# Mathers Hydraulics Technologies

## Power Regeneration for Hybrid Truck Power

# Overview

- Fuel Saving Vane Pump
- REPTO-Regen Explained
- Hybrid Truck Power Application
- Power Regeneration
  - Hybrid Truck Power
    - City Driving Data
    - Highway Driving Data
  - Hydraulic power storage and recovery data

# Fuel Saving Vane Pump

**The Heavy Duty Fuel Saving Vane Pump (FSV) is a hydraulic pump that can be switched on and off with an electrical signal or hydraulics pilot.**



High Pressure

Noise Reduction
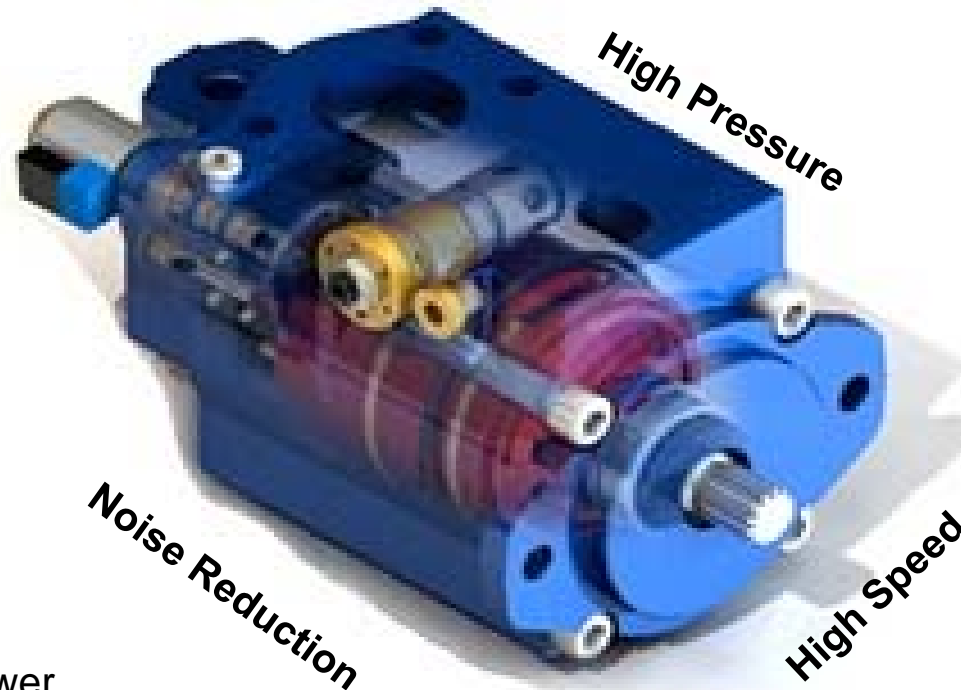
High Speed

In applications like power steering it will save thousands of dollars in annual fuel bills and reduce greenhouse emissions.
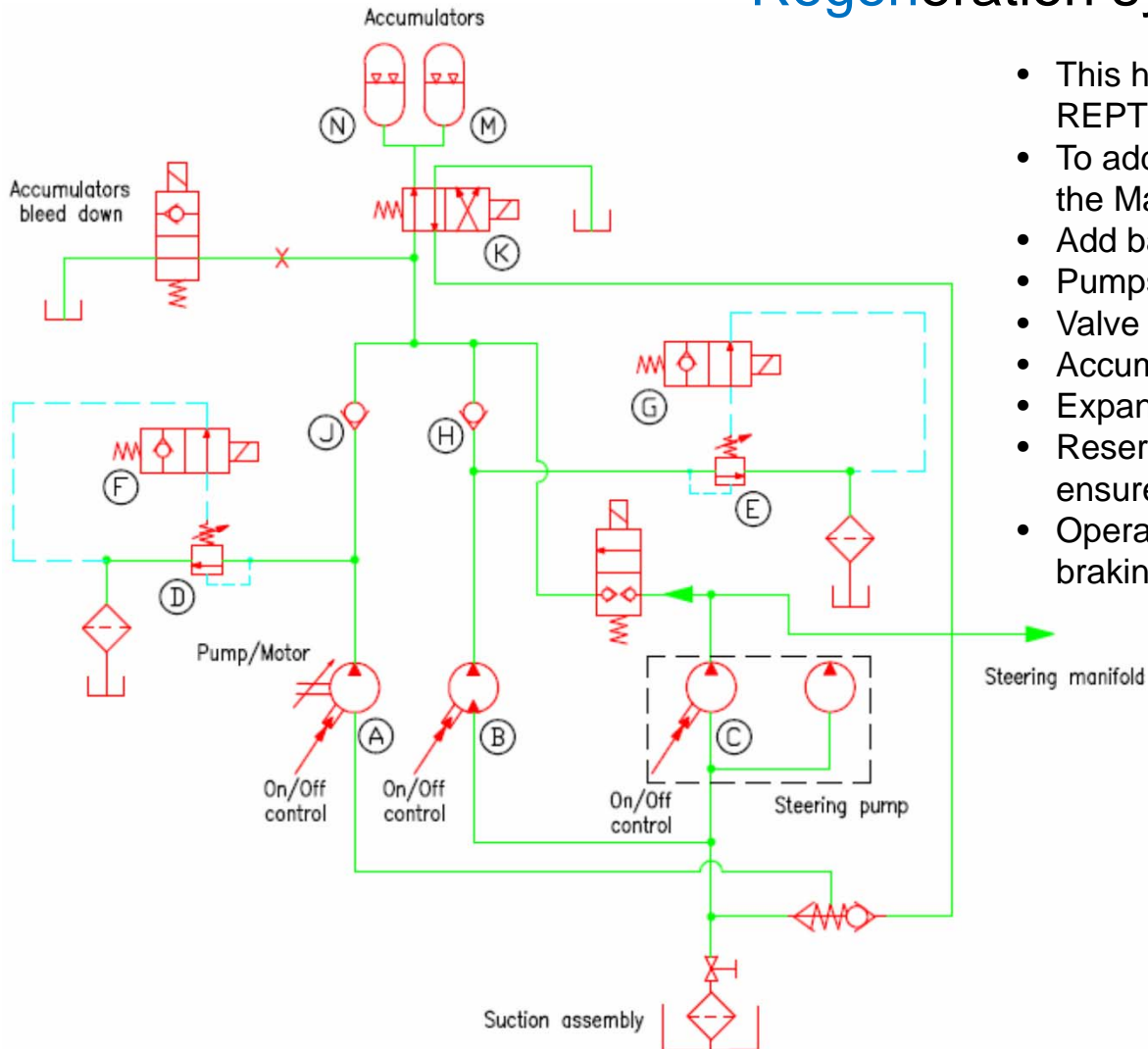
The high speed capacity enables the FSV to be direct "Line Drive" mounted, replacing existing wear prone power take off drives.

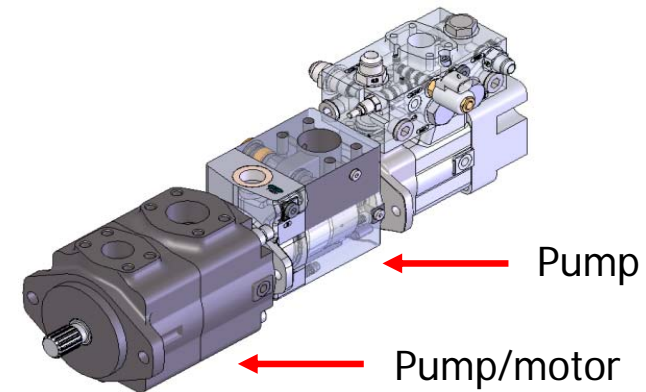**A measurable carbon reduction foot print for many industry applications.**

MATHERS HYDRAULICS

# REPTO-REGEN Explained

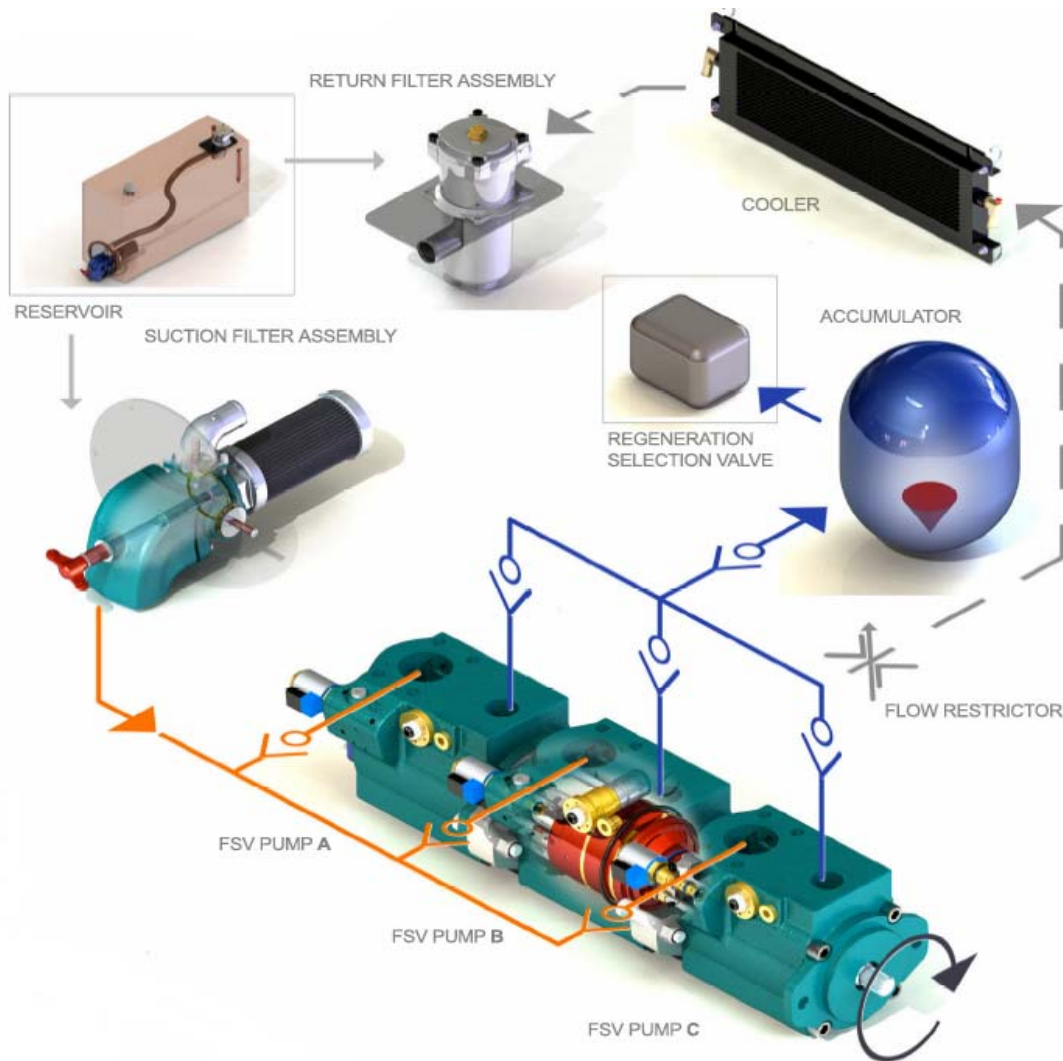## Rear Engine Power Take Off mounted power Regeneration systems



- This hydraulic schematic is a representation of how the Mathers REPTO-REGEN works in theory.
- To add low cost power regeneration on a Volvo or Mack Truck with the Mathers Tipper Stability System.
- Add bankable pumps A & B on REPTO drive.
- Pumps include valves D & E in their assembly.
- Valve block includes valves F,G,H,J & K.
- Accumulators M & N.
- Expand electronics.
- Reservoir suction assembly 2 positioned higher than 1 in reservoir to ensure adequate steering oil if a hose fails.
- Operation combination according to high braking or minimum braking:

**A+B+C, A+B, A+C, A,B or C**



Pump

Pump/motor

# Hybrid Truck Power Application

## Hybrid Truck Power - REPTO-REGEN



RETURN FILTER ASSEMBLY

COOLER

RESERVOIR

SUCTION FILTER ASSEMBLY

ACCUMULATOR

REGENERATION
SELECTION VALVE

FLOW RESTRICTOR

FSV PUMP **A**

FSV PUMP **B**

FSV PUMP **C**

- Our proposal is to use 3 FSV pumps on the Rear Engine Power Take Off prior to the gearbox.
- Typical Analysis:

  **Pump A + B + C**.

- Accumulator charged to 70 bar/1,000 PSI nitrogen
- Initial braking power:

  **Equals -  A + B + C x 70 bar**  i.e.

**Volume** x **Pressure**

- Assume in 3 pumps the volume was 600 litres per minute – the braking power starts at 120 HP.
- If we let the pressure rise to 210 bar or 3,000 PSI the braking is 360 HP.
- Braking occurs from 7 to 10 seconds in general.
- The captured energy helps re-acceleration to save fuel.

**MATHERS HYDRAULICS**

# Hybrid Truck Power Application
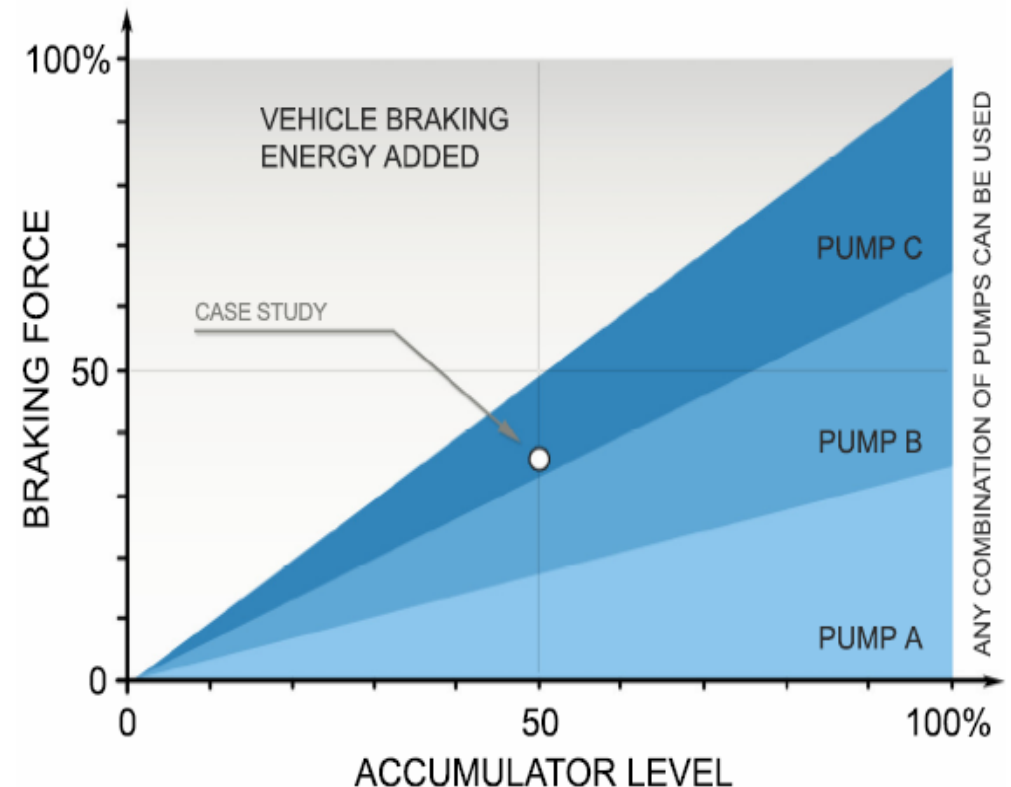
## Hybrid Truck Power

- While using the hydraulic regeneration system the mechanical or exhaust brakes can be added to the braking force to quicken deceleration – In power regeneration programs they work together.

- Tail shaft drop box regeneration systems, such as EATON HLA, have one advantage as they are an analogue system – IE: It is infinitely variable to adjust the braking power and is smooth.

- However:
    - There is the step-up gearbox, clutch and expensive heavy piston pump giving high cost and weight.
    - It cannot work over 40 KPH.
    - Has poor performance below 10 KPH as the piston pump shaft speed is low .
    - They work to 420 bar/6,000 PSI to try to accommodate these limitations.
    - The pump can not be used for any other function.
    - They have to carry separate oil reservoirs, as they need super clean oil – No steering, tipper etc, type hydraulic systems can share the special oil.
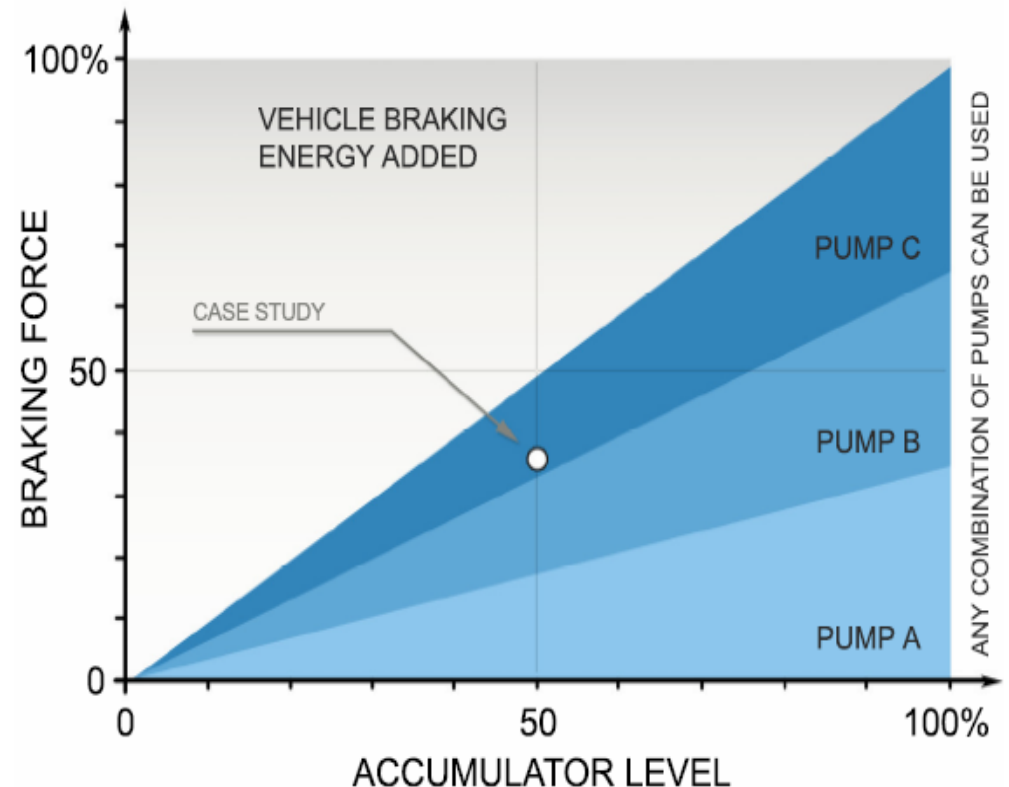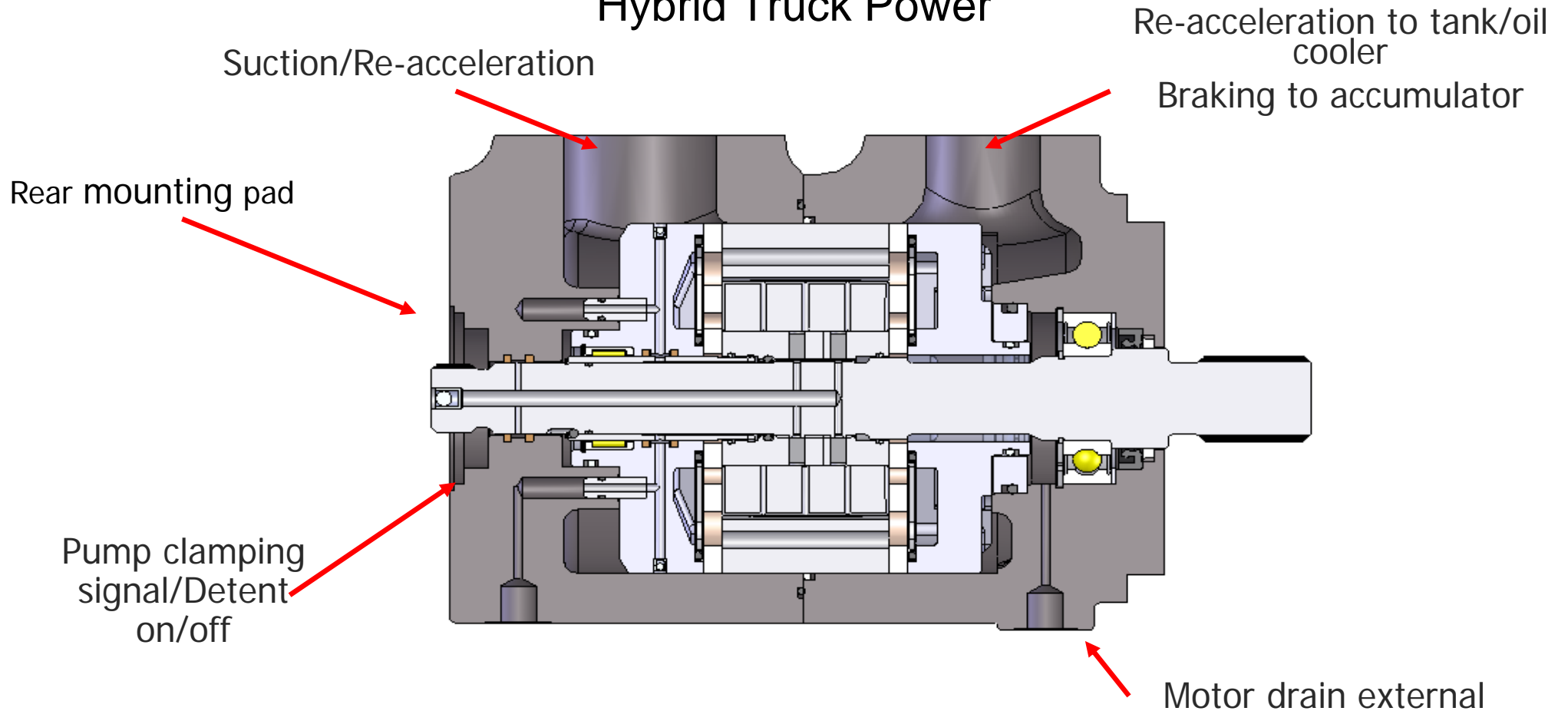
# Hybrid Truck Power Application

## Hybrid Truck Power

- Our system is on the engine side of the gearbox and the pump/motors are running at close to optimum speeds regardless of road speed.
- The pumps can work to 100+ KPH and still act as brakes and regenerators.
- Our pumps can be used for tipper, steering, waste collection etc
- Three pumps give seven steps, and gearbox changes occur simultaneously for smooth operation
- Adding the on/off power steering pump gives four pumps and up to 25 steps in a digital mode, and at the same time the gearbox is changing gears again.
- Thus we can save and reuse more energy; save cost and save weight.
- On tippers/concrete agitators and the like, we already have an oil reservoir of considerable capacity.



MAT**H**ERS YDRAULICS

# Power Regeneration

## Hybrid Truck Power



Suction/Re-acceleration

Re-acceleration to tank/oil cooler

Braking to accumulator

Rear mounting pad

Pump clamping signal/Detent on/off

Motor drain external

- Mathers designed vane pump/motor (MUMP) for the REPTO-REGEN system offers very high power density and value.

- This design is used to capture and re-use stored braking energy.

# Power Regeneration

## Hybrid Truck Power



On/Off Regeneration / retardation / auxiliary flow

Pump Suctions

Power Steering

Motor inlet for Reacceleration

Regeneration On/Off. Discharge for Reacceleration.

Combination pump (dual section) with On/Off for back up steering flow, additional regeneration/retardation or auxiliary flow for dumpers, waste collection cranes etc.

Rear Engine PTO (Live Drive)

Pump with On/Off for regeneration / retardation or auxiliary flow for waste collection, cranes etc.

Combined Motor/pump

- Stackable on/off pump/motor assembly for REPTO-REGEN and hydraulic power available for multifunction applications.
- This assembly is mounted directly onto the rear engine PTO.
- Regeneration has digital variable braking control with 3 pumping sections available for regeneration we have seven combinations of braking.

MATHERS HYDRAULICS

# Power Regeneration

## Hybrid Truck Power - City Driving Data (Full Load)
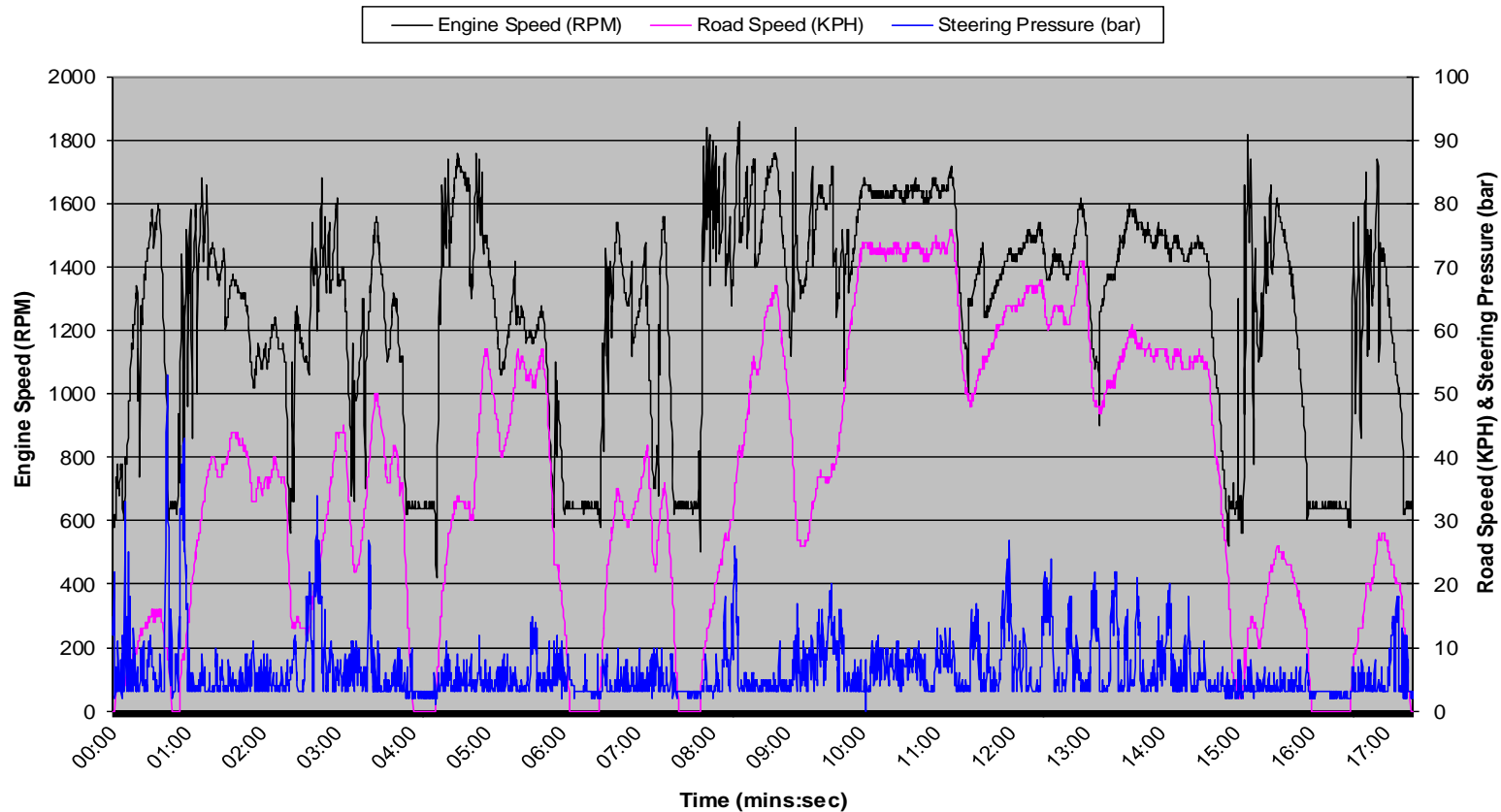


The following graph is typical of a loaded rigid truck and dog operating in suburban Brisbane in light to moderate traffic and illustrates the amount of potential recoverable braking energy. Not all decreases in speed are braking as the vehicle may be travelling up an incline and maintaining or increases in speed can be under braking down a decline. In 17 minutes we have approximately 17 opportunities to capture Kinetic energy. Note: The Mathers system does not require the vehicle to stop, only be braking to capture energy.

# Power Regeneration

## Hybrid Truck Power - Highway Driving Data (Full Load)
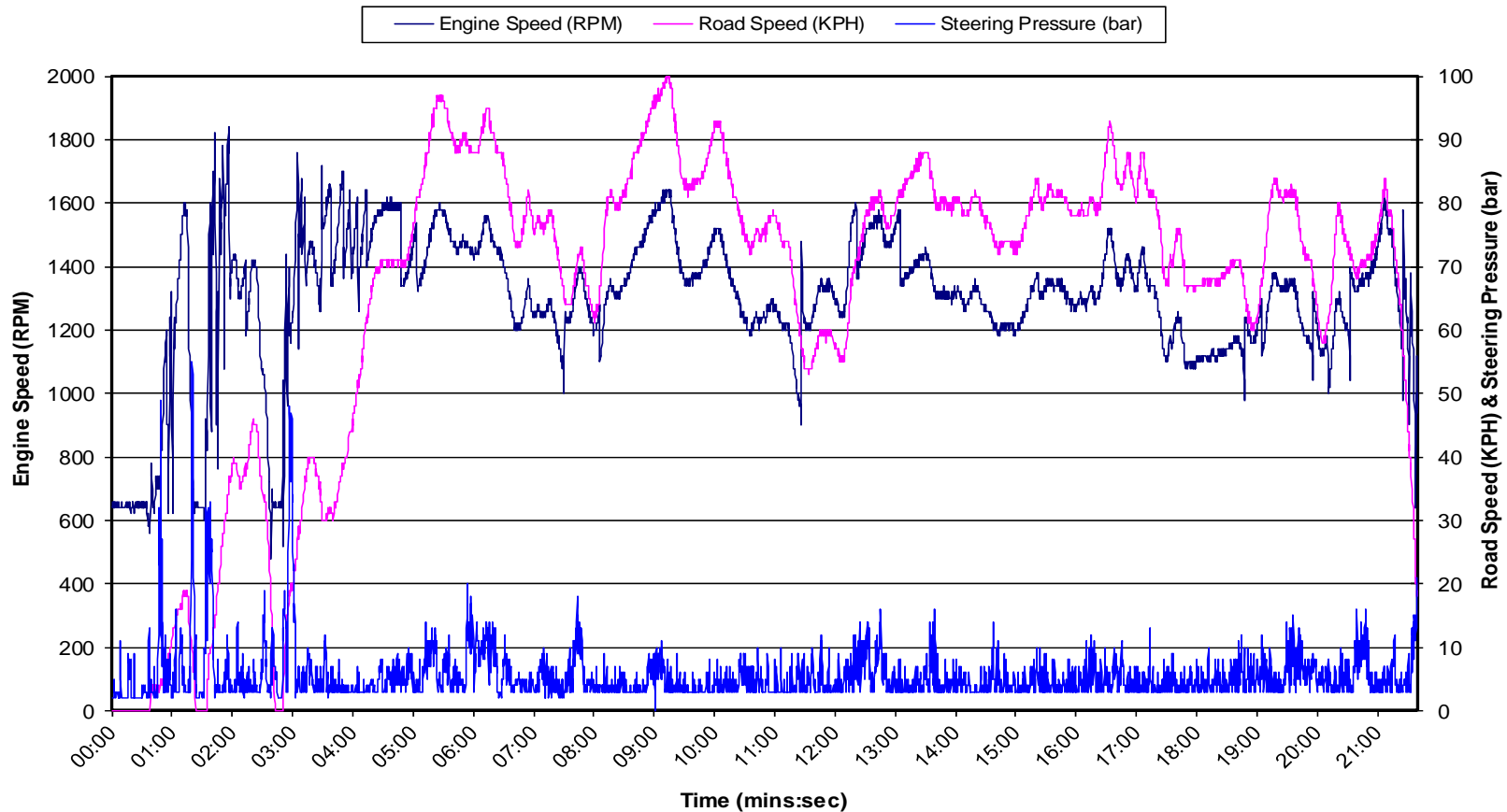


The following graph is the same vehicle on major roads/highways in the same traffic conditions. We have again approximately 17 opportunities to capture braking energy. Braking effort (storable energy) at high speed is greater than at low speeds and a portion of this can be captured and re-used. The higher the mass of the vehicle the more energy required to decelerate and accelerate. A low mass vehicle offers less storable energy, but requires less energy to accelerate.

# Power Regeneration

## Hydraulic power storage and recovery data

| | Value | Unit |
|---|---|---|
| **Truck Weight** | **24,000** | kg |
| **Overall Efficiency** | **100** | % |
| | | |
| **Initial Speed** | **100** | kph |
| **Final Speed** | **80** | kph |
| **Retard/Acc (Time)** | **12** | Seconds |
| Retard/Acc (Distance) | 300 | m |
| Energy | 3333 | KJ |
| Fuel | 21.3 | cc |
| Power for time period | 278 | KW |
| | | |
| **Initial Speed** | **20** | kph |
| **Final Speed** | **0** | kph |
| **Retard/Acc Time** | **12** | Seconds |
| Retard/Acc Distance | 33 | m |
| Energy | 370 | KJ |
| Fuel | 0.2 | cc |
| Power for time period | 31 | KW |

# Power Regeneration

## Hydraulic power storage and recovery data

| Mump Size | cc/rev |
|---|---|
| 45MFSV | 193 |
| 35MFSV | 121 |
| **Total** | **314** |

| Hydraulic Braking | Kw |
|---|---|
| Maximum braking power | 207 |
| Average braking power | 131 |
| Minimum braking power | 55 |

| Brake Energy Storage | Unit |
|---|---|
| Engine speed | 1200 rpm |
| Pump Shaft speed | 1320 rpm |
| Step up ratio :1 | 1.1 |
| | |
| **Pump flow** | **414 L/m** |

| Energy Regeneration | Nm |
|---|---|
| Maximum torque (Initial) | 1645 |
| Average torque | 1042 |
| Low torque | 439 |
| | **Unit** |
| Time to exhaust stored energy | 14 sec |
| **Power added in "Time" Kw** | **144 Kw** |

# Power Regeneration

## Hydraulic power storage and recovery data

| Accumulator Storage | |
|---|---|
| Accumulator pressure high | 300 bar |
| Accumulator pressure average | 190 bar |
| Accumulator pressure low | 80 bar |
| Accumulator useable volume | 100lt |
| Energy stored | 32 Kw/min |
| Time to charge accumulator | 14 sec |

| Potential energy recovery | |
|---|---|
| Number of regeneration events per hour | 40 events/hr |
| **Potential power** | **23 Kw/hour** |
| Efficiency Percent as decimal | 0.6 % |
| **Expected power per hour recovered** | **14 Kw/hr** |
| | |
| | |

MAT**H**ERS **H**YDRAULICS