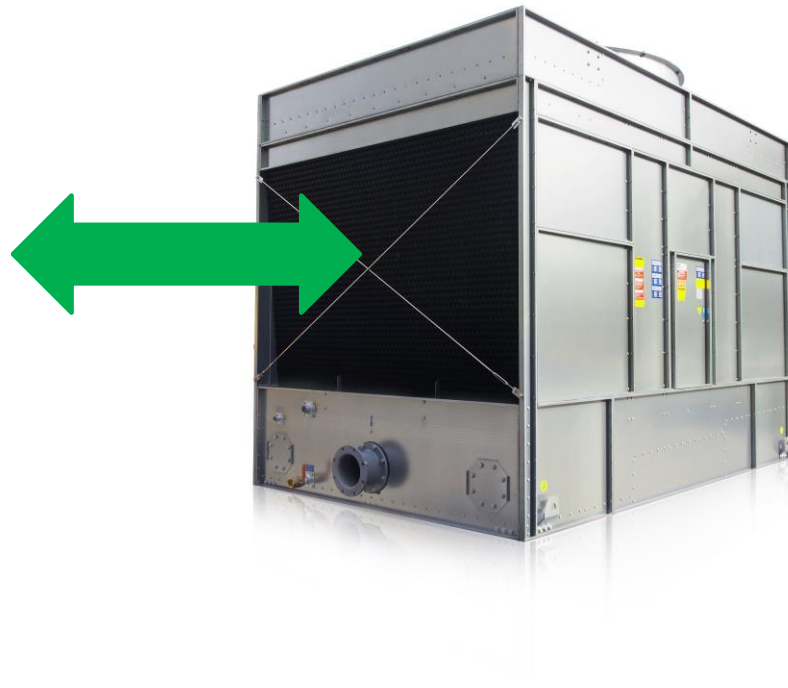
These combine to produce a total net static pressure which determines the fan motor power applied.

If something should happen to cause an increase in the static pressure, air flow through the tower will decrease, and a higher cold water temperature will result.

Air Inlet Space Requirements

Tower Type / Orientation

- How many faces of the tower have air inlets?
- How will the air inlets be oriented?
- What obstacles surround the tower?
- Are there any potential sources of interference nearby?
- What is the prevailing wind direction?
- Are there any noise sensitive directions?



Different towers can have 1, 2, 3 or 4 air inlet sides

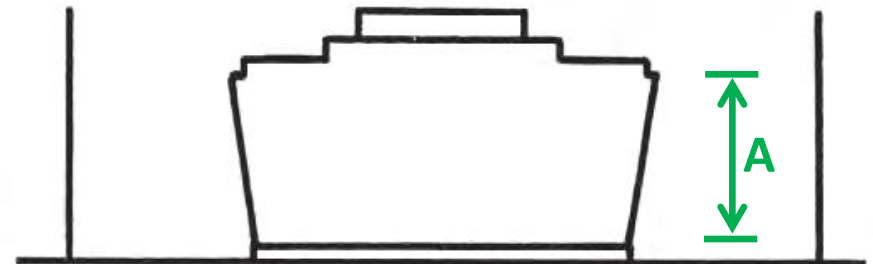
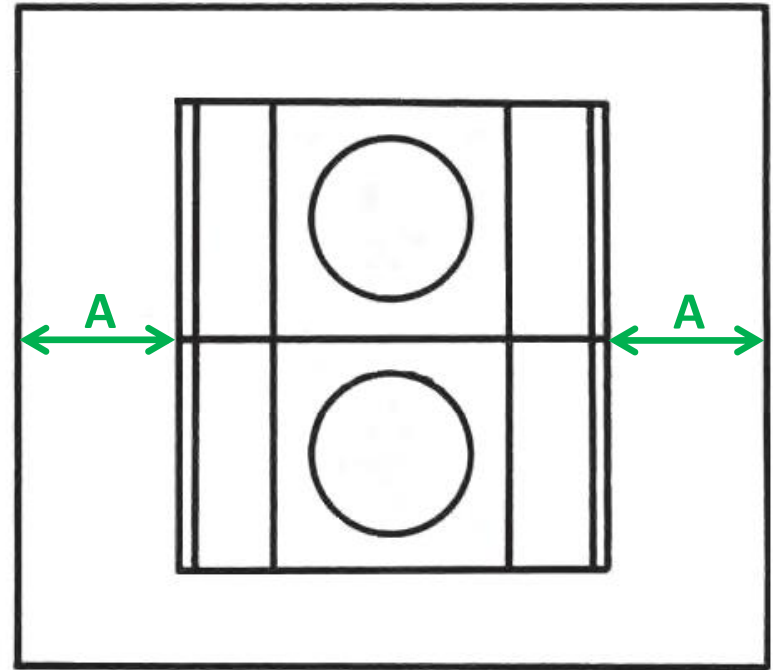
Air Inlet Space Requirements – Walls / Enclosures

- Air restrictions are a form of interference since they interfere with the free flow of air into the cooling tower.
- Due to the effect that air restrictions can have on the air velocity entering the tower, they can also intensify recirculation.

Which of these 2 effects is of greatest concern depends on the type of tower.

Rules of Thumb – Induced Draught Crossflow Tower

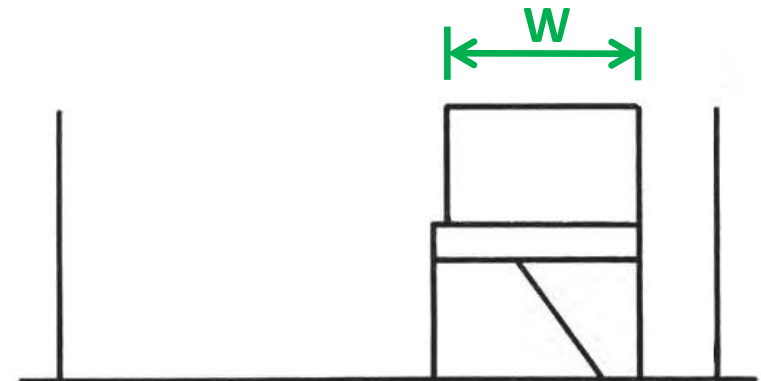
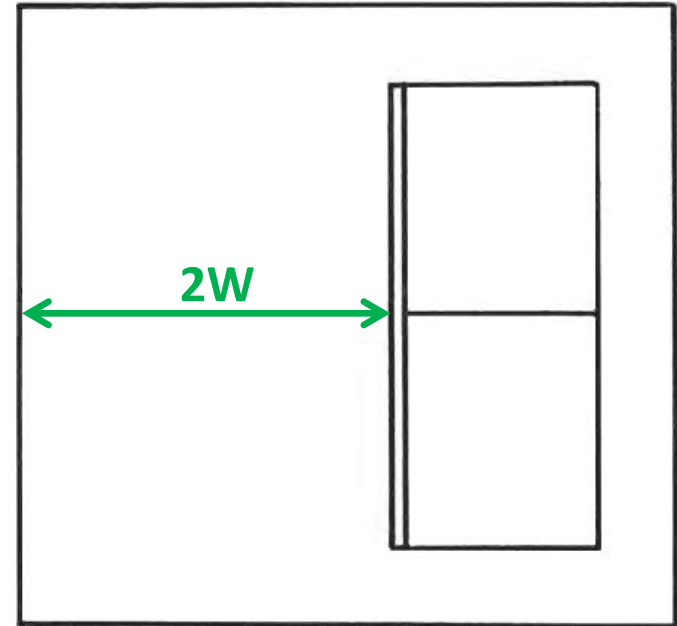
- In approximate terms, the distance from air inlet to nearest enclosure wall should be the same dimension as the air inlet height of the tower.
- Induced draught towers develop less total static pressure than forced draught towers.
 - more sensitive to the impact of external air losses
 - ***air inlet clearances must be governed by their potential to add system air losses***
- With minimum clearances as shown, the maximum possible downward air velocity will not exceed the lowest velocity component of the tower, the air inlet face.
- Since pressure is a direct function of velocity, the added air loss can be considered negligible.
- Although the downward movement of air has effectively moved the tower inlet closer to the discharge, the 3:1 ratio between discharge and inlet velocities has been maintained, so the chance of recirculation has only slightly increased.



Rule applies to 1 or 2 cell towers only. For towers with more than 2 cells, add 15% to the dimension for every extra cell

Rules of Thumb – Forced Draught Tower

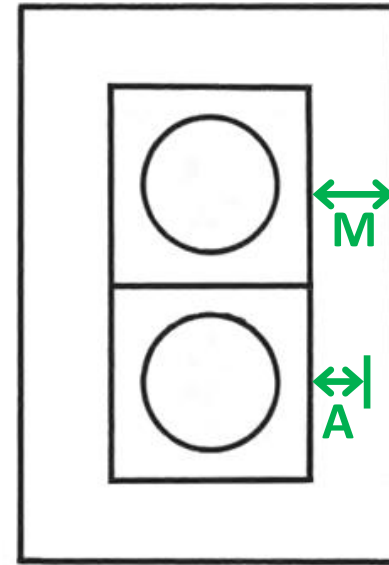
- In approximate terms, the distance from air inlet to nearest enclosure wall should be double the width dimension of the cooling tower.
- Forced draught towers have a relatively high internal static pressure, so the impact of a small amount of air loss is of less importance.
- However, because a forced draft tower is more prone to recirculating, **the air inlet clearances must be determined by their potential to contribute to recirculation.**
- With the minimum dimensions shown, we ensure an upward discharge velocity at least twice that of the downward velocity into the enclosure.
- Although a greater out/in velocity differential is better in order to reduce the possibility of self-imposed recirculation, increasing the overall enclosure area more than this becomes impractical – and does nothing to improve the situation further.
- A tapered discharge duct would be an additional recommendation to reduce the recirculation potential.



Rule applies to 1 or 2 cell towers only. For towers with more than 2 cells, add 15% to the dimension for every extra cell

Rules of Thumb – Induced Draught Counterflow Tower

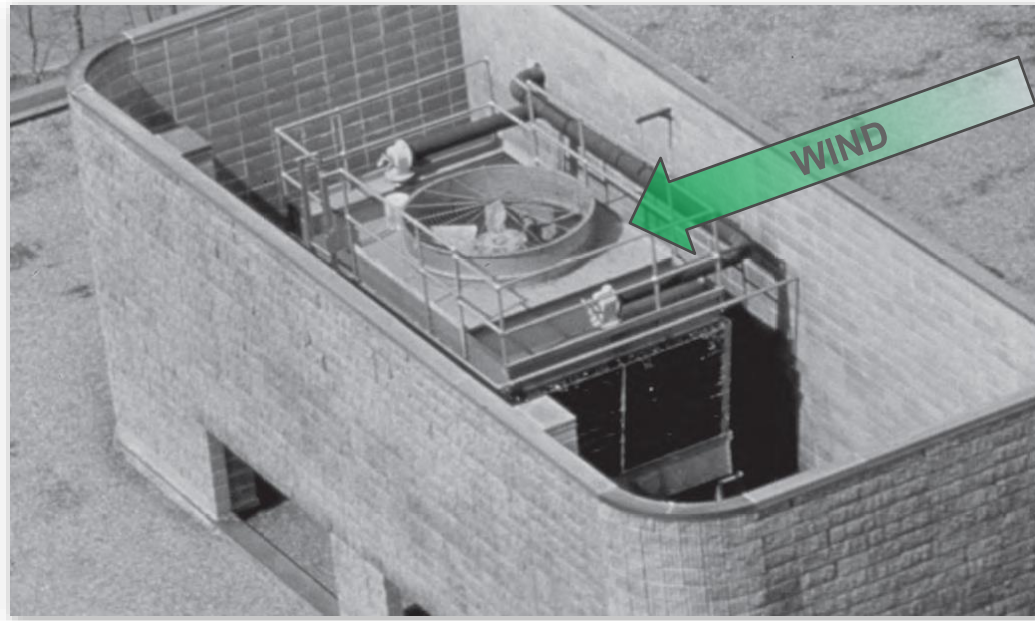
- In theory, the same rule applies as per an induced draught crossflow – distance to nearest wall should be equal or greater than air inlet height
- Because this distance is so much smaller typically on an induced draught counterflow, maintenance access becomes the deciding factor, not airflow.
- Typical maintenance access for this type of tower would be a minimum of 1000mm. Under normal circumstances, more than this would be given to allow for comfortable working.



Rule applies to 1 or 2 cell towers only. For towers with more than 2 cells, add 15% to the dimension for every extra cell

Rules of Thumb - General

- To minimise recirculation, enclosure walls must be equal to, or less than, the elevation of the tower's point of air discharge
- Depressing a tower in an enclosure will increase recirculation considerably
- Openings can be included in the walls to “ventilate” the enclosure. Caution should be taken as this is nowhere near as effective as having correct air inlet space.
- Also, with a prevailing wind in the direction shown, a low pressure area would form on the lee side of the enclosure, promoting recirculation.



Air Inlet Space Requirements - Update

UPDATE tower data sheet

Weights & Dimensions

	Per Cell	Total
Shipping Weight	2141 kgf	2141 kgf
Heaviest Section	2141 kgf	
Max Operating Weight	4996 kgf	4996 kgf
Width	4.319 m	4.319 m
Length	2.560 m	2.560 m
Height	3.129 m	

Minimum Enclosure Clearance

Clearance required on air inlet sides of tower without altering performance. Assumes no air from below tower.

Solid Wall	1.587 m
50 % Open Wall	1.165 m

Weights and dimensions do not include options; refer to sales drawings. For CAD layouts refer to file 8402_ALN.dxf

Cold Weather Operation

Heater Sizing (to prevent freezing in the collection basin during periods of shutdown)

Heater kW/Cell	12.0	9.0	7.5	6.0	4.5	3.0
Ambient Temperature °C	-30.74	-21.42	-16.75	-12.09	-7.42	-2.76

- 50% open wall is to reflect a typical architectural screen for hiding plant equipment. Usually seen on commercial buildings or near residential areas.

Air Inlet Space Requirements –

- Enclosure velocity is the rate at which air needs to be drawn down in between the enclosure walls and the cooling tower air inlets, to supply it with as much air as it needs to perform the cooling duty.
- This velocity is calculated from the amount of air needed by the tower, and the amount of air available in the surrounding enclosure.
- If this air inlet velocity is increased because the enclosure is too small, this increases the external static pressure on the tower, and causes a drop in performance.
- We assume an enclosure velocity of anything less than ~ 1.5 m/s to be negligible – or in other words if the velocity does not rise above 1.5 m/s, there is no performance impact on the tower.
- Our 2 major competitors use anything from 1.5 – 2.0 m/s as their negligible enclosure velocity, so in some instances we are more strict than them with our calculations.
- SPX calculation is based on a specific model operating at 100% capacity, with a nominal flowrate at 35 / 29.4 / 23.9°C (95 / 85 / 75°F).

On selections where air inlet space requirements are restricted, if you have extra capacity in the tower, or different operating temps from those above, send your selection to Ratings – they may be able to give you a reduced space requirement.

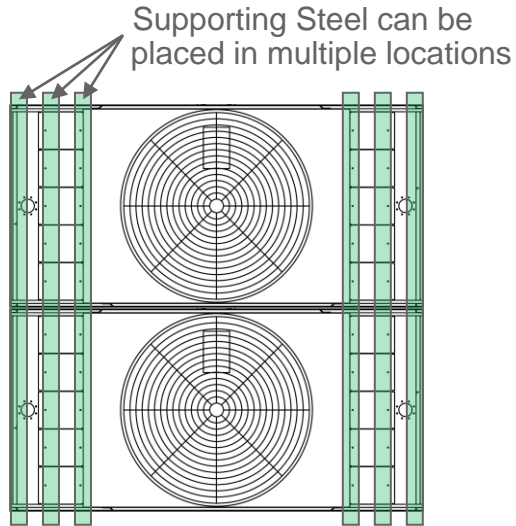
- Existing Basins / Supporting Steels

Concrete / Supporting Steels – Decision factors

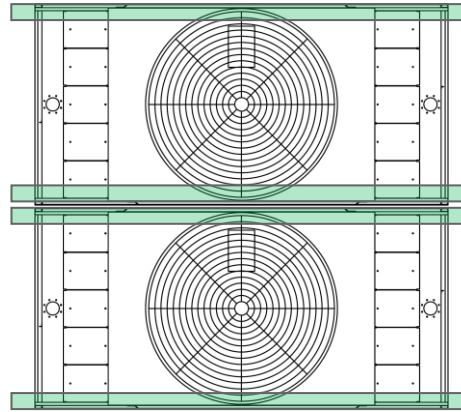
- Existing concrete basin installation
- Pipework / pumping requirements
- Location load-bearing capabilities
- Size of duty – package / field erected
- Project lead time
- Available downtime
- Water storage requirements
- Customer budget
- Water quality

Supporting Steel Layout –

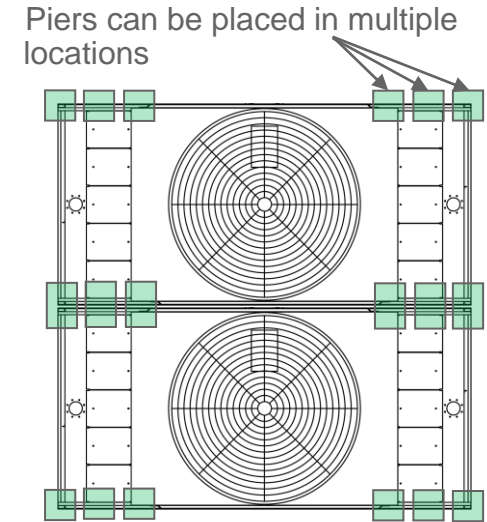
■ Transverse steels



■ Longitudinal steels



■ Concrete piers



- Various methods of steel supporting is available with these towers
- Ability to support in different locations is a sign of the build quality
- Relatively easy to mount over existing concrete basins
- More likely to be able to match up to existing steelwork on replacement towers

Concrete Basin – Tower Outlet

- If supporting a package tower over a concrete basin, you should use a gravity flow bottom outlet on the tower



- Installation and Maintenance Access

Installation & Maintenance Access

▪ **Regional Considerations**

- Some access requirements to the cooling tower will be strict, regardless of region
- Some requirements vary depending on regional legislation / health and safety guidances

▪ **Dimensions**

- Maintenance dimensions shown will be minimum requirements
- Allowing for minimum requirements only will enable maintenance to be made, but restricted space will often add time
- Allow as much space above the minimum as possible – taking into consideration space available and budget for platforms etc.

▪ **Transport Access**

- Can a truck get near to the installation location
- Is there sufficient space for crane

Maintenance Access – Induced Draught Crossflow

- If hanging fill pack needs to be cleaned in between sheets, or removed, it has to come out through the side casing panels
- Just the end panel at each end of the side casing can be removed, but typically the next one in will be removed for improved access
- 908mm is a standard fan deck bridging plate dimension – this forms the minimum distance possible to perform this task



Maintenance Access – Induced Draught Crossflow

Mechanical equipment needs to be removed through the top of the tower so either..

- Identify location for crane around the tower
- Include crane on tower

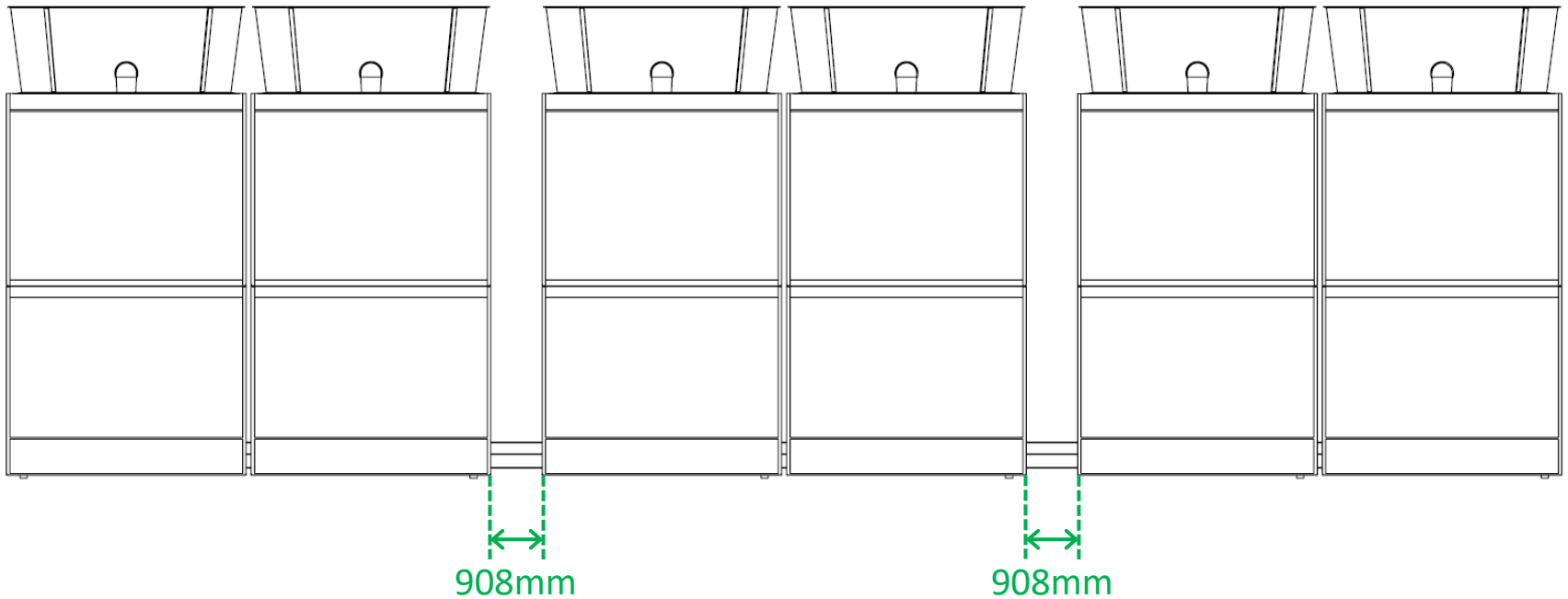


Maintenance Access – Induced Draught Crossflow Multi-cell

If you have a multi-cell selection which...

- Has more than 2 cells
- Customer requires fill pack needs to be removable for cleaning

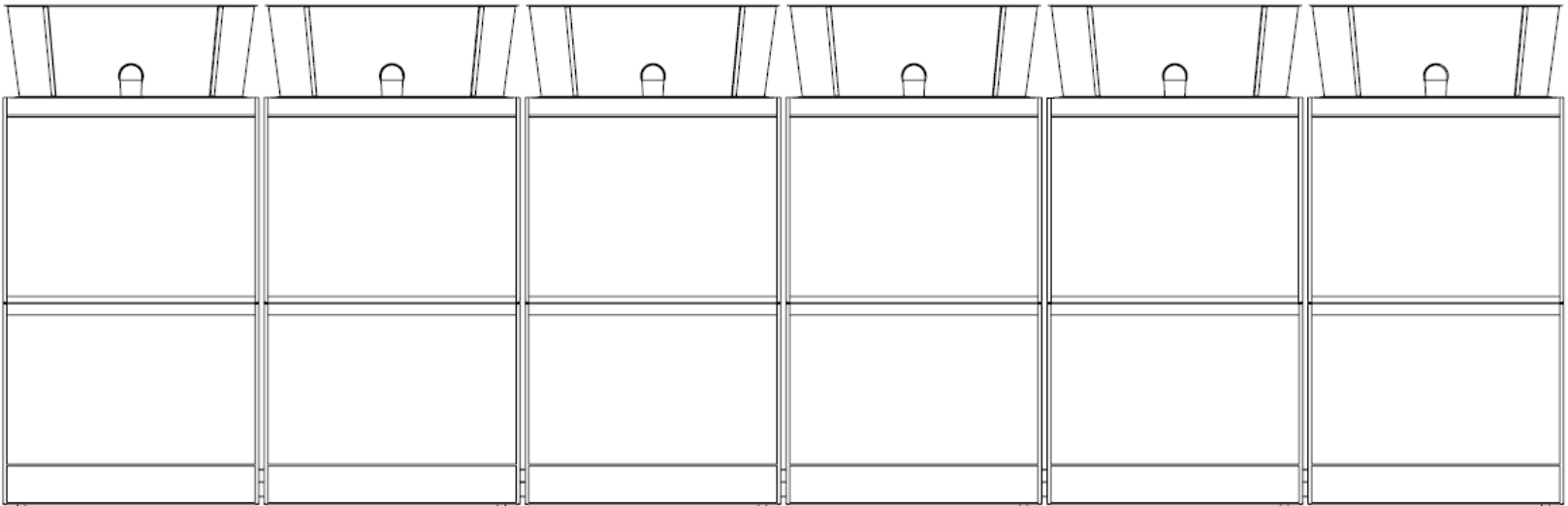
... then you will need to arrange the tower with at least 908mm gap every 2 cells



908mm spacing is based on standard fan deck bridging plate dimension. 1321mm is also available.

Maintenance Access – Induced Draught Crossflow Multi-cell

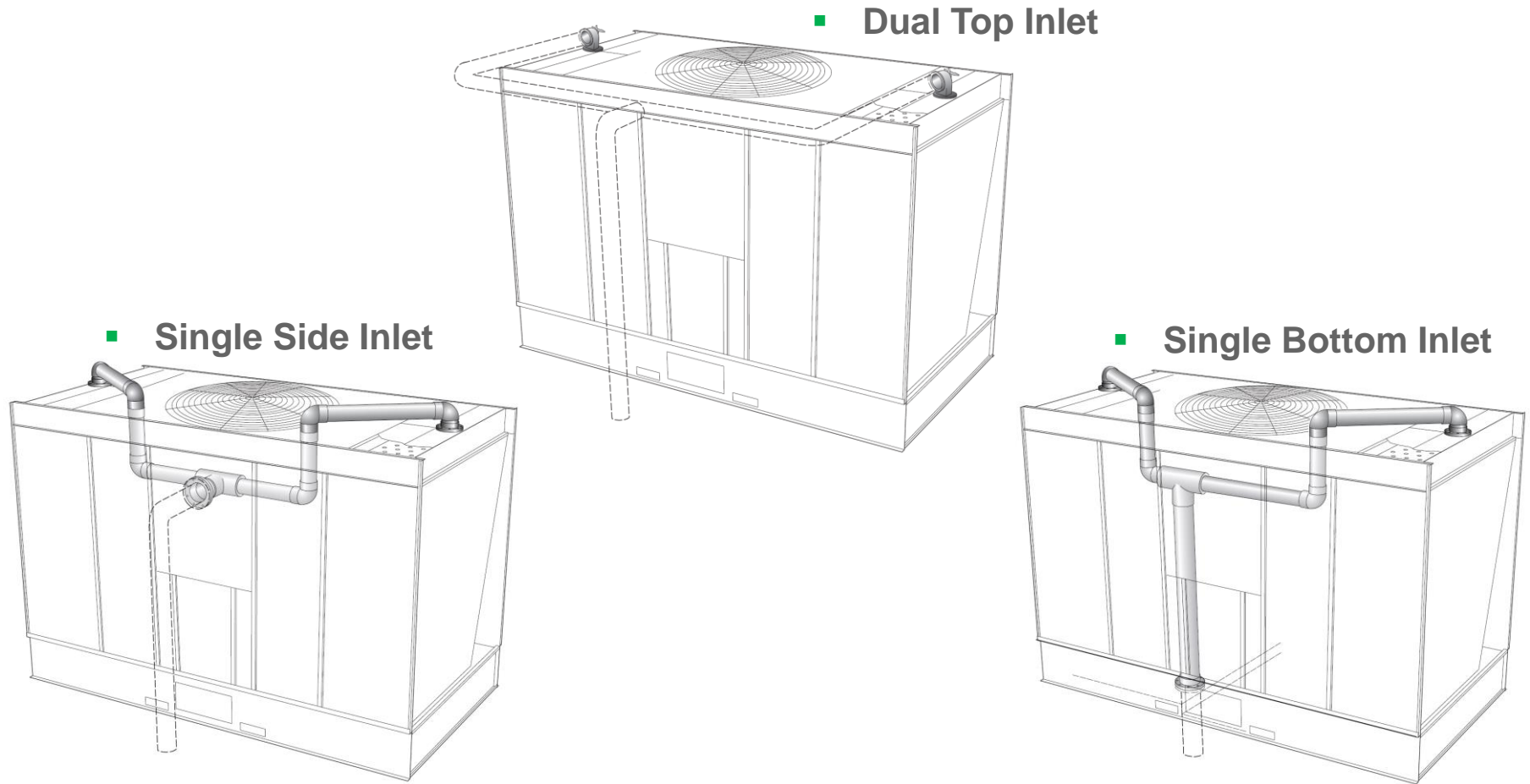
If you do not need to remove the fill pack for cleaning, then you can install the cells all with the standard 89mm spacing



Understand the customers maintenance requirements

Installation – Induced Draught Crossflow Inlet Piping

As well as the standard dual top inlet configuration, there are 2 single inlet options available..



Installation – Induced Draught Crossflow Outlet Piping

Standard for the tower is side suction outlet. Options are also available for bottom outlet (piped or gravity), and sump outlet..

■ Side



■ Bottom



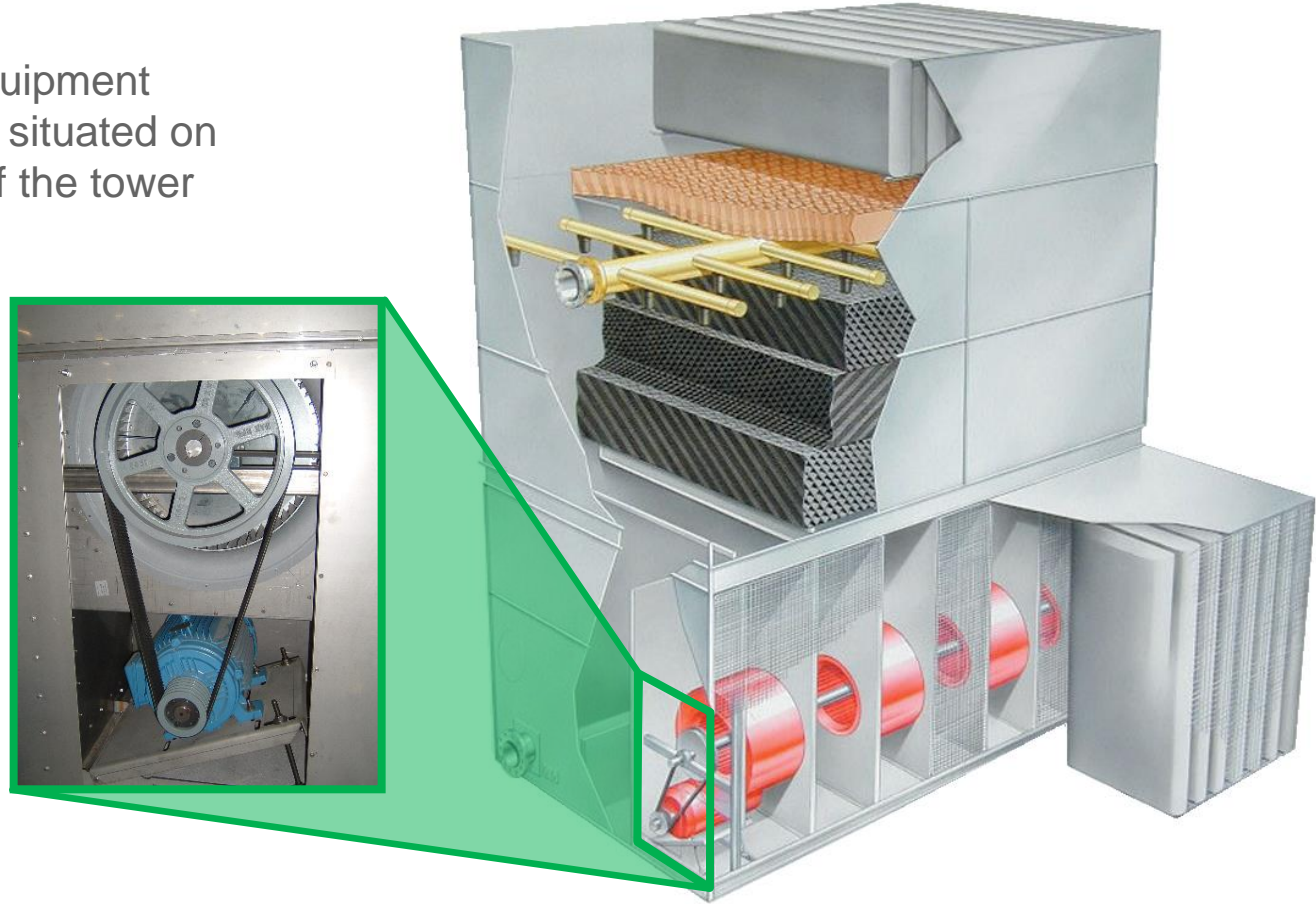
■ Sump



Configure the tower to suit your customers piping / location requirements

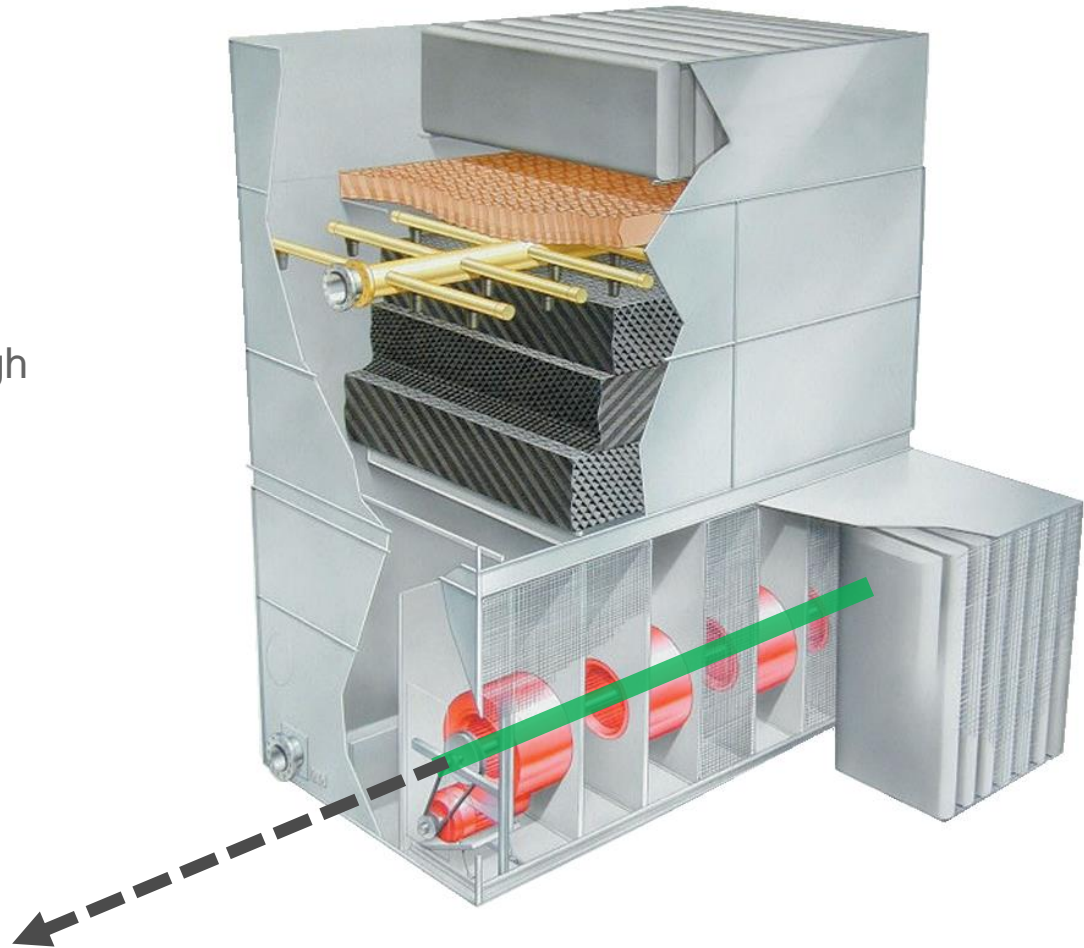
Maintenance Access – Forced Draught Counterflow

- Mechanical equipment access door is situated on the end face of the tower



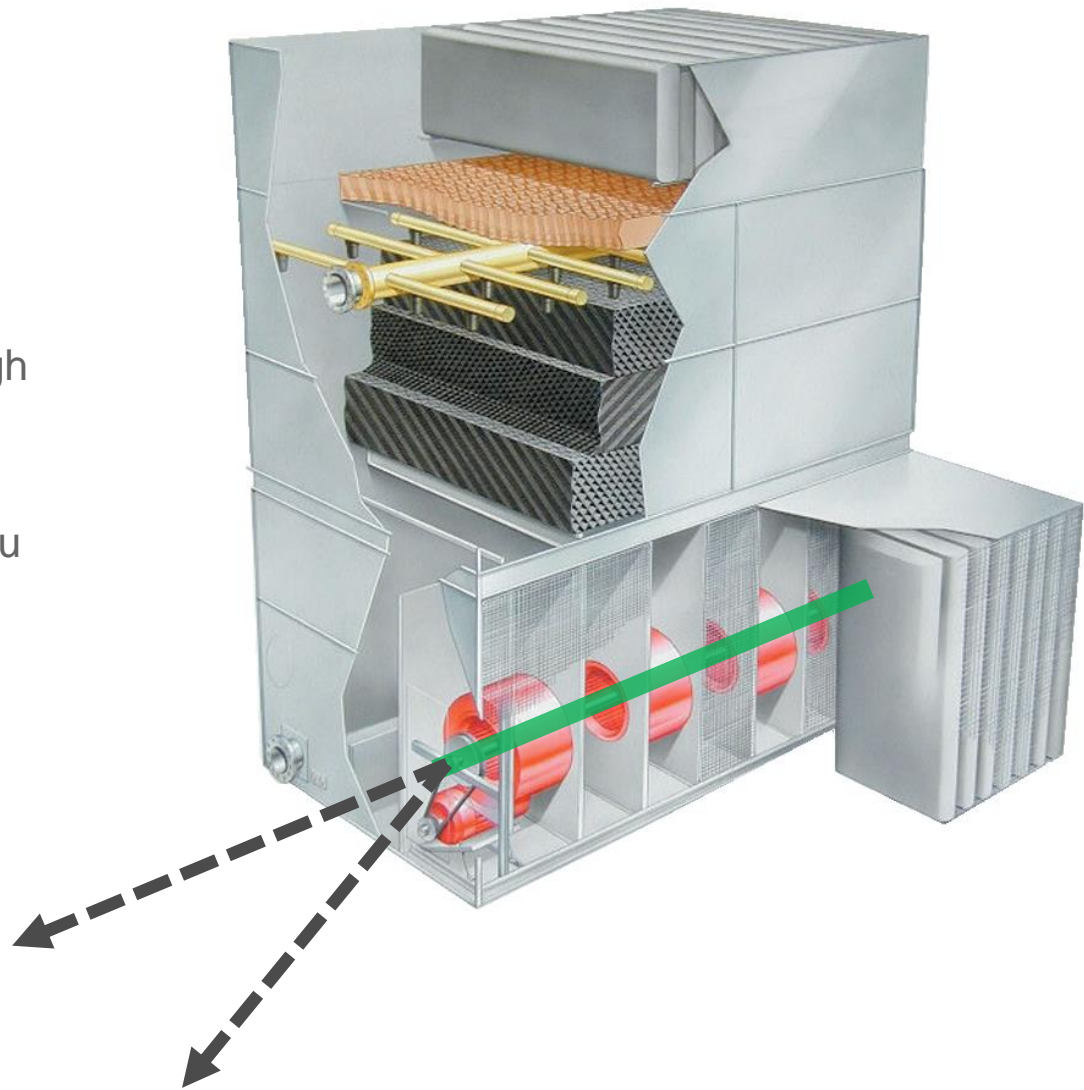
Maintenance Access – Forced Draught Counterflow

- Mechanical equipment access door is situated on the end face of the tower
- Drive shaft needs to be removed through end face of the cooling tower, through the mechanical equipment access door



Maintenance Access – Forced Draught Counterflow

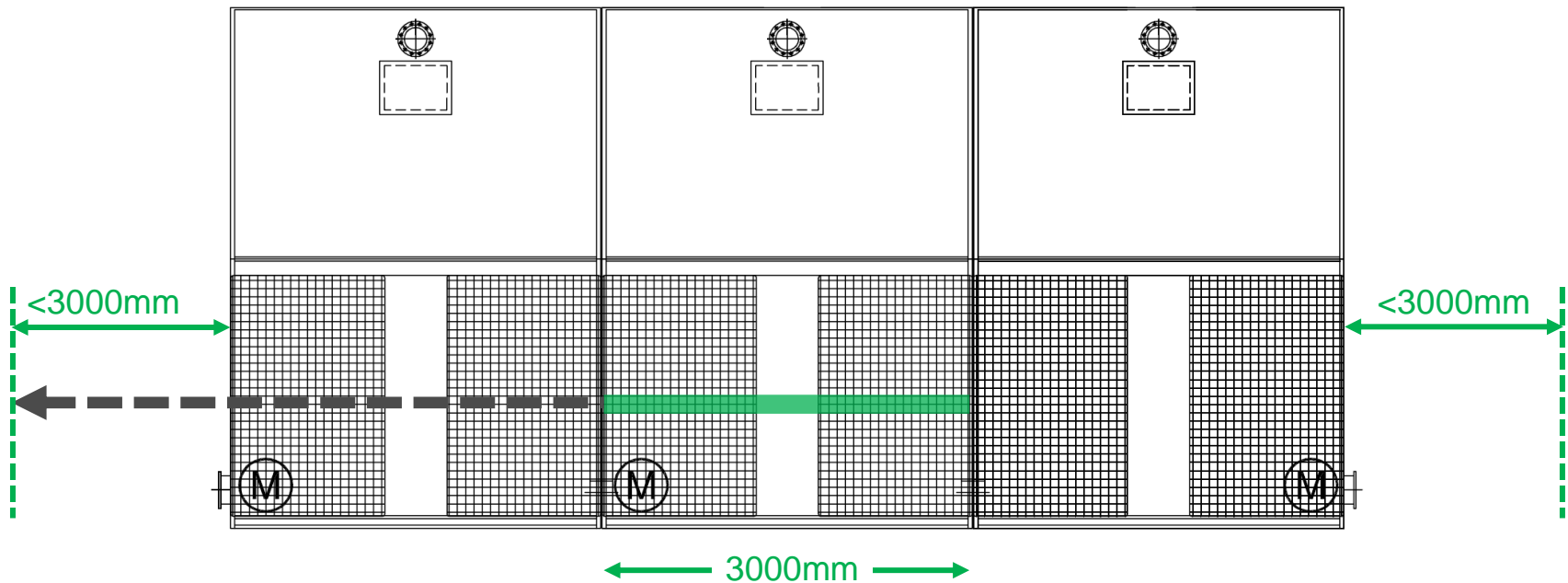
- Mechanical equipment access door is situated on the end face of the tower
- Drive shaft needs to be removed through end face of the cooling tower, through the mechanical equipment access door
- Shaft can be angled, so you may not need the entire length of the shaft as clearance



Confirm with manufacturer if less space available

Maintenance Access – Forced Draught Counterflow

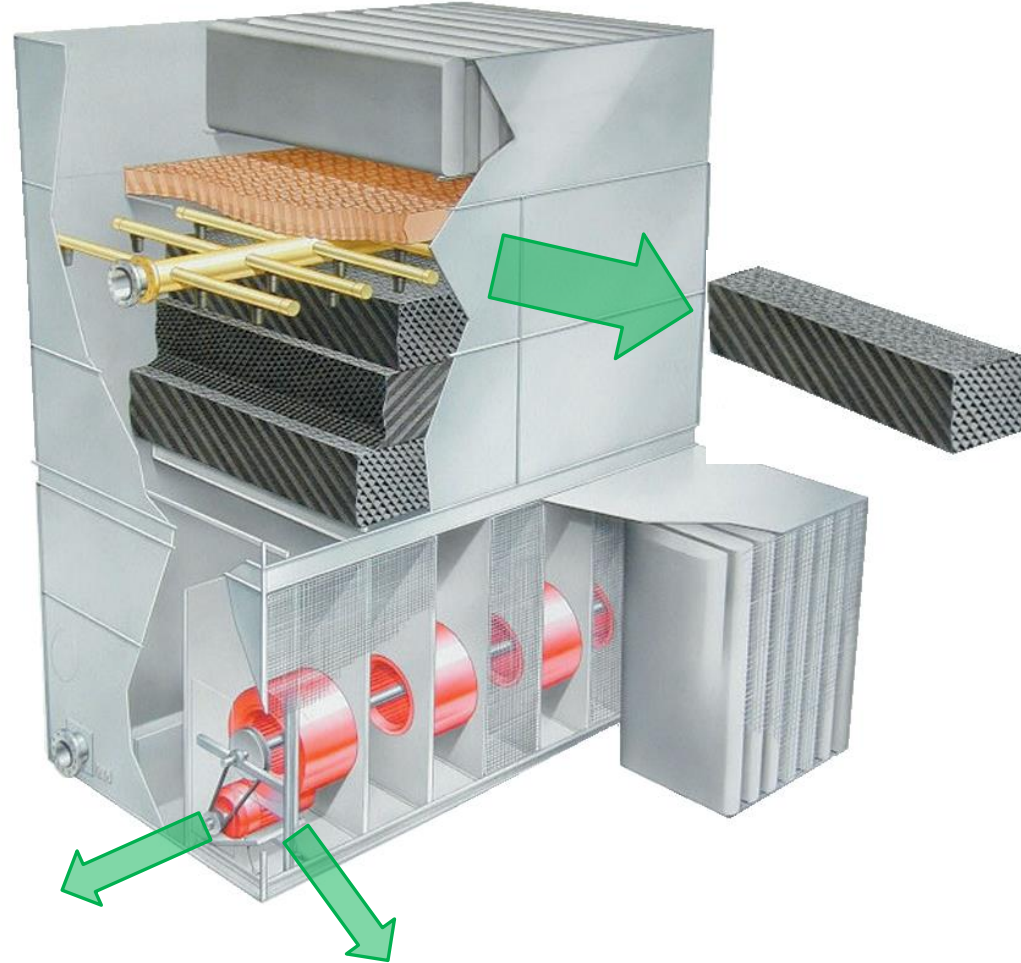
- On a multicell tower, the driveshafts can be removed from the end cells, and the shaft from the centre cell can be passed through the end cell and out
- Bear in mind this means that the centre cell can not be shut down in isolation for shaft removal
- Clearance distances at the ends of the installation are required as per single cell



Allow for full shaft length, or confirm with manufacturer if less space available

Maintenance Access – Forced Draught Counterflow

- Ideally motor should be removed through the mechanical equipment access door
- On a multicell where space is not available, air inlet face of the cooling tower can be used instead
- Fill pack is removed and distribution can be inspected through the front face of the cooling tower for cleaning / replacement
- Access door is provided in tower casing for this purpose



Maintenance Access – Forced Draught Counterflow

- Distribution access door

Maintenance Access – Forced Draught Counterflow

If you use the air inlet face to access mechanical equipment – bear in mind it can be restricted access!



Maintenance Access – Induced Draught Counterflow

- Tower requires minimum of 1000mm from each air inlet face to enable access through the air inlet to the basin.
- Fill pack removal and distribution inspection are possible through the access door on the side face of the tower
- Mechanical equipment can be removed through the top of the tower, so consider crane locations when siting the tower



Maintenance Access

- Include page on platform requirements / ladders etc.

Tower Siting - Summary

- **What space is available?**
- **Which direction is the prevailing wind?**
- **What obstacles / other heat sources surround the site**
- **What noise requirements are there?**
- **What plume requirements are there?**
- **What existing / new infrastructure do the towers have to link in to?**
- **How will the towers be maintained?**
- **What type of towers are possible to use?**