Smarter Irrigation for Profit

Centre Pivot System Capacity & Energy Implications

Tasmanian State Water for Profit, Campbell Town
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Visualisation & Optimisation Tools

- Infiltration
- Scheduling
- Design
Why are we here? Production Costs vs Profit
Reducing your Costs a little means increasing Profit a lot

- Production Costs
Centre Pivot System Capacity

• Measure of flowrate for irrigated area in mm/day
• Low system capacities have been responsible for more CP&LM “failures” than all other issues combined
• Single greatest reason for low uptake of CP&LMs
• Calculate by dividing your CP&LM flowrate, in Litres per day, by irrigated area in square metres
• Remember that 1 litre on 1 square metre = 1 mm
• CP&LMs are built to run 24 hrs a day, seven days a week – make sure they do through Dec-Jan
System Capacity

The system capacity is the maximum possible rate at which the machine can apply water to the irrigated field area

Expressed in mm/day

NOT the depth applied per pass (mm)

System Capacity = \( \frac{\text{Daily pump flow rate (L/day)}}{\text{Field irrigated area (m}^2\text{)}} \)
System Capacity Recommendations

6.5 to 7.0 mm/day

7.5 to 8.0 mm/day
Why focus on Energy?

- Agricultural production is energy intensive
  - based on machinery, fertilizer & pesticide inputs
- Fastest growing input cost to irrigated prod’n
- Energy is the stuff we buy that allows machinery to do work. Measured in MegaJoules (MJ)
  - 1 Litre Diesel holds 38.4 MegaJoules (MJ)
  - 1 kiloWatt.hour Electricity holds 3.6 MegaJoules
- Efficiency is all about how well machinery converts Energy into useful work
What is Power? – what is Energy?

- Energy is “the stuff you buy”
- You buy “Litres of Diesel” or “kiloWatt.hours of electricity”
- Power rating is all about how fast you can burn “the stuff you buy”
- A motor with a big power rating in kiloWatts will burn “the stuff you buy” more quickly
Need irrigation but water is heavy. Needs lots of energy to shift it

• Water is very **HEAVY** material!!

• 1 Litre is a kilogram. 1000 litres is a tonne.

• 1 MegaLitre (ML) is 1000 tonnes = 20 B-double truck

• Need **Lots** of Energy to lift & move water

• 1 ML in this room (15m × 30m) is 2.22 m deep

• 1 ML on 1 ha is same as 100 mm rainfall

• Every ML per ha is 1000 tonnes per hectare
Lots of Energy needed to lift water

- 1 ML per ha is 20 B-double trucks per ha!!

- In an *ideal* world, each MegaLitre (ML) lifted up one metre of height uses 9.81 MegaJoules (MJ) or 2.725 kiloWatt.hours (kW.h) of Energy

- In the *real* world, to lift 1 ML up 1 metre, with pump efficiency of 80% and electric motor efficiency of 90% you need 3.785 kiloWatt.hours (kW.h) of Energy

- Best possible case is 3.3 kW.h per ML per metre lift

- Worst likely case is 5.8 kW.h per ML per metre lift
Pump Curve

Suction lift shown is based on clear water at not over 85°F at sea level and includes static lift plus friction losses.
Pump Curve

TDH, Total Dynamic Head (m)

Q, Flowrate (m³/s)

TDH

Duty Point

Q
Total Dynamic Head

• Total Dynamic Head
  – Is a measure of the energy per unit weight imparted to the water by the pump

• Calculate from:
  – the discharge dynamic head minus the suction dynamic head
  – suction dynamic head – measured relative to the pump centreline
Five key parts involved in pump Total Dynamic Head

• Pressure Head
• Elevation Head
• Velocity Head
• Friction Headloss
• Minor Headloss
Energy or TDH Line

• Energy line is made up of the five components of Head and Headloss just discussed above
• Shows all parts of Total Dynamic Head
• Units of metres head of water
• Graphical way of “seeing” the energy line and change through a pumped system
Energy Line & TDH

TDH

\[ h_{ld} \]

\[ H_{ST} \]

\[ h_s \]

\[ Z_1 \]

Suction pipe

Delivery pipe

Datum

Screen & bend Headloss

Friction Headloss

Velocity Head

Valve loss

Elevation

Suction Loss
Pump Total Dynamic Head & Energy Line
System Resistance Curve
or Pipeline Resistance Curve

• Describes the relationship between the head and discharge for a specific pipeline configuration
• accounts for the static, friction & minor head loss over a wide range of discharge
• developed for increments of flowrate, calculating headlosses for each
System Resistance & Pump Curve

![Diagram showing System Resistance & Pump Curve with labels for Duty Point, Pump Curve, System Resistance Curve, TDH, Static Head, and Q.](image)
Altering System Curve

- **Pump Curve**
- **Duty Point**
- **More System Resistance**
  - Valve Shut or Smaller Pipe

**Graph Details:**
- **TDH, Total Dynamic Head (m)**
- **Static Head**
- **Q, Flowrate (m^3/s)**

- **Duty Point**
  - TDH, Q crossing point

- **Pump Curve**
  - TDH vs Q graph

- **More System Resistance**
  - Effect of valve shut or smaller pipe

**Legend:**
- **TDH**
- **Q**

**Legend Text:**
- **Pump Curve**
- **Duty Point**
- **More System Resistance**
  - Valve Shut or Smaller Pipe

**Graph Description:**
- The graph illustrates the relationship between dynamic head (TDH) and flowrate (Q) for a pump and system resistance changes.
- The duty point is where the pump curve intersects the total dynamic head curve.
- Adjustments to system resistance (valve shut or smaller pipe) affect the duty point and system performance.
Altering System Curve

Pump Curve

Less System Resistance
- Valve Open

Duty Point

or Larger
- pipe

TDH, Total Dynamic Head (m)

Static Head

Q, Flowrate (m$^3$/s)
System Curve

TDH, Total Dynamic Head (m)

Q, Flowrate (m³/s)

Duty Point

Low Static Head

Q
Efficiency Curves

Lines of equal pump efficiency
Pump Curve & Efficiency

- Highest pump efficiency
- Lower pump efficiency

Graph showing the relationship between total dynamic head (TDH) and flowrate (Q) for pumps.
Altering Duty Point

![Graph showing Pump Curve, Duty Point, System Resistance Curve, TDH, Static Head, and Q, Discharge (m³/s).]
Altering Duty Point

Pump Curve

Total Dynamic Head (m)

Less System Resistance - Larger Pipe

Duty Point

Static Head

Q, Discharge (m³/s)
Energy use of Centre Pivot

• Example: CP of 400 metres length with 450 metre length of 150 NB PVC pipe Class 6 to a pump 2.5 m lower than pad at centre of machine, with vacuum gauge reading of 5 m:

  • A 6 mm per day sprinkler package will have a flow of 34.9 L/s and a pump TDH = 37.3 m head
  • A 8 mm per day sprinkler package will have a flow of 46.5 L/s and a pump TDH = 47 m head
  • Comparison with 42 mm applied for the week, which is 21.1 ML pumped for the week.
Energy use of Centre Pivot

• For same 400 m long machine

• Calc’d with Tariff 75 : Summer, 7am to 10 pm
  23.788 c/kW.h, rest at 14.864 c/kW.h, $2.72/day

• The 6 mm per day sprinkler package will run all week (168 hrs) & have pumping costs of $581/wk, which is $27.53 per ML pumped

• The 8 mm/day pack runs 93 hrs off-peak, and 33 hrs shoulder rate, and would have pumping costs of $665/wk, which is $31.50 per ML pumped
Irrigation Energy Costs

• Moving water is all about using energy (kW.h)
• Every ML of water per ha is a 1000 tonne/ha
• Increasing energy costs force improved conversion of the energy you buy (kW.h)
• Electricity(kWh) to pump 1 ML =\((2.725 \times \text{TDH}) ÷ (\text{Eff.}_{\text{Pump}} \times \text{Eff.}_{\text{Drive}} \times \text{Eff.}_{\text{Motor}})\)
• Moving toward lower pump TDH = lower energy costs
• Don’t burn your profit to irrigate better
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