Energy Efficiency:
Tractors and Field Machines

Energy in Agriculture 2017

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Teagasc CELUP
Oak Park Crops Research
Field Operations

- Significant Impact on Energy Use
  - Impacts on Costs (Fuel but also other costs)
  - Impacts on Carbon Footprint/Balance
  - Impacts on factors such as workrate and sustainability also
Outline

♦ Impact of energy on fuel and costs
♦ Machine energy saving options:
  ♦ Systems
  ♦ Machines and settings
  ♦ Tractors and fuel
♦ Other factors
♦ Grassland machinery options
Energy and Fuel - not the same

♦ Farmers / Contractors think of fuel
  ▶ Focus on fuel savings
♦ Energy savings can be much greater!
♦ Two sources
  ▶ Fuel efficiency of tractors/engines: Fuel
  ▶ Energy savings
    ▶ Machine types and settings
    ▶ Machine system
    ▶ Transport etc

Other cost savings

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Double benefit!

Reduce Energy:
Reduces fuel costs
Can Reduce Other Costs Also e.g.
- Machine wear
- Depreciation
- Frequently less Labour

\[2-3 \times \text{Fuel saving}\]
### Example: Plough depth

#### Plough at 125mm vs 250mm

<table>
<thead>
<tr>
<th></th>
<th>Std depth</th>
<th>Half depth</th>
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<tbody>
<tr>
<td>Plough cost</td>
<td>€28.47</td>
<td>€14.23</td>
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<tr>
<td>Tractor cost</td>
<td>€29.52</td>
<td>€14.76</td>
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<tr>
<td>Fuel</td>
<td>€15.12</td>
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<tr>
<td>Labour</td>
<td>€13.02</td>
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<tr>
<td>Total</td>
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<td>€43.10</td>
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</table>

#### Impacts:
- Workrate
- Fuel
- Labour
- Machine depreciation
- Machine wear / tear

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Fuel price and costs

Cereal production

Field operations: (excl transport, straw etc)

85 litres/ha

€54 / ha
Machine Energy Saving Options

♦ Change of System
♦ Machine Type and Setting
♦ Matching machines within System
♦ Tractors / Power Units
♦ Operation in the Field
♦ Ground drive and Tyres
♦ (Tillage) Grassland
Non-Machine Factors

- Soil type - heavier soils ➞ more fuel!
- Crop Choice (other factors determine)
- Weather

- Distance between land blocks
  - Size of blocks
  - Block cropping
  - Field size/shape
Factors: Block distance, size, crops. Base locations

Costs: Fuel, Labour, Depreciation, Repairs

- €150/ha extra total
- Approx 58 litre/ha extra fuel
- >50% extra fuel!
Coping with land distance issues

- Know the impact on costs
- Value land based on its location
- Pick crops to suit and match block size to machinery capacity
- Swap land with others if it makes sense
- Use ‘local’ contractor if sensible
Machine Energy Saving Options

- Change of System
- Machine Type and Setting
- Matching machines within System
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- (Tillage) Grassland
Changing system

- Tillage System - Step Change Possible
- Fuel/Energy proportional to:
  - Tillage Intensity
  - Tillage Depth
Plough 225mm deep
+ Secondary cultivation
+ Sowing + Rolling
Min-till 80mm deep
+ Cultivator drill
Minimum Tillage and Fuel

- Plough one pass
- Plough/Drill
- Min till (1)
- Min till (2)

- Roll
- Till/Sow
- Primary

Fuel l/ha
Fuel Savings

Min- Till

- Less than 50% energy input possible
  - 50% fuel (20 litre/ha) saving
  - Similar machine cost savings for cultivation:

- But!! Other factors:
  - Grass weeds
  - Autumn establishment in wetter climate
  - Sustainability
  - Deeper Min-till: more fuel
Direct drilling: lower energy

Direct Drilling
- Further fuel saving possible
- But further challenges in our climate

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Machine Fuel Saving Options

- Change of System
- **Machine Type and Setting**
  - Matching machines within System
  - Tractors / Power Units
  - Operation in the Field
  - Ground drive and Tyres
  - (Tillage) Grassland

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Depth and Intensity

- Ploughing 18 - 30 litres/ha
- Modern ploughing
  - Typically 250mm Deep
  - 175mm Vs 250mm = >30% Energy + fuel saving!
- Why do we plough so deep?
  - Because we can; Looks well; Loosens.
  - Could we plough less deep?
  - Plough shallow 3 years in 4
Shallow ploughing saves fuel

100mm Ploughing !!
Intensity

- Cultivate shallow and as little as required
- Know your soils
  - e.g. Work heavy soils carefully, avoiding creating clods which require huge energy for subsequent breakdown
- Only do what is necessary
  - Better for Energy / Fuel
  - Better for Soils
- Choose simpler systems
Settings and Maintenance

- Settings can affect fuel use:
  - Plough draft
  - Replacement of worn parts
  - Correct setting of all machine components:
    - Clearances, Speeds, Depth
  - Tractor maintenance

- Tractor Power: don’t notice the difference!
- Consult the Instruction Manual!
Machine Fuel Saving Options

- Change of System
- Machine Type and Setting

**Matching machines within System**
- Tractors / Power Units
- Operation in the Field
- Ground drive and Tyres
- (Tillage) Grassland
Matching Machines

- Aim for a balanced machinery system.
- Match tractors to implements
- Unloaded tractor engines less efficient
- E.g. 5F plough decision:
  - Bigger tractor required (120kW)
  - Over-sized for other operations?
- Choose lighter machines if possible
Machine Fuel Saving Options

- Change of System
- Machine Type and Setting
- Matching machines within System

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Tractor Make and Model?

♦ Individual models from three brand leaders:
♦ 6 cylinder 85kW (115hp) approx
♦ Specific Fuel Consumption (g/kWh - OECD)

♦ Warning!
  ▶ Models within brands differ
  ▶ Emissions changes (NOX, PM) forcing change
  ▶ Tier II, IIIb etc
  ▶ Often 'Poorer' Fuel Consumption
Tractor Fuel Use

- 18% difference
What's that worth?

- **Heavy work mix:**
  - 17 vs 18.3 vs 19.3 litres/hour (14% range)
  - **2.25** litres/hour difference

- **Light - Medium work mix:**
  - 12.3 vs 13.5 vs 13.46 litres/hour (9% range)
  - **1.17** litres/hour difference
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<th>Annual Hours</th>
<th>Diesel Price €/litre</th>
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<td>1000</td>
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## Annual difference (€)-Light-Medium

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<tbody>
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<tr>
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<tr>
<td>1500</td>
<td>965</td>
<td>1228</td>
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Machine Fuel Saving Options

- Change of System
- Machine Type and Setting
- Matching machines within System
- Tractors / Power Units

Operation in the Field

- Ground drive and Tyres
- (Tillage) Grassland
Operation in the Field

♦ Loaded engines are efficient
  ▶ Match implement to tractor
  ▶ Make the most of torque characteristics
  ▶ Shift up and throttle back
  ▶ Understand sophisticated transmissions
  ▶ Use economy PTO

♦ Efficient Work Patterns in Field
♦ Turn off engines when not working!
Machine Fuel Saving Options

♦ Change of System
♦ Machine Type and Setting
♦ Matching machines within System
♦ Tractors / Power Units
♦ Operation in the Field

♦ Ground Drive and Tyres
♦ Tillage Grassland
Ground Drive / Tyres

♦ Field – Cultivation + Soft conditions
  ▶ Reduce sinkage and Rolling Resistance
  ▶ Reduce wheel slip
  ▶ Larger tyres ➔ Lower pressures
  ▶ Reduce weight, Correct tyre pressure

♦ Road – Very hard conditions
  ▶ Smaller tyres, higher pressures
    ➔ Less tyre flexing
Larger Tyre
Lower Pressure
Less sinkage
Less Fuel
Machine Fuel Saving Options

- Change of System
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- Operation in the Field
- Ground drive and Tyres

(Tillage) Grassland
Grassland Farms

- Huge variations in fuel depending on system
- Summer grazing vs Intensive feeding
- Variable scope for fuel saving.

Silage making
- Step Change = Precision Chop Vs Wagon
- 50% harvester fuel saving = 25-30% overall
- Machine selection, matching and operation
- Wilting: reduces weight and costs
  - 33t/ha at 18% DM = 17t at 35%DM
Grassland Farms - Other

- Reduce: topping, rolling, spiking.
- Winter feeding system
- 5t Tractor to herd cattle?
- 4WD Jeep: not very fuel efficient
- Maintenance
- Centralised land base will save fuel
  - Silage + Slurry expensive to transport
Know your fuel use

♦ Accurate Information Scarce
  ▶ National and Farm level - Std Figures limited

♦ Record annual fuel use
  ▶ Stocks and Contractor use: challenging
  ▶ Total annual info difficult to analyse

♦ Single-operation analysis (e.g. Plough):
  ▶ Brim to brim measurement with fuel meter
  ▶ Accurate work recording
  ▶ Using on-board tractor fuel meter (check accuracy)
Bulk fuel meter + In Cab Monitor
Conclusions

Energy / Fuel ➔ priority

♦ System choice is essential
♦ Machines
  » Choose Wisely
  » Set / Adjust Correctly
  » Use Wisely
♦ Land Fragmentation needs to be considered
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