Water efficiency vs Energy efficiency

What’s the difference?

Water Efficiency

vs

Energy Efficiency

What’s the Difference?
Water efficiency vs Energy efficiency
What’s the difference?

PROGRAM

• About the Presenter – career experiences
• WE vs EE – what’s the difference’ ?
• Applying energy efficiency in irrigation
About the Presenter

- Mixed farm GULNARE, South Australia
- 1948 - 1958
- 2km creek for playground
- Did farm “apprenticeship”

- Innovation permeated farm life
- Made own toys etc
- Pedal car = prime mover
- Challenged status quo throughout life
Water efficiency vs Energy efficiency

What's the difference?

South Australia

Driest State of the Driest Continent in the World

Murray/Darling catchment

2/3 size of Mississippi/Missouri

South Australia

- 95% area < 10” rainfall
- River Murray lifeline
- 1.5 x area of Texas

By Robert L Welke
Associate Diploma, Mechanical Engineering, Irrigation Agronomist, Irrigation Auditor
Adelaide, South Australia
Water efficiency vs Energy efficiency
What’s the difference?

Note that USA almost all above 30th Lat Nth.
Australia almost all above 30th Lat Sth.

Therefore, Australia much hotter/drier climate.
Water efficiency vs Energy efficiency
What’s the difference?

- Adelaide, 1.2 million
- Dry year, 90% water pumped from River Murray
- 1000' lift, 3 or 4 stages
- 4 major pipeline systems
- Approx 130,000 kW (175,000 HP)
- $millions/annum pumping costs
- > 1000 pump tests over 20 yrs

PUMP TESTING
with SA Water for 20 years.

Murray Bridge – Onkaparinga Pipeline and No 3 PS
3 x 5,600 kW pumps (7,500 HP each)
Water efficiency vs Energy efficiency
What’s the difference?

PIPELINE FRICTION TESTING with SA Water for 20 years

- From largest (1.8m) to smallest (80mm) pipeline, (Hazen & Williams “C” Values)
- Determine maintenance policy
- Pumping economics

Mannum – Adelaide Pipeline No 3 PS (1955)
3 x 1,600 kW pumps (2,500 HP each)

Murray Bridge – Onkaparinga Pipeline and No 3 PS (1973)
3 x 5,600 kW pumps (7,500 HP each)
Pump Design and Build
Hydrotech (Aust) 6 yrs

- 100 pumping systems
- Turf, Horticulture, Ag, Golf
- Design, Build, Commission
- Engineered Product

Defining moment

“There’s a wheel barrow in my Pipeline”

- 10 km of 450NB PVC
- Pumps reduced output
- Pipeline friction test, 2000
- Willunga Basin Water Co
Water efficiency vs Energy efficiency
What's the difference?

Tallemenco Pty Ltd, 2003 to present
- Designed P.S. up to 3,000 l/s
- Bore draw-downs
- Field Evaluations – Irrigation (CIAL Certified)

System Evaluations
- Pumping systems
- Pipeline systems
- Irrigation systems
- Pumping Energy Efficiency audits

Pump Design 3 yrs
HydroPlan (Aust)
- Pumping systems
- Pipeline systems, Dams
- Irrigation systems (drip)
Water efficiency vs Energy efficiency
What's the difference?

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Tallemenco Pty Ltd 2003 to present, (16 yrs)

Pumping System Evaluations

- Pumping Energy Efficiency audits,
  identified > $630,000 annual elect savings
- More energy efficiency losses in pipes (hydraulics) than in pumps
- Case Study: Pumping energy efficiency audit, Windsor NSW turf farm (for DPI NSW 2014)
  - Efficient Lateral Move
  - 90% losses in pipes
  - 10% losses in pump
Water efficiency vs Energy efficiency

What’s the difference?

How many “MPG” does your pump system do?

\[
\text{\$$/yr}^* = 3.15 \times \text{feet head} \times \text{c/kWh} \times \text{Mg/yr} \times \text{motor } \eta \times \text{pump } \eta \times \text{drive } \eta
\]

Pump less water
a) scheduling
b) Soil moisture monitoring

Elevation
Filter head loss
Main line head loss
Laterals head loss
Layflat hose head loss
Emitter head loss
Residual head

Tariff – choice of
- peak
- Off-peak
- Week-end

Motor efficiency fixed

Motor \( \eta \)
MkW
Pump \( \eta \)

EkW

*Refer www.talle.biz/data.html
Water efficiency vs Energy efficiency
What’s the difference?

Water Efficiency

a) Water Requirement
b) Irrigation scheduling
c) Distribution Uniformity
d) Crop water use efficiency

Energy Efficiency

a) Head pumped
b) Pump effy
c) Motor effy
d) Tariff (c/kWh, $/Litre diesel)
e) ML pumped
Water efficiency vs Energy efficiency

What’s the difference?

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V’s

Energy Efficiency

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e) ML pumped
Water efficiency vs Energy efficiency

What’s the difference?

Water Required vs Pumped Volume

Soil Moisture Monitoring

Eg, Capacitance Probe

Less irrigation = less pumping costs.

By Robert L Welke
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# Water efficiency vs Energy efficiency

## What’s the difference?

### Water Efficiency

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Water efficiency vs Energy efficiency
What’s the difference?

Irrigation Scheduling vs Pumped Head

Sanctuary Cove Resort,
Gold Coast, QLD. 2010

Manual scheduling 1
70 acres landscaping site, 31 stand alone controllers
Pump system failing on low pressure

Concentration of scheduling resulted in high peak flow rates, high head losses in pipes

Charts: 
R Welke

Sanctuary Cove Resort, Gold Coast, QLD. 2010

By Robert L Welke
Associate Diploma, Mechanical Engineering,
Irrigation Agronomist, Irrigation Auditor
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Water efficiency vs Energy efficiency

What’s the difference?

Irrigation Scheduling vs Pumped Head

Manual Scheduling 2
28Ha landscaping site, 31 remote controllers
Rescheduling optimised pump duty required

Rescheduling reduced peak flow by 35%, resulting in less friction losses.

By Robert L Welke
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Adelaide, South Australia
What’s the difference?

Water Efficiency  V’s  Energy Efficiency

- a) Water Requirement
- b) Irrigation scheduling
- c) Distribution Uniformity
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- a) Head pumped
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Water efficiency vs Energy efficiency
What's the difference?

Irrigation Scheduling vs Pump Effy/motor effy

Irrigating cabbages 57kW (75hp) diesel
Lindenow, VIC. 125x100-315
Mitchell River 2950rpm pump

Charts: R Welke

Can affect energy efficiency if irrigation flows are reduced or increased.

$300/ML ($370/ac.ft)
Water efficiency vs Energy efficiency

What’s the difference?

Water Efficiency  V’s  Energy Efficiency

Water Efficiency

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e) ML pumped

Energy Efficiency

a) Head pumped
b) Pump effy
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Water efficiency vs Energy efficiency
What’s the difference?

Irrigation Scheduling vs Pumped Volume

- Clay soil
- 6 watermelon plants
- 8” x 8” soil (paver removed)
- Pulse irrigation (Hunter X-Core)
- 1 x Shrubblter
- Pulse application
- 1 minute x 4 times/day
- 0.7 litre per application
- 360 litres (95 US gall) total
- 9 melons
- 86kg (190 lb) crop

Irrigation Scheduling – pulse irrigation

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Irrigation Agronomist, Irrigation Auditor
Adelaide, South Australia
Water efficiency vs Energy efficiency

What’s the difference?

Water Efficiency V’s Energy Efficiency

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a) Head pumped
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Water efficiency vs Energy efficiency
What's the difference?

Distribution Uniformity vs Pumped Head

Scheduling Co-efficient

- If CU/DU down
- SC up (Scheduling Coefficient)
- Eg, DU falls from 84% to 73%
- SC rises from 1.3 to 1.6
- That’s 23% more water required

Example:
Toro 640 @ 450 kPa
DU = 84%
SC = 1.3

Example:
Toro 640 @ 350 kPa
DU = 73%
SC = 1.6

Image: Space Pro by Hunter
Water efficiency vs Energy efficiency

What's the difference?

Distribution Uniformity vs Pumped Head

Example:
Toro 640 @ 350 kPa
DU = 73%
SC = 1.6

Restoring Pipeline efficiency – known as Pigging or Swabbing

Pigging 6" PVC, Penrith NSW

SC Restored
Toro 640 @ 450 kPa
DU = 84%
SC = 1.3

Image: Space Pro by Hunter
**Pipeline friction**

Combine “Hazen & Williams” and “Darcy Weisbach Friction factor”

Graph of “Pipe Wall Roughness” to “C” value

Reduction of 10% pipe efficiency (C=135) due to only 0.1mm (4 thou) of pipe wall roughness.

This level of roughness cannot be seen with naked eye.

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Water efficiency vs Energy efficiency

What’s the difference?

**Distribution Uniformity vs Pumped Head**

Irrigation Trust, SA
2 x 270hp pumps
675 acres vines, almonds, citrus

- Founded 1968
- 15”, 12”, 10”, 8” Asbestos Cement pipes
- Audited 2015
- H&W C Value new = 140, now = 80 to 110
- Bryozoa - aquatic invertebrate animals (20 thou long)
- Overheads at end of farm < ½ irrigation radius
- DU’s 10 to 20%
- PIR reduced 40% to achieve required distribution efficiency

Long term solution: Replace pipes

River Murray, Mannum SA
Water efficiency vs Energy efficiency
What’s the difference?

Distribution Uniformity vs Pumped Head

Pump Corrosion (Pump efficiency and H-Q loss)

Materials Evaluation
Blue Lake PS, Mt Gambier, SA. 1971
Austenitic Cast Iron casings (Ni Resist)
  - Resistance to sea water corrosion
  - used on ships propellers
  - Ni 20.0, Cr 2.5, C 3.0, Si 2.0, Mn 1.0 typ.

- Tested after 1 year for efficiency
- Down 10%
- Casings badly corroded
- Materials specific to water quality
Water efficiency vs Energy efficiency
What’s the difference?

Distribution Uniformity vs Pumped Head

Impeller Coatings Evaluation

Mannum Adelaide No. 1
Pumping Station. 1975

Cast Iron casings, Bronze impellers
- pump tested, efficiency recorded
- impeller coated - DULUX gloss enamel
- pump retested – 4% efficiency gain
- pump tested 1 yr, lost η% and paint

Conclusions
- smooth coating > increased η%
- conventional coatings not satisfactory
- search for hi-tech coatings
- adopted “Belzona”, 25% metallic content

Photo: R Welke 1973
Water efficiency vs Energy efficiency
What’s the difference?

**Distribution Uniformity vs Pumped Head**

**Impeller Coatings (pump corrosion)**

Eg, Irrigation and Water Supply Pumps, Riverland Region, SA, 1980’s

- Eliminate Blulon (asbestos) gland packing
  - move to mechanical seals
  - rotating elements balanced
  - pump casings coated (Belzona)
  - impellers coated (Belzona – 25% metal)

- Pumps tested less regularly
  - Sustained efficiency
  - High reliability
Water efficiency vs Energy efficiency

What’s the difference?

Distribution Uniformity vs Pumped Head

As designed
25 l/s flow
10m head loss

Modified
- Add 3 l/s end of pipe
- 8m extra head loss

Optimized pipe system
- Extend 6” by 150m
- Shortened 4” by 50m
- Shortened 3” by 100m
- Gained 3.4m
- Saved $13,400 / 15 yrs

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Water efficiency vs Energy efficiency

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Water efficiency vs Energy efficiency
What’s the difference?

Distribution Uniformity vs Tariff

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675 acres vines, almonds, citrus

- H&W C Value new = 140, now = 80 to 110
- Overheads at end of farm < ½ irrigation radius
- DU’s 10 to 20%
- PIR reduced 40% to achieve required distribution uniformity
- Overflow irrigation into higher day time tariff

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Water efficiency vs Energy efficiency

What's the difference?

Crop Yield vs Pumped Volume (+ Scheduling + Tariff)

Sugar cane crop, Nth QLD

**BEFORE**
- PIR 11mm/day (43 pts/day)
- CP/LM or Big Gun (SC 1.2/1.6)
- 11 ML/Ha (8.9 ac.ft)
- Evenly across crop life
- 95 t/Ha (38t/ac) ave
- $2600/Ha ($1040/ac) ave

**AFTER**
- PIR 14mm/day
- Sub Surface Drip (+30% CAPEX, -30% pumping head, -30% SC)
- 7 ML/Ha (5.7 ac.ft)
- (50% less kWh pumping)
- Growth based irrigation (flowering/fruiting)
- 137 t/Ha (55t/ac) ave, 238 t/Ha max
- $4500/Ha ($1800/ac) ave

Example per Jim Phillips, ASIC’s Aussie member – ph +61 435 187 486

ML x 0.81 = ac.ft

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Adelaide, South Australia
### Water efficiency vs Energy efficiency

**What’s the difference?**

**Water Efficiency**

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Water efficiency vs Energy efficiency

What’s the difference?

Irrigation during day time “crop water uptake” = higher tariff costs

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Crop Yield vs Tariff

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ML x 0.81 = ac.ft
Water efficiency vs Energy efficiency
What’s the difference?

Water Efficiency V’s Energy Efficiency

Summary

Water Requirement
Irrigation scheduling
Distribution Uniformity
Crop water use efficiency

Head pumped
Pump effy
Motor effy
Tariff (c/kWh, $/Litre diesel)
ML pumped

By Robert L Welke
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Adelaide, South Australia
Water efficiency vs Energy efficiency
What’s the difference?

Water Efficiency  Vs  Energy Efficiency

- Where can energy be saved?
- How to design best practice energy efficiency irrigation systems
- Get more “MPG” from your pumping system!
Irrigation System Design approach - typical

Water efficiency vs Energy efficiency
What's the difference?
Water efficiency vs Energy efficiency
What’s the difference?

Irrigation System Design approach - typical

Irrigation design

Pumping/pipeline design – all too often

Life Cycle Costs
- Pump cost
- NPSH
- Energy cost
- Corrosion
- Pump control
- Pipeline friction
- PS design
- Specification

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Irrigation System Design approach - Tallemenco

Water efficiency vs Energy efficiency
What’s the difference?
Pumping Energy Efficiency
More than just testing pumps....

- By Robert L Welke
- Associate Diploma, Mechanical Engineering,
- Irrigation Agronomist, Irrigation Auditor
- Adelaide, South Australia
Water efficiency vs Energy efficiency
What’s the difference?

Where can energy be saved?
Water efficiency vs Energy efficiency
What’s the difference?

Where can energy be saved?

Pump efficiency
Typically < 50%
Recoverable energy losses

Hydraulic efficiency
Excess Friction losses + excess residual
Typically > 50% recoverable energy losses

Friction loss controllable by design and maintenance

Excess residual head

Pumped Head

Total Pumped Head

Emitters

Friction

Lift (fixed)

Mains
Submains
Pipe ageing
Pump suction
Valves
Filters

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Adelaide, South Australia
Water efficiency vs Energy efficiency

What’s the difference?

Conduct a pump efficiency audit

- Subtract adjacent pressure readings, flow
- Compare with manufacturer’s curve
- Assess potential energy improvement

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Adelaide, South Australia
Water efficiency vs Energy efficiency

What’s the difference?

Conduct a pumping system energy efficiency audit

✓ Subtract adjacent pressure readings, flow
✓ Compare with best practice
✓ Assess potential energy improvement

What is “best practice”?

By Robert L Welke
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TALLEMENCO – 2 Day Workshop Training

“Pumping System Master Class”

(Teaches how to design pumping energy efficiency principles into new irrigation systems)

- Re-defines “pumping energy efficiency for irrigation”
- Numerous software for energy efficiency design
- Comments:
  - “This training course has no equal…” Senior Irrigation Designer
  - “The course was excellent, it has definitely raised the bar for NZ irrigation pumping design”. PGG Consultant, New Zealand
  - “Rob, I learned sooooo much..” 51 yr veteran, water operations engineer, Lower Murray Water

“Limits of Operation”

Determined by Rob’s 5 decades of pumping & hydraulics experience
Water efficiency vs Energy efficiency
What's the difference?

Water Efficiency v’s Energy Efficiency

Proudly presented by

Rob Welke, Tallemenco

Thank you