# CENTRE PIVOT SYSTEM CAPACITY

## HOW IT'S CALCULATED AND WHY IT'S IMPORTANT

**FACT SHEET** 2025

### WHAT IS SYSTEM CAPACITY?

System Capacity is the most important design criterion for centre pivot and lateral move (CPLM) systems. The design and management issues associated with the system capacity are often not well understood by Australian growers using these machines and account for many of their perceived failures.

This case study walks through the calculation of system capacity in centre pivot (CP) systems. Additional detail can be found in CottonInfo's WATERpak[1]

System capacity is the maximum depth of water that can be applied to the total irrigated area in one day. It is not the amount of water that the machine applies per irrigation pass.

### THINGS TO CONSIDER

- Low system capacity has been the single greatest reason for the low uptake of centre pivots (CP) in Australia.
- Design system capacity relates to irrigation area and pump flow rate.
- The managed system capacity is usually below the design system capacity because the pumping utilisation ratio and application efficiency are usually less than 100%.
- Managed system capacity must be able to meet the crop water requirements.
- Daily average crop evapotranspiration (ET) and 3-day peak ET provide a benchmark water application rate to align managed system capacity during system design to minimise the risk of yield loss.
- As a long-term investment, consider the potential for crop ET to increase with climate change.

### SYSTEM CAPACITY MATHS:

$$\text{System Capacity (mm/day)} = \frac{\text{Average daily pump flow rate (L/day)}}{\text{Area Irrigated (m}^2\text{)}}$$

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## A CENTRE PIVOT EXAMPLE

### » *Design pivot capacity*

Design system capacity is the maximum possible flow rate that the centre pivot (CP) can apply to the area of an irrigated field and is a factor of pump flow rate and system length.

| DESIGN SYSTEM CAPACITY | | |
|---|---|---|
| Pump flow rate | 141 | L/s |
| Daily application | 12,182,400 | L/day |
| CP length (radius) | 495 | m |
| Area irrigated | 769,769 | m$^2$ |
| **Design System Capacity** | **15.8** | **mm/day** |

Area of circle $= \pi \times \text{radius}^2$ Where $\pi \approx 3.14$

$$= \frac{L/day}{m^2}$$

### » *Pumping utilisation ratio*

The system capacity is reduced considerably in the real world by the number of hours that the pump is turned off during any given irrigation cycle, which may include time system maintenance, or pest and weed management. The amount of time the pump is running during any irrigation cycle is called the pumping utilisation ratio (PUR).

| PUMPING UTILISATION RATIO | | |
|---|---|---|
| Days running | 8.5 | days |
| Days not running | 1.5 | days |
| **Pumping utilisation ratio** | **85** | **%** |

$$= \frac{days\ running}{total\ days}$$

### » *Managed system capacity*

Managed system capacity reflects the realities of CP operation within field and farm dynamics. Managed system capacity accounts for the PUR, as well as the Application Efficiency. Application Efficiency (Ea) reflects the proportion of water that actually makes it into the crop root zone relative to the total amount of pumped water. For modern centre pivot emitters (drag socks, bubblers, and sprinklers), application efficiencies of 0.95 to 0.98 are achievable.

| MANAGED SYSTEM CAPACITY | | |
|---|---|---|
| Design System Capacity | 15.8 | mm/day |
| Pumping utilisation rate | 85 | % |
| Application efficiency | 95 | % |
| **Managed System Capacity** | **12.8** | mm/day |

$$= MSC \ x \ PUR \ x \ E_a$$

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## MATCHING SYSTEM CAPACITY TO CROP WATER NEEDS

System capacity should be sufficient to meet the daily crop water requirements in peak demand periods, which may be January in the central growing regions or at some other time of year depending on where you are located.

### » *Daily average evapotranspiration*

The highest point potential evapotranspiration (ET) will typically coincide with the period of greatest crop water requirement for cotton and is a good indicator of crop water needs. Average monthly point potential ET data is available from the Bureau of Meteorology[1]. To convert this reference ET to a cotton specific ET, a crop coefficient is applied. Crop coefficients change throughout the season, so the peak crop-coefficient should be applied when considering peak water demand[2].

| **Daily av. crop water requirement (January example)** | | |
|---|---|---|
| Monthly average point potential ET[1] | 330 | mm/month |
| Daily average ET | 10.6 | mm/day |
| Crop coefficient (cotton, mid-season peak) | 1.2 | |
| **Daily av. crop water requirement** | **12.8** | **mm/day** |

$$= \frac{Monthly\ ET}{days/month}\ x\ 1.2$$

Cannot be larger than MSC

### » *Peak crop evapotransipiration rate*

The above data provides the monthly average daily ET; however, there will inevitably be days with higher ET and crop water requirements. Three-day peak crop ET rates are available for some regions, and provide a risk profile for comparing system capacity. In effect, when growers choose their irrigation system capacity, they are choosing the level of risk that the machine will not be able to keep up with particularly high evaporative days. Investing in higher system capacity reduces the risk of not meeting crop water requirements in peak demand periods, but comes with higher capital costs.

| **Daily av. crop water requirement** | | |
|---|---|---|
| 3 day peak crop ET rate | 14.5 | mm/day |
| **Required pumping utilisation rate** | **100** | **%** |

$$= \frac{3\ day\ peak}{DSC\ x\ E_a}$$

If larger than 100%, the system cannot meet 3-day peak ET.

### » *Changing climate and system capacity risk*

The effects of climate change have the potential to significantly affect crop ET and subsequent crop water requirements. Regional ET has been shown to increase or decrease with increased climate variability depending on the specific changes in air temperature, humidity, wind speed, and solar radiation experienced in a region[1],[2]. Given the long term investment in irrigation systems, consideration of the regional implications for ET would help to ensure irrigation system capacity can continue to meet crop water demands in a changing climate.

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## IMPLICATIONS

Many machines installed in Australia in the past did not have a system capacity large enough to ensure cotton crop success.

The problem of low system capacity has been the single greatest reason for the low uptake of CPLMs in Australia.

If system capacity is below the crop requirements for a given area, then there is an increased risk of lost yield. For every day that MSC does not meet daily crop water use, the available water in the crop root zone will decrease, leading to increased risk of crop stress and decreased yield. Furthermore, CPLM systems do not have the ability to apply large volumes of water to 'catch up' if the crop experiences a period of high water use.

System capacity should be high enough to satisfy peak crop water demand but not so excessive that capital and running costs are too high.
The key implication is to talk to an appropriately qualified irrigation designer to ensure that managed system capacity and peak crop water requirements are fully understood and matched accordingly at the time of planning and installation.


[1] CottonInfo, 2012, WATERpak
[2] Bureau of Meteorology, Average annual and monthly evapotranspiration maps
[3] See WaterPak Section 2.1 Irrigation Scheduling for further information
[4] Fan, J., Wu, L., Zhang, F., Xiang, Y. and Zheng, J., 2016. Climate change effects on reference crop evapotranspiration across different climatic zones of China during 1956–2015. Journal of Hydrology, 542, pp.923-937.
[5] Shi, L., Feng, P., Wang, B., Li Liu, D., Cleverly, J., Fang, Q. and Yu, Q., 2020. Projecting potential evapotranspiration change and quantifying its uncertainty under future climate scenarios: A case study in southeastern Australia. Journal of Hydrology, 584, p.124756.


**For further information:**

**Visit www.cottoninfo.com.au**

For more information on system capacity see CottonInfo's WATERpak.
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