

# Water efficiency vs Energy efficiency

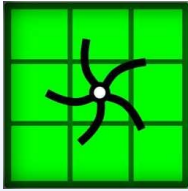
What's the difference?



Water Efficiency  
vs  
Energy Efficiency

What's the Difference?





**TALLEMENCO**  
Irrigation Pumping  
Academy

# 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

**IRRIGATION SHOW** | Dec. 4-5, 2019  
**EDUCATION WEEK** | Dec. 2-6, 2019

Las Vegas Convention Center  
Las Vegas, Nevada

By Robert L Welke  
Associate Diploma, Mechanical Engineering,  
Irrigation Agronomist, Irrigation Auditor  
Adelaide, South Australia



## About the Presenter

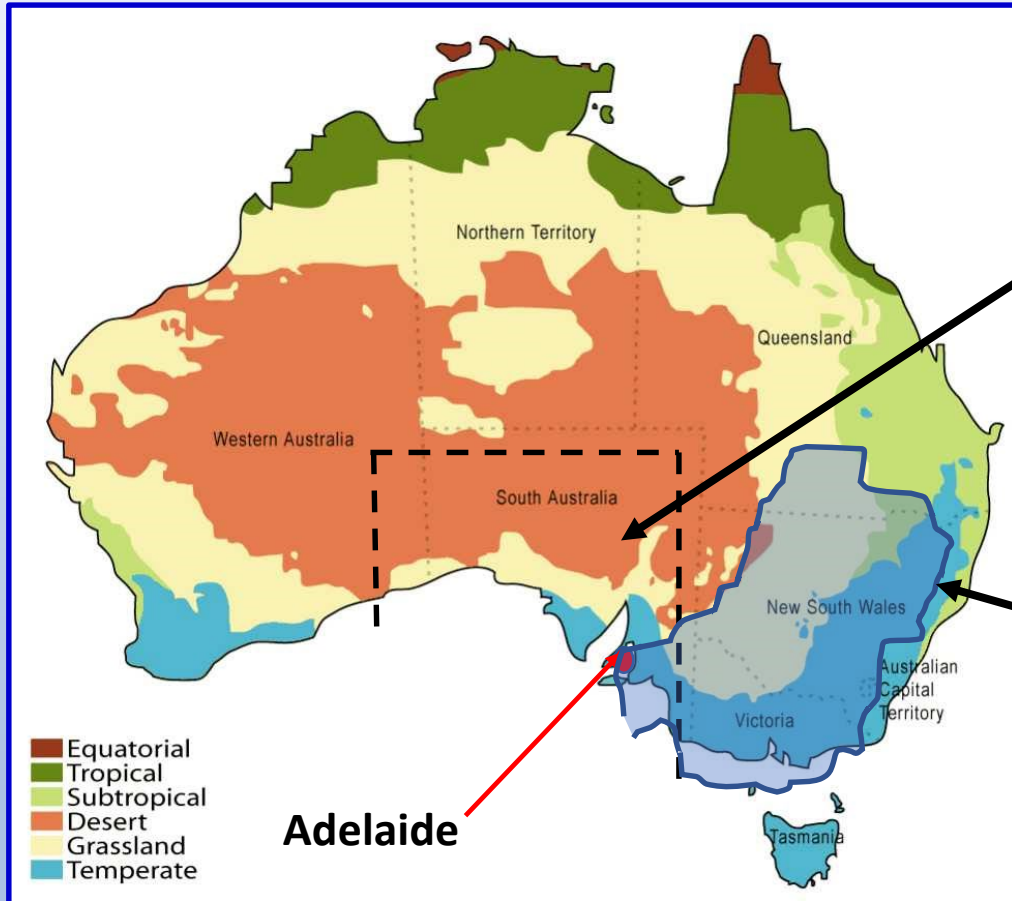
- Mixed farm GULNARE, South Australia
- 1948 - 1958
- 2km creek for playground
- Did farm "apprenticeship"
- Innovation permeated farm life
- Made own toys etc
- Pedal car = prime mover
- Challenged status quo throughout life



me

# Water efficiency vs Energy efficiency

## What's the difference?



South Australia

Driest State  
of the  
Driest Continent  
in the World

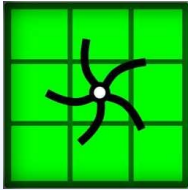
Murray/Darling  
catchment

2/3 size of Mississippi/Missouri



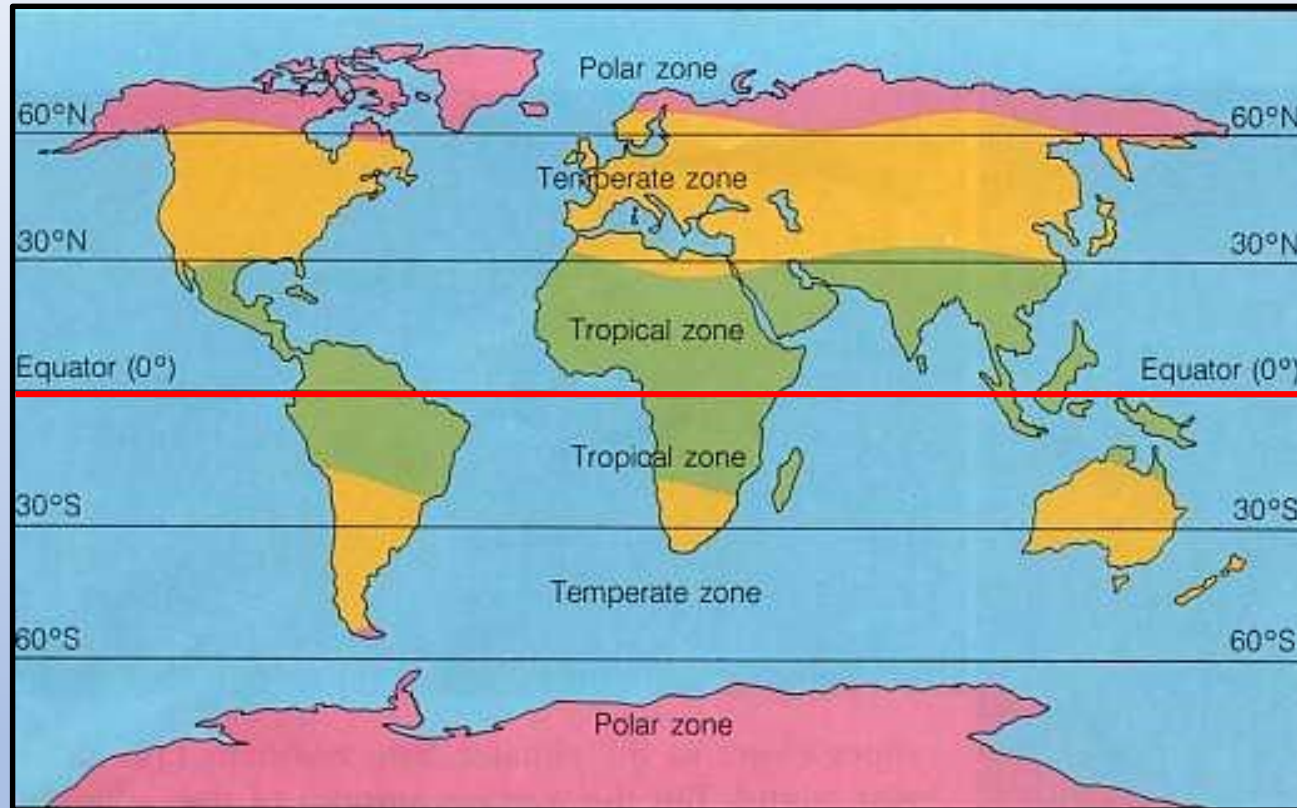
South Australia

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



# Water efficiency vs Energy efficiency

## What's the difference?



Note that USA almost all above 30<sup>th</sup> Lat Nth.  
Australia almost all above 30<sup>th</sup> Lat Sth.

Therefore, Australia much hotter/drier climate.

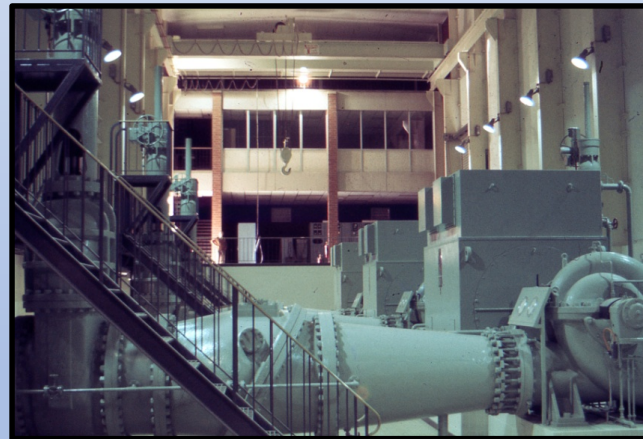


# Water efficiency vs Energy efficiency

## What's the difference?

**PUMP TESTING**  
with SA Water for 20  
years.

- 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

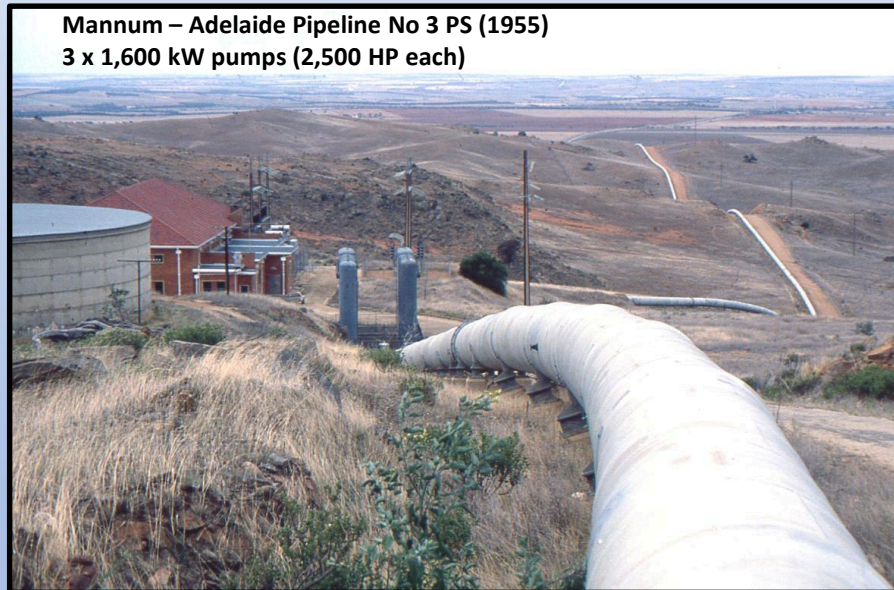


Murray Bridge – Onkaparinga Pipeline and No 3 PS  
3 x 5,600 kW pumps (7,500 HP each)



### 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



Murray Bridge – Onkaparinga Pipeline and No 3 PS (1973)  
3 x 5,600 kW pumps (7,500 HP each)



# Water efficiency vs Energy efficiency

## What's the difference?

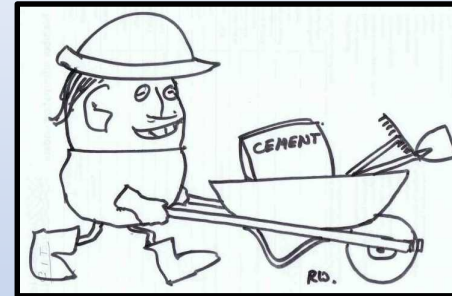


### Pump Design and Build Hydrotech (Aust) 6 yrs

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

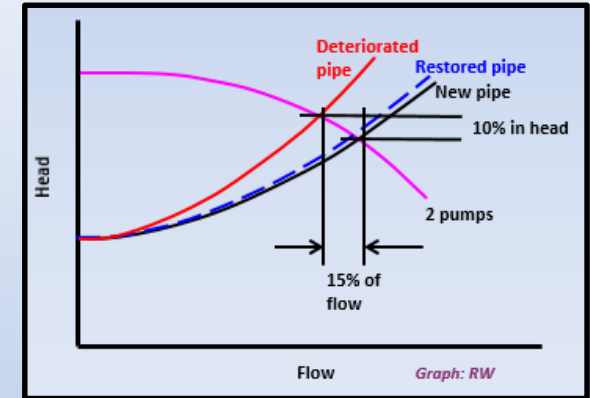


Defining moment



**“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?



### Pump Design 3 yrs HydroPlan (Aust)

- Pumping systems
- Pipeline systems, Dams
- Irrigation systems (drip)

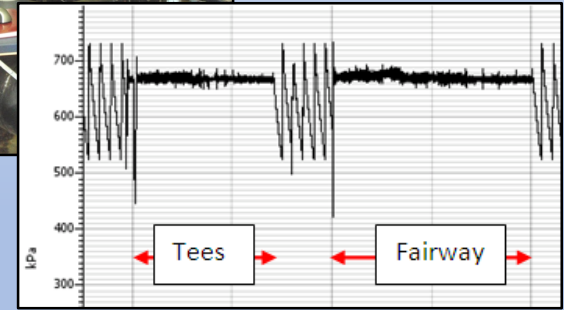
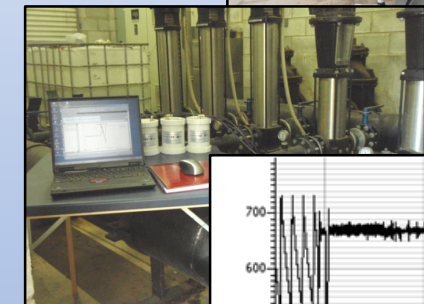
### Tallemenco Pty Ltd 2003 to present

- 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





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

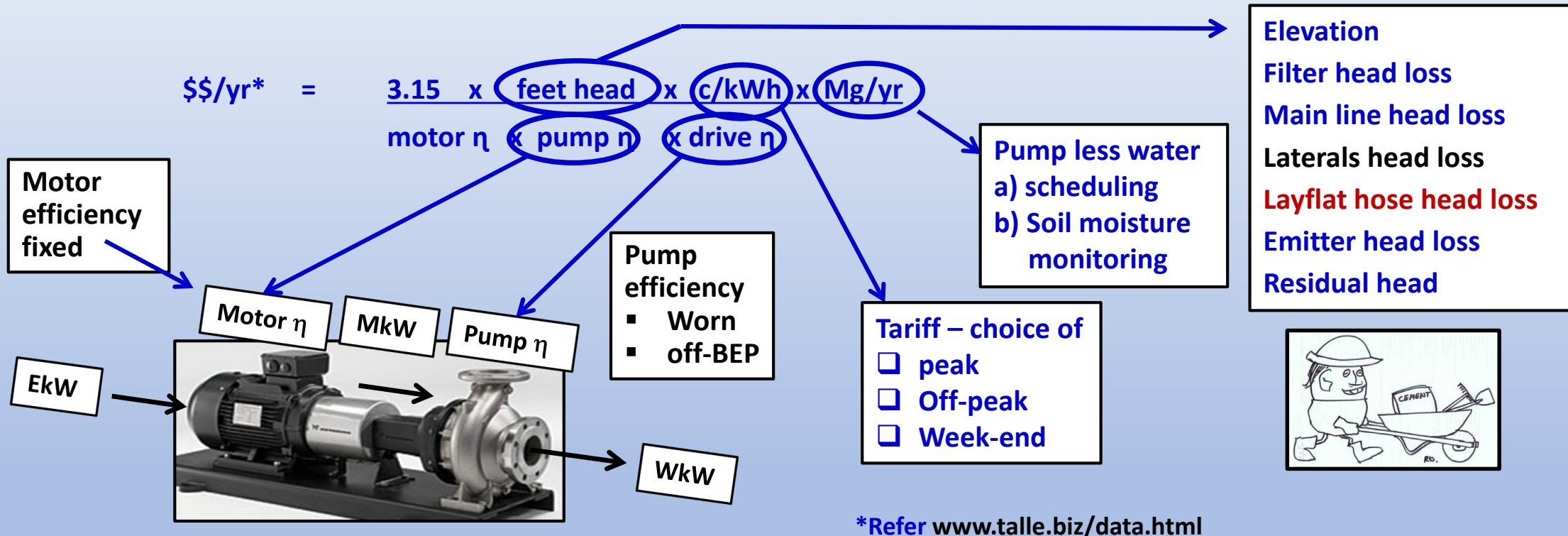
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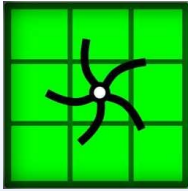


# Water efficiency vs Energy efficiency

## What's the difference?

How many "MPG" does your pump system do?





# Water efficiency vs Energy efficiency

What's the difference?



## Water Efficiency

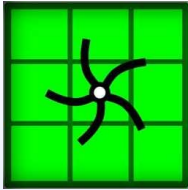
- a) Water Requirement
- b) Irrigation scheduling
- c) Distribution Uniformity
- d) Crop water use efficiency

V's

## 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?



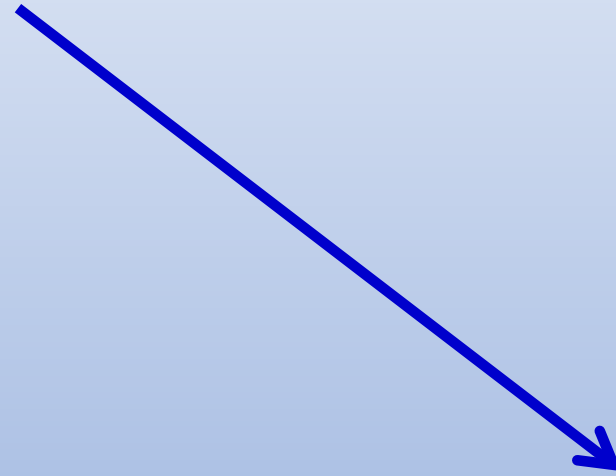
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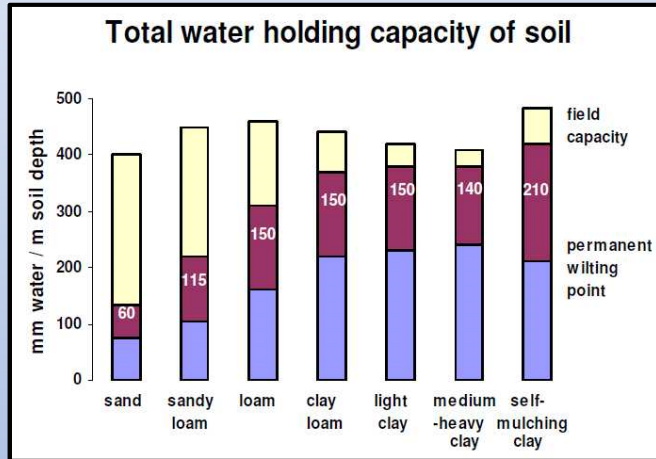
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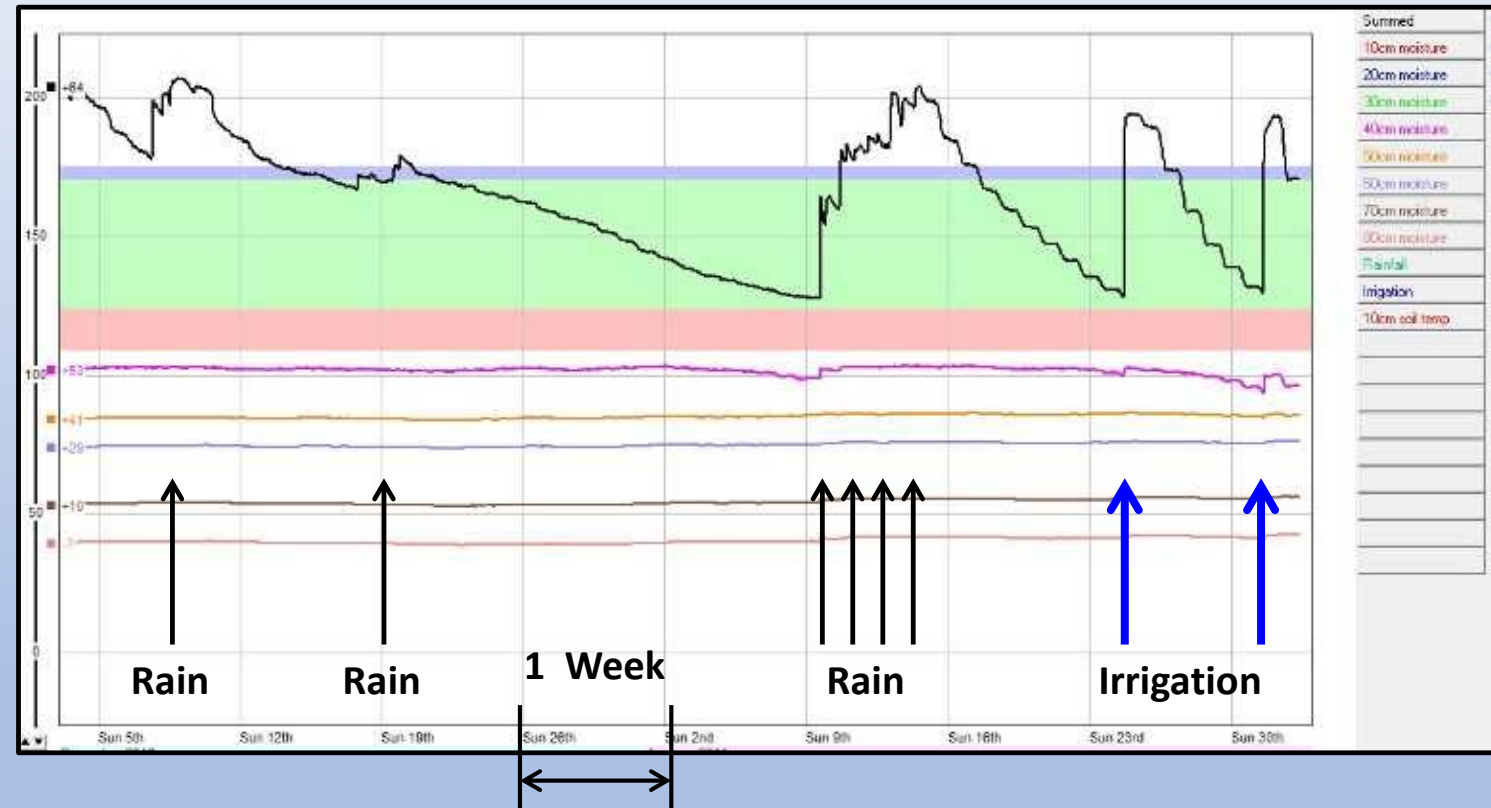
### Water Required vs Pumped Volume

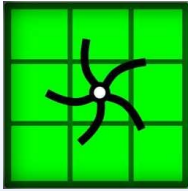
### Soil Moisture Monitoring

Eg, Capacitance Probe



Less irrigation = less pumping costs.





# Water efficiency vs Energy efficiency

What's the difference?

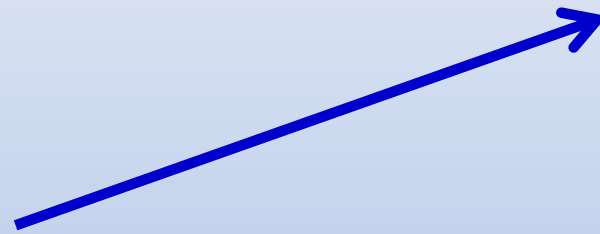


## Water Efficiency

V's

## Energy Efficiency

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### Irrigation Scheduling vs Pumped Head

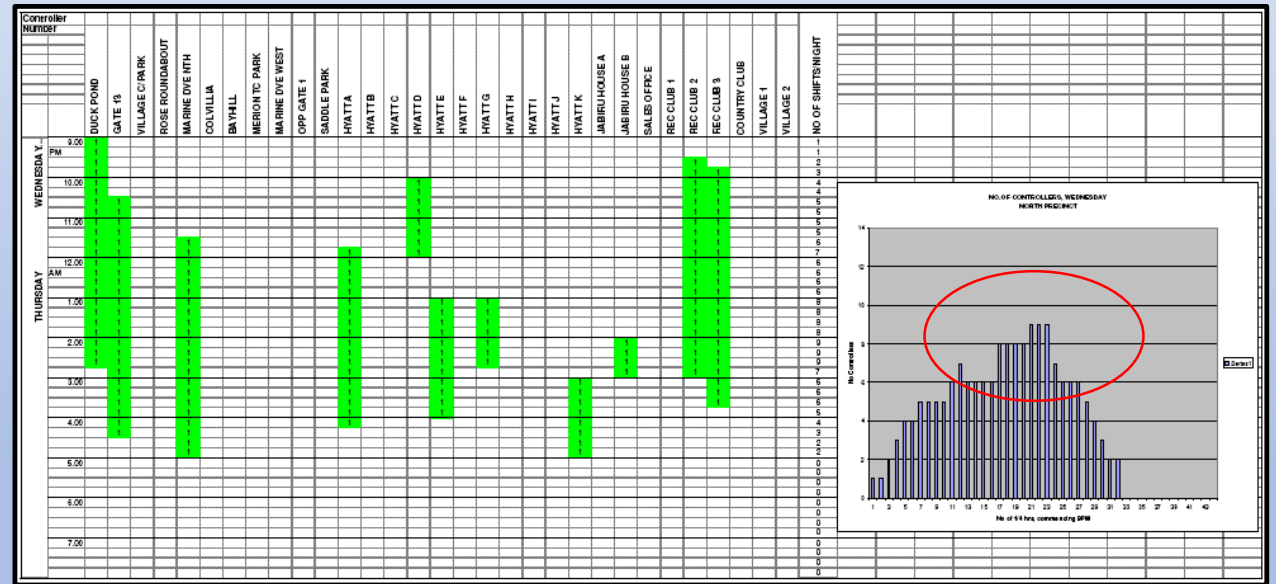
Sanctuary Cove Resort,  
Gold Coast, QLD. 2010



### 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



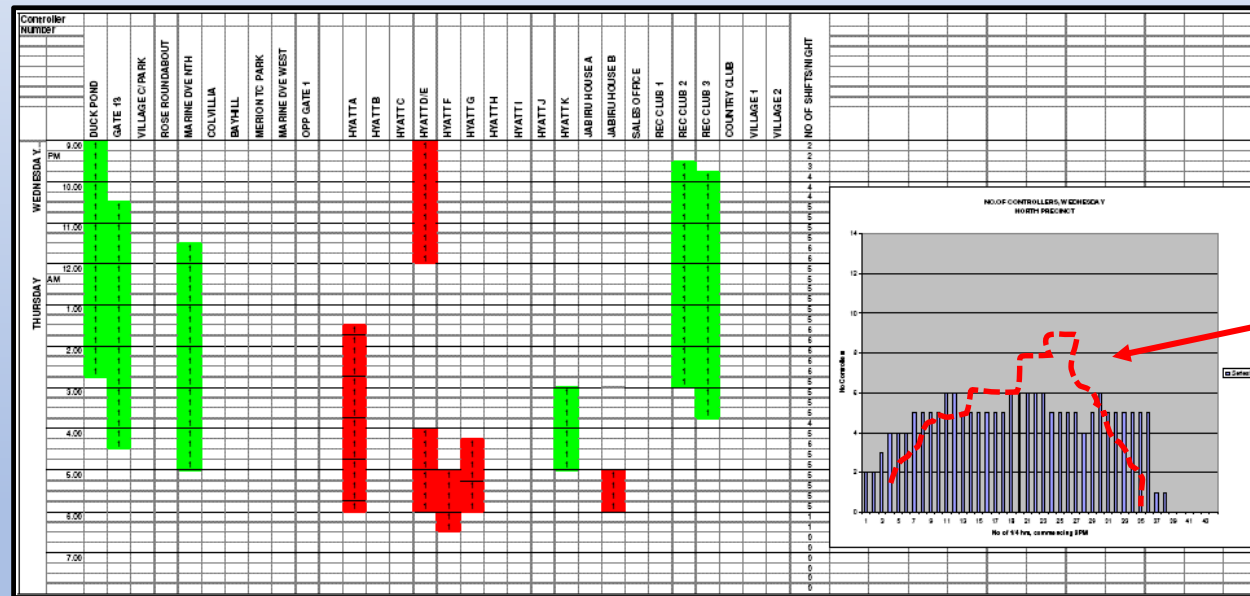
# Water efficiency vs Energy efficiency

## What's the difference?

### Irrigation Scheduling vs Pumped Head

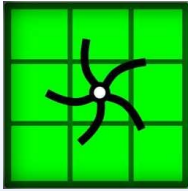
### Manual Scheduling 2

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



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





# Water efficiency vs Energy efficiency

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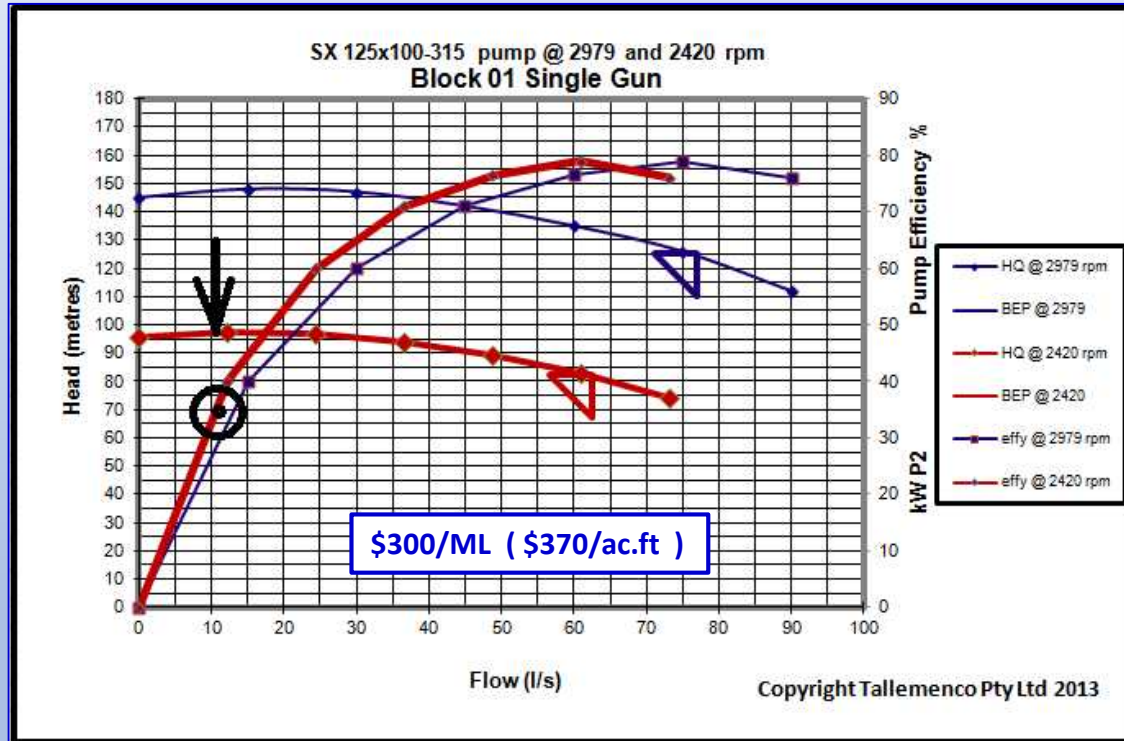


- a) Head pumped
- b) Pump effy
- c) Motor effy
- d) Tariff (c/kWh, \$/Litre diesel)
- e) ML pumped

### Irrigation Scheduling vs Pump Effy/motor effy

Irrigating cabbages  
Lindenow, VIC.  
Mitchell River

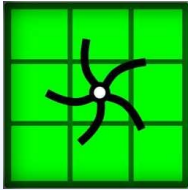
57kW (75hp) diesel  
125x100-315  
2950rpm pump



Charts: R Welke

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





# Water efficiency vs Energy efficiency

What's the difference?



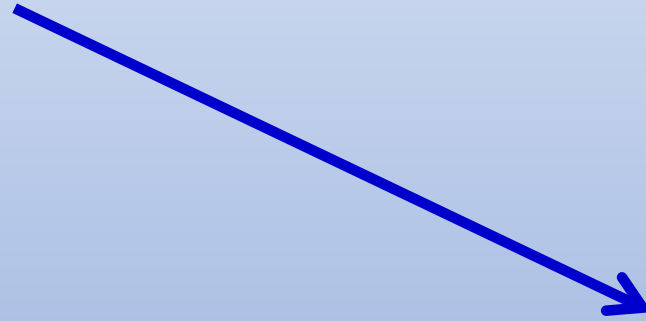
## Water Efficiency

V's

## Energy Efficiency

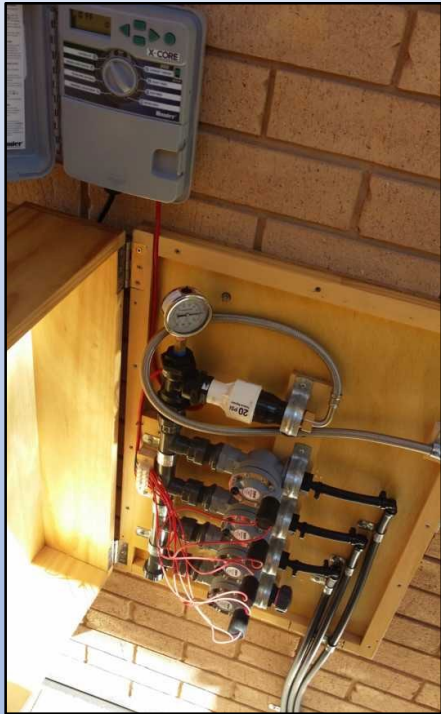
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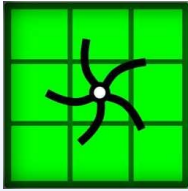
### Irrigation Scheduling vs Pumped Volume



- Clay soil
- 6 water melon plants
- 8" x 8" soil (paver removed)
- Pulse irrigation (Hunter X-Core)
- 1 x Shrubber
- 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





# Water efficiency vs Energy efficiency

What's the difference?

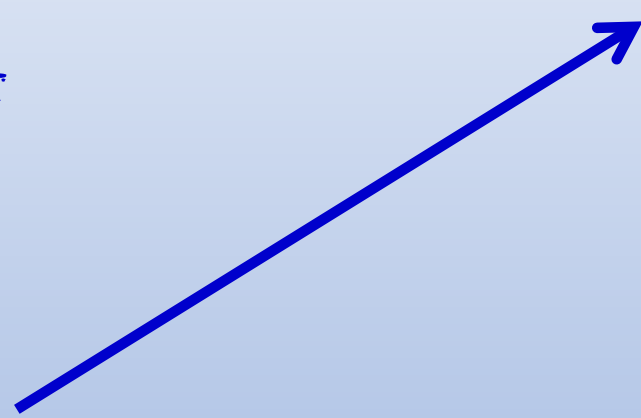


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V's

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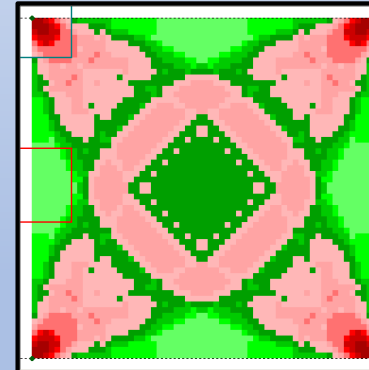
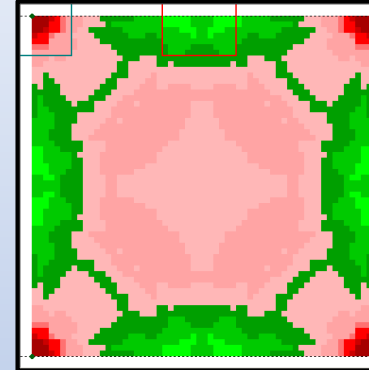
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### Distribution Uniformity vs Pumped Head

#### 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

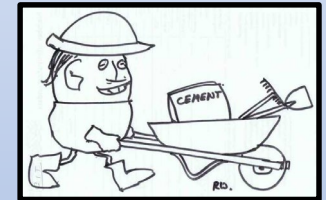


#### Example:

Toro 640 @ 450 kPa

DU = 84%

SC = 1.3



#### Example:

Toro 640 @ 350 kPa

DU = 73%

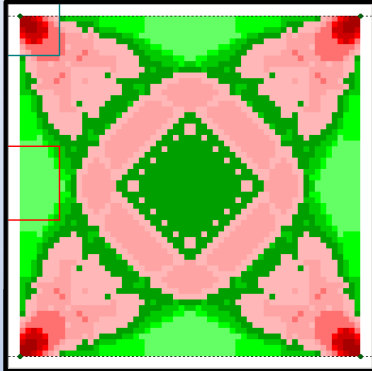
SC = 1.6

*Image: Space Pro by Hunter*

# Water efficiency vs Energy efficiency

## What's the difference?

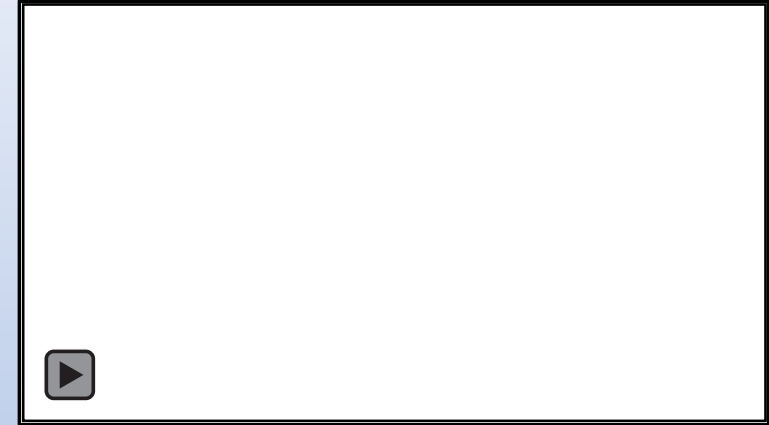
### Distribution Uniformity vs Pumped Head



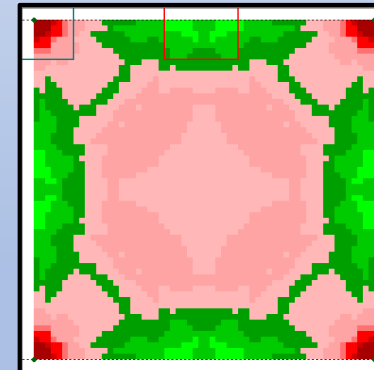
Example:  
Toro 640  
@ 350 kPa  
DU = 73%  
SC = 1.6

**Restoring Pipeline efficiency – known as Pigging or Swabbing**

(removing the wheel barrows)



Pigging 6" PVC, Penrith NSW

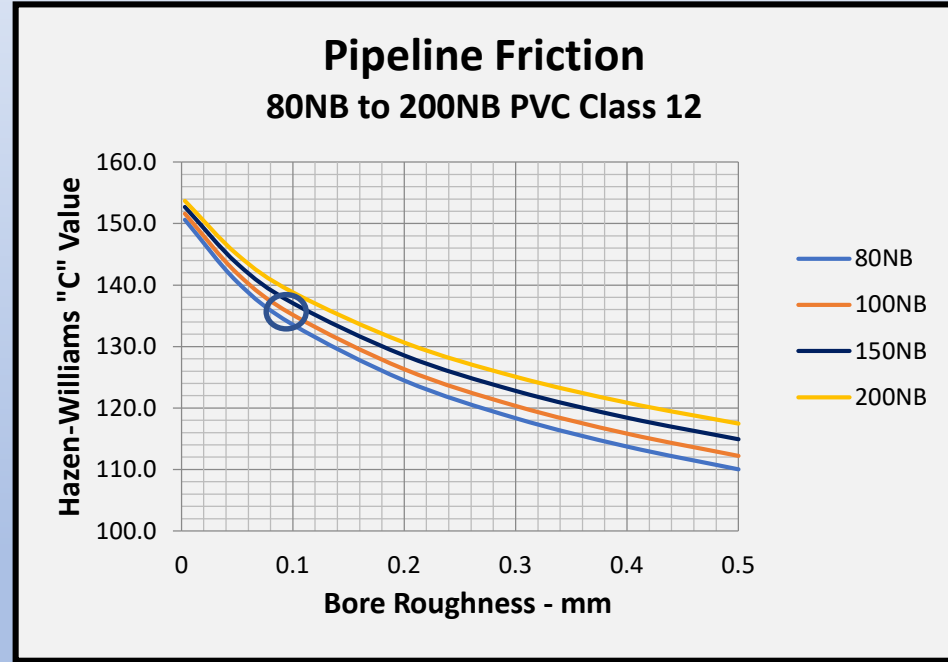


SC Restored  
Toro 640 @ 450 kPa  
DU = 84%  
SC = 1.3

Image: Space Pro by Hunter

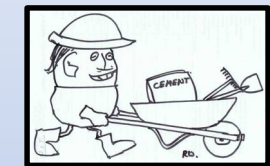
### Pipeline friction

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.



New pipe



Old pipe



# Water efficiency vs Energy efficiency

## What's the difference?



### Distribution Uniformity vs Pumped Head

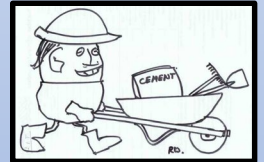


Irrigation Trust, SA  
2 x 270hp pumps  
675 acres vines, almonds, citrus



River Murray, Mannum SA

- 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**



### 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



Blue Lake PS  
Mt Gambier, SA.  
Primary Lift Pumps

## 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  $\eta$ % and paint

### Conclusions

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

Mannum - Adelaide No.1 PS



*Photo: R Welke 1973*

### 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

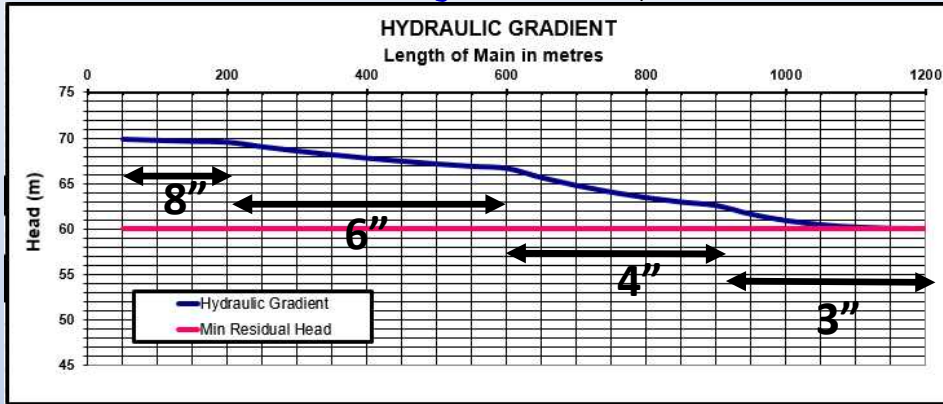


Neil Harvey painting a rebalanced pump impeller with an epoxy coating.

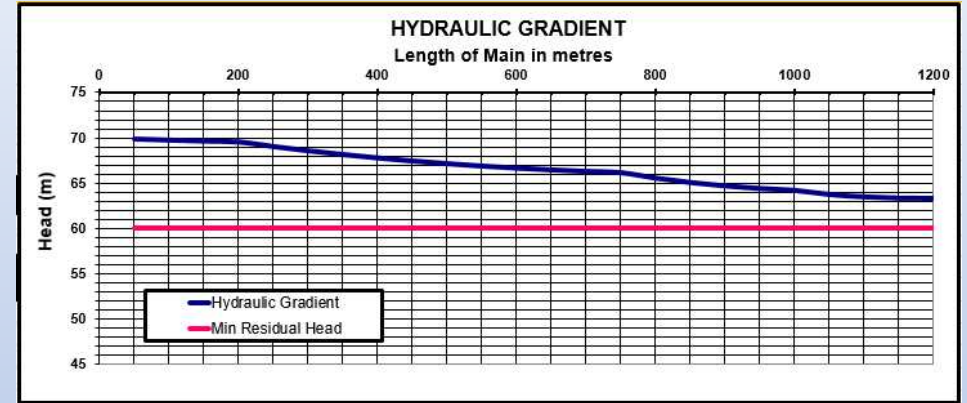
*Photo: R Welke*



### Distribution Uniformity vs Pumped Head

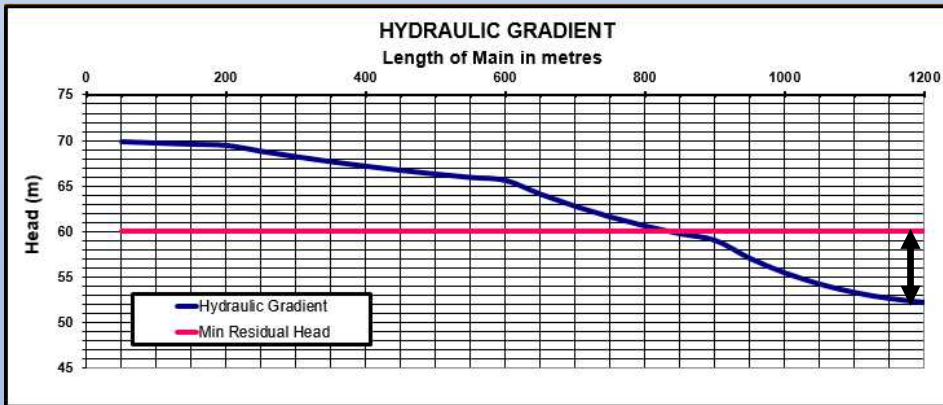


As designed  
25 l/s flow  
10m head loss



#### Optimized pipe system

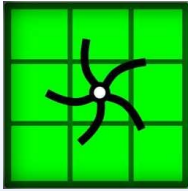
- Extend 6" by 150m
- Shortened 4" by 50m
- Shortened 3" by 100m
- Gained 3.4m
- Saved \$13,400 / 15 yrs



#### Modified

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





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# Water efficiency vs Energy efficiency

## What's the difference?



### Distribution Uniformity vs Tariff

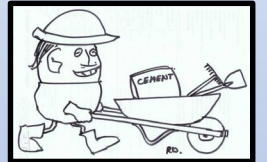


River Murray, Mannum, SA



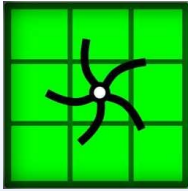
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675 acres vines, almonds,  
citrus

- H&W C Value new = 140, now = 80 to 110
- Overheads at end of farm < 1/2 irrigation radius
- DU's 10 to 20%
- PIR reduced 40% to achieve required distribution uniformity
- Overflow irrigation into **higher day time tariff**



1. Energy Charges  
Peak  
Off Peak

43063.50 kWh	8.4598 c/kWh
54288.50 kWh	5.2035 c/kWh



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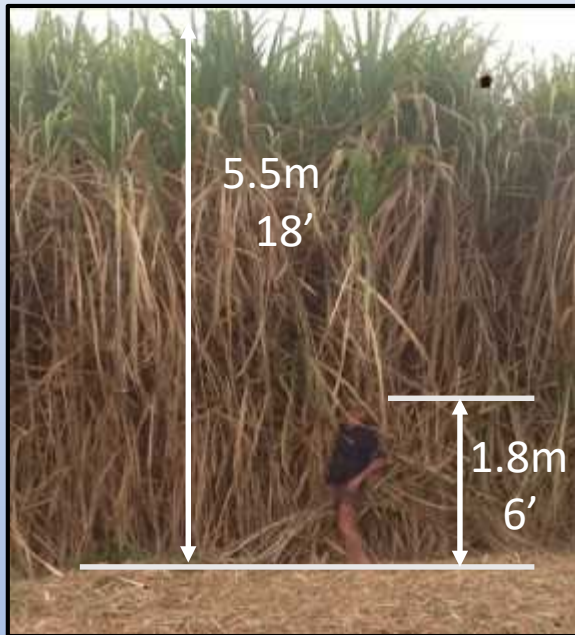
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### Crop Yield vs Pumped Volume (+ Scheduling + Tariff)

Sugar cane crop, Nth QLD



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

#### BEFORE

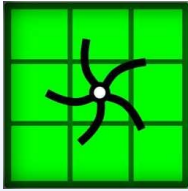
- PIR 11mm/day (43 pts/day)
- CP/LM or Big Gun (SC 1.2/1.6)
- 11 ML/Ha** (8.9 ac.ft)
- Evenly across crop life
- 95 t/Ha** (38t/ac) ave
- \$2600/Ha (\$1040/ac) ave

#### 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, 238t/Ha max
- \$4500/Ha (\$1800/ac) ave

ML x 0.81 = ac.ft





# Water efficiency vs Energy efficiency

What's the difference?



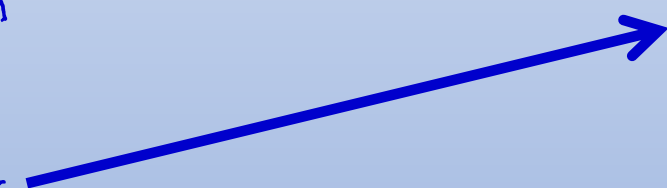
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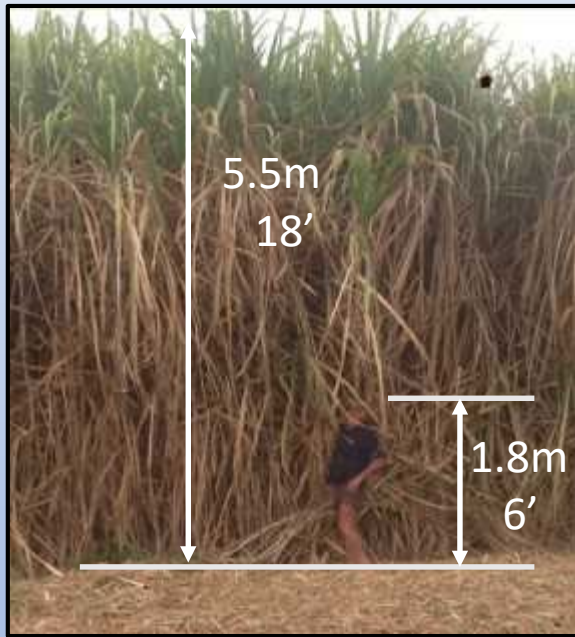


# Water efficiency vs Energy efficiency

## What's the difference?

### Crop Yield vs Tariff

Sugar cane crop, Nth QLD



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

Irrigation during day time  
"crop water uptake"  
= higher tariff costs

#### BEFORE

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- 7 ML/Ha (5.7 ac.ft)
- (50% less kWh pumping)
- Growth based irrigation (flowering/fruiting)
- 137 t/Ha (55t/ac) ave, 238t/Ha max
- \$4500/Ha (\$1800/ac) ave

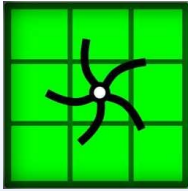
ML x 0.81 = ac.ft



1. Energy Charges  
Peak  
Off Peak

43063.50 kWh	8.4598 c/kWh
54288.50 kWh	5.2035 c/kWh





# Water efficiency vs Energy efficiency

What's the difference?

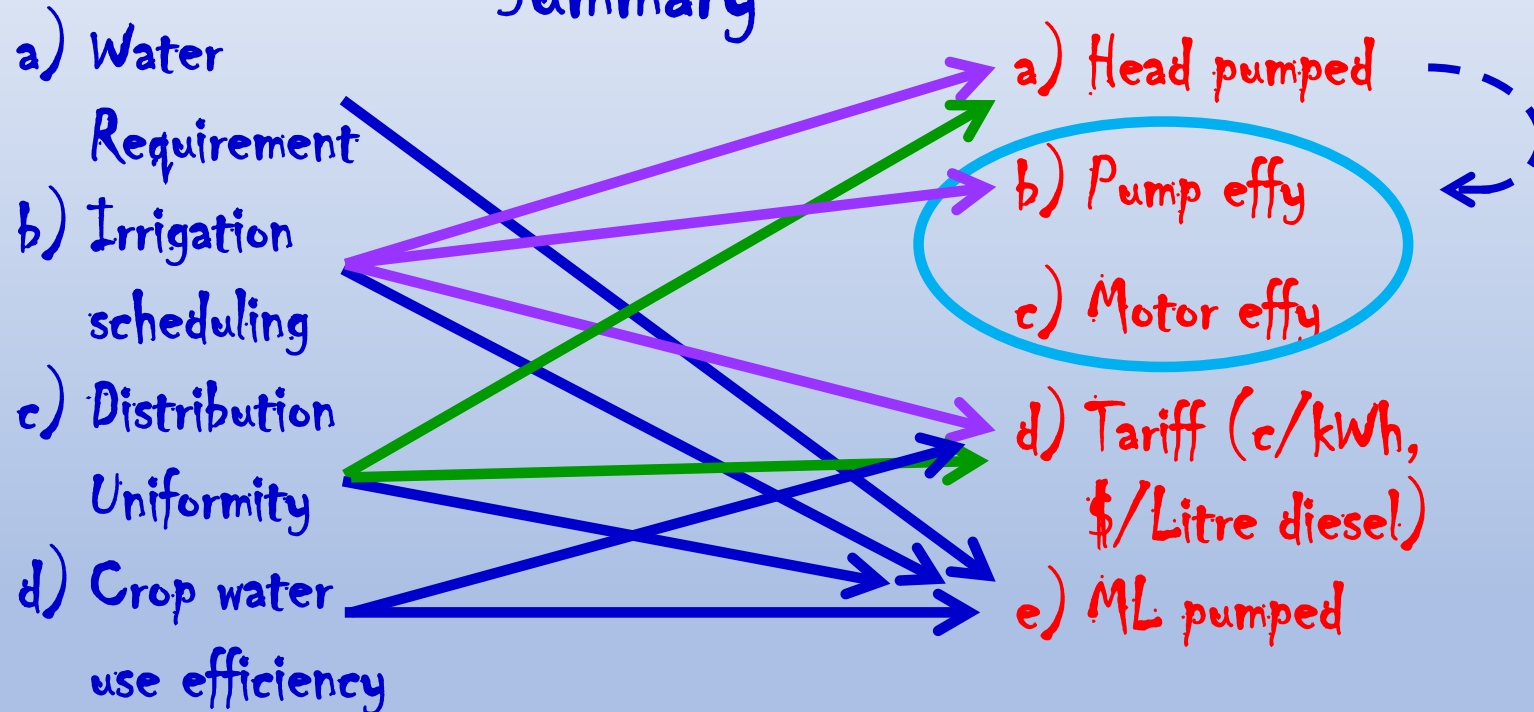


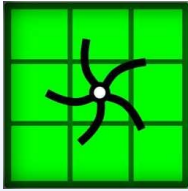
## Water Efficiency

V's

## Energy Efficiency

Summary





**TALLEMENCO**  
Irrigation Pumping  
Academy

# Water efficiency vs Energy efficiency

## What's the difference?



Water Efficiency      V's      Energy Efficiency

- Where can energy be saved?
- How to design best practice energy efficiency irrigation systems
- Get more "MPG" from your pumping system!

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Las Vegas Convention Center  
Las Vegas, Nevada

By Robert L Welke  
Associate Diploma, Mechanical Engineering,  
Irrigation Agronomist, Irrigation Auditor  
Adelaide, South Australia

# Water efficiency vs Energy efficiency

## What's the difference?

### Irrigation System Design approach - typical



Irrigation design





### Irrigation System Design approach - typical



Irrigation design



Irrigation control



Pumping/pipeline design – all too often

Life Cycle Costs

Pump cost

NPSH

Energy cost

Corrosion

Pump control

Pipeline friction

PS design

Specification



### Irrigation System Design approach - Tallemenco



Irrigation design



Pumping/pipeline design

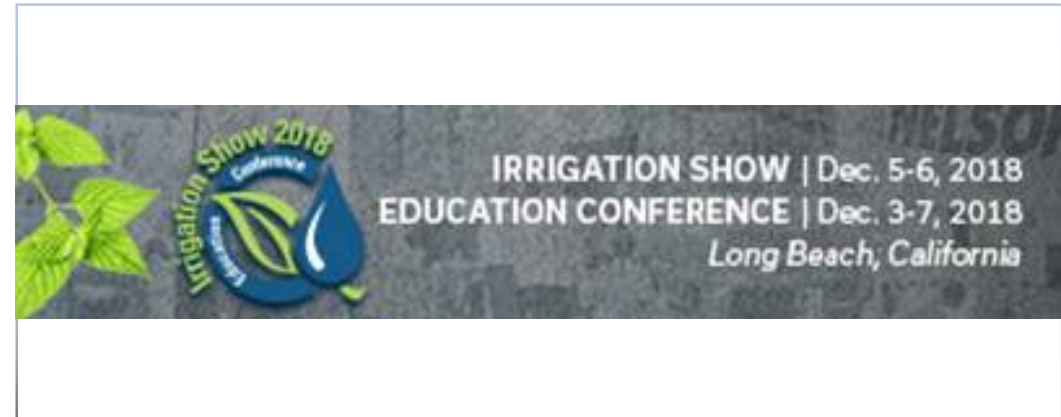




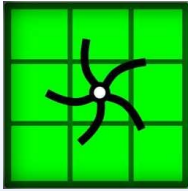
# Pumping Energy Efficiency

More than just testing pumps....

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- Associate Diploma, Mechanical Engineering,
- Irrigation Agronomist, Irrigation Auditor
- Adelaide, South Australia







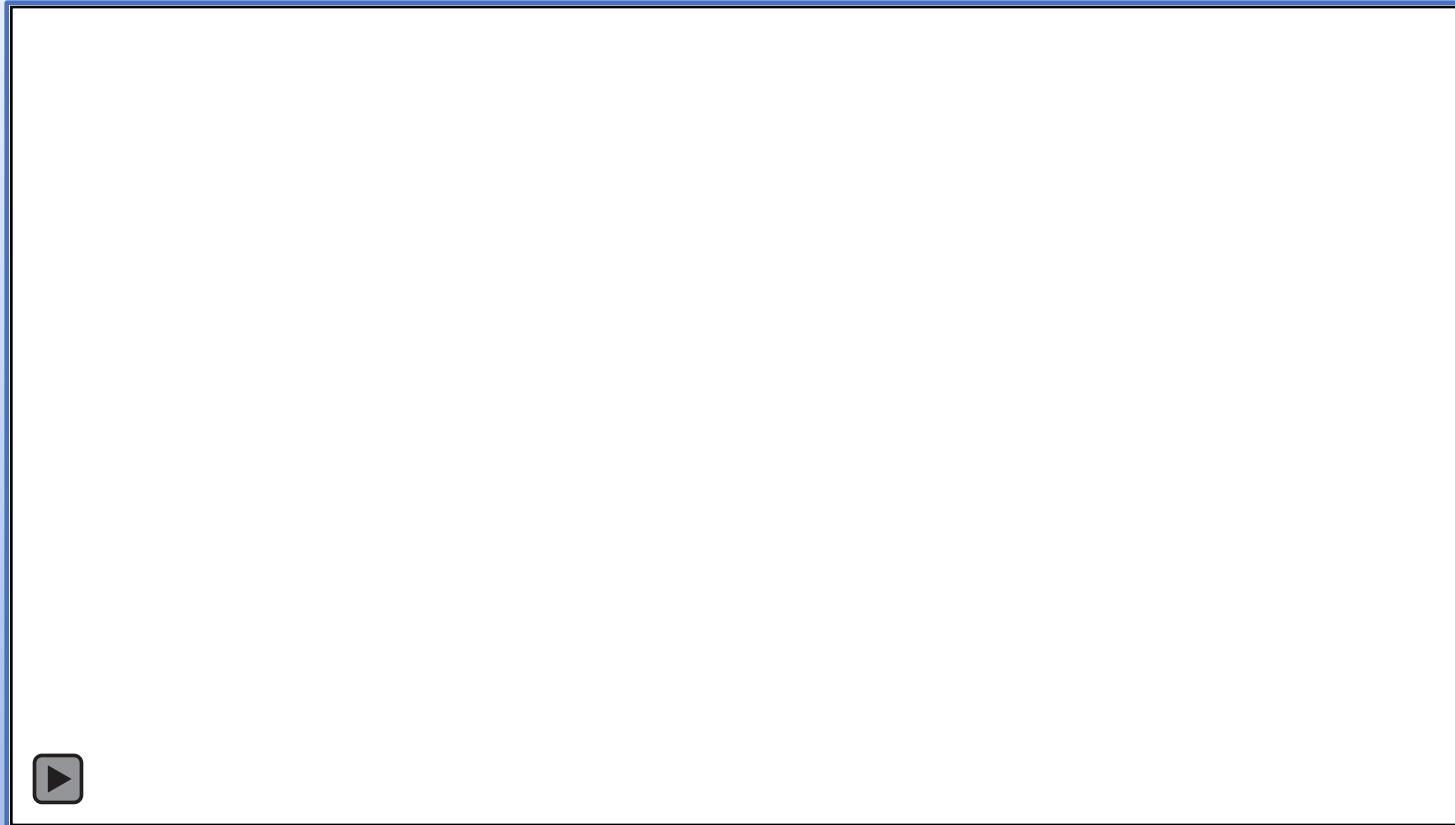
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# Water efficiency vs Energy efficiency

## What's the difference?



Where can  
energy be  
saved?



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# Water efficiency vs Energy efficiency

## What's the difference?

Where can  
energy be  
saved?

### Pump efficiency

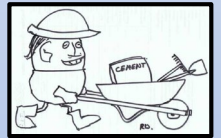
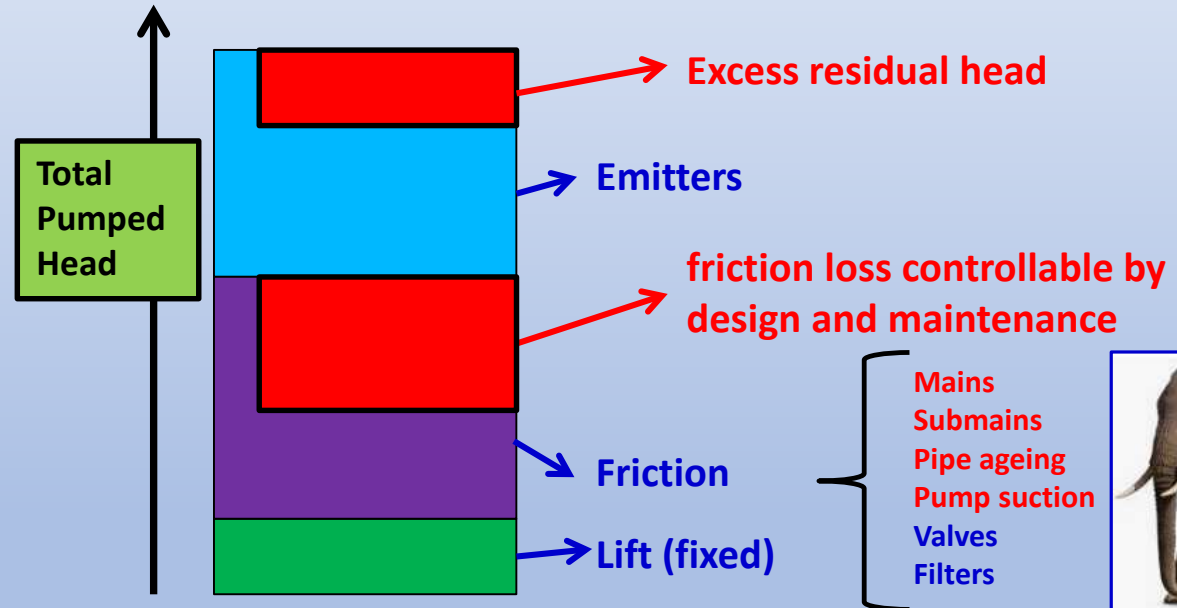
Typically < 50%  
Recoverable  
energy losses

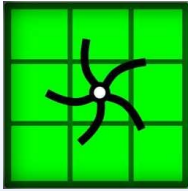
Pump efficiency



### Hydraulic efficiency

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





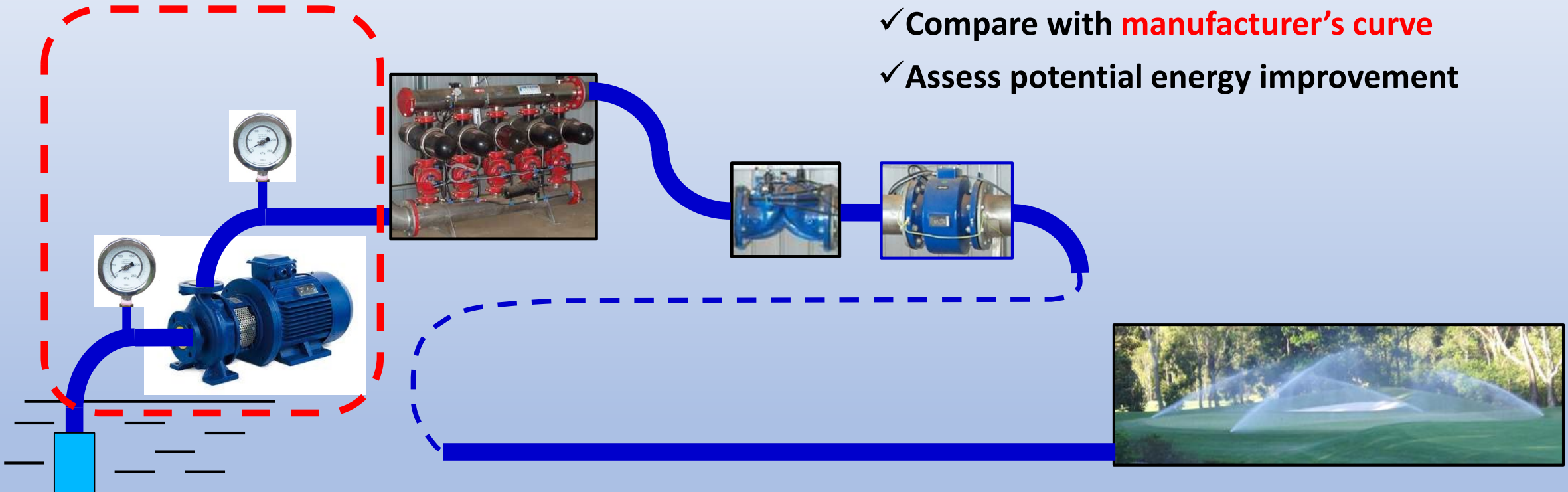
# Water efficiency vs Energy efficiency

What's the difference?

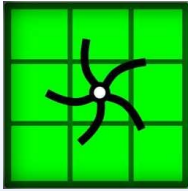


## Conduct a **pump efficiency** audit

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







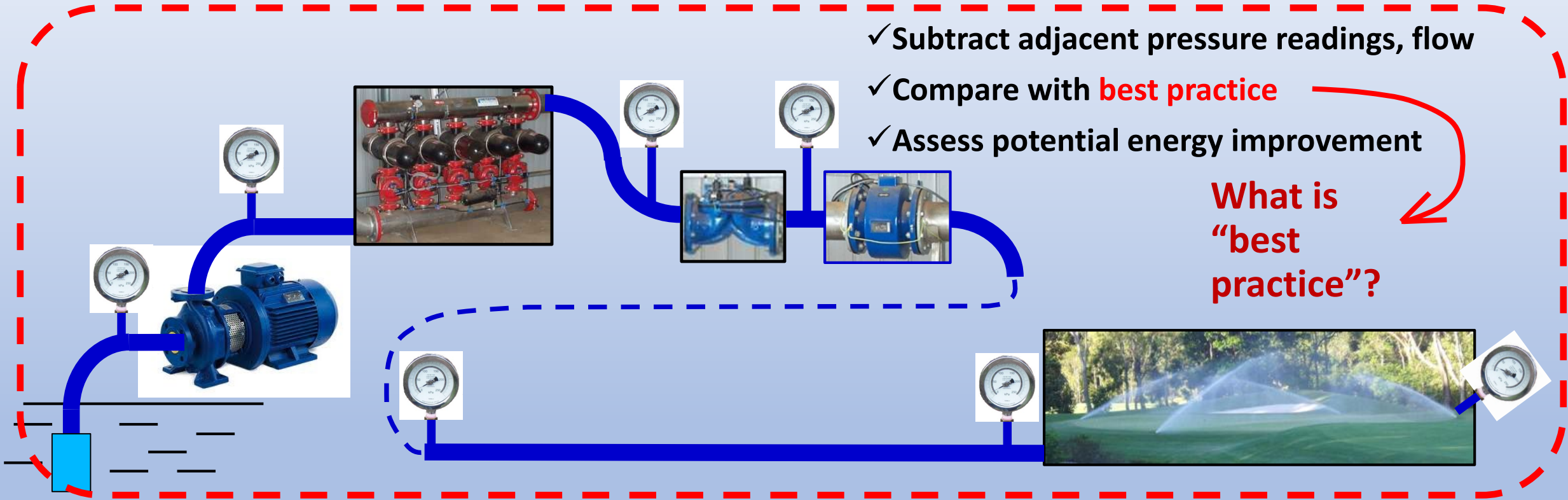
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# Water efficiency vs Energy efficiency

## What's the difference?



### Conduct a **pumping system energy efficiency** audit



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## TALLEMENCO – 2 Day Workshop Training

### “Pumping System Master Class”

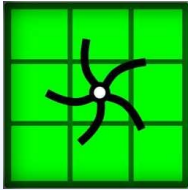
(Teaches how to design **pumping energy efficiency principles** into new irrigation systems)

- ❑ 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



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# Water efficiency vs Energy efficiency

What's the difference?



Water Efficiency      V's      Energy Efficiency

Proudly presented  
by

Rob Welke, Tallemenco

Thank you

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