

ENERGY EFFICIENCY, STORAGE AND GENERATION IN A RAILWAY ELECTRICAL DISTRIBUTION SYSTEM THROUGH HYBRID DIESEL-ELECTRIC LOCOMOTIVES

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Objectives

- To increase the efficiency of diesel-electric haulage and reduce emissions.
- To recover the energy of electric units and avoid dynamic braking.
- To develop and improve tools for evaluating energy efficiency.

Train Characteristics:

Diesel Loc. GM JT26TW: 120 t; 140km/h



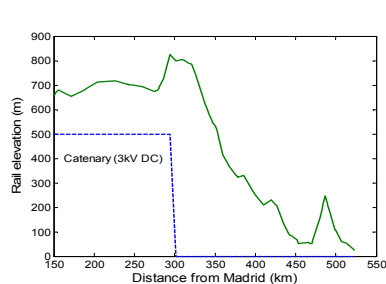
- Diesel engine: 2237kW
- Max. tractive effort: 320kN
- Dynamic braking: R

Electric Loc.: S-250; 123t; 160/100km/h



- Power: 4600 kW
- Max. tractive effort: 256/410kN
- Braking: R & Regenerative

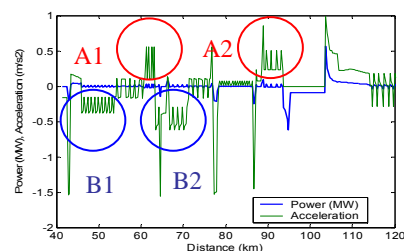
Line Profile: Rough profile



Electrified: km 150 to 300
Voltage: 3kV DC
Substations: one each 20km
Power flow: **unidirectional!!!**
Braking zones ► Storage & Generation

Sizing of Storage of Diesel Units

- Self-storage: the energy of diesel is stored during braking (B) and used later (A).



► **Size: 105 MJ**

- Complex storage: Diesel profits the generation due to braking of electric units hauling in the same track ► **150MJ**

Results: Gains in Efficiency

- Option I: Diesel locomotive alone (batteries or capacitors store energy during braking)

Itinerary	Demand (GJ)	Storage (GJ)	Efficiency (%)
Alcazar to Chinchilla*	2.99	0	8.4
Chinchilla to Cartagena	2.34	0.59	
Cartagena to Chinchilla	6.08	0.27	4,6
Chinchilla to Alcazar *	2.14	0.11	

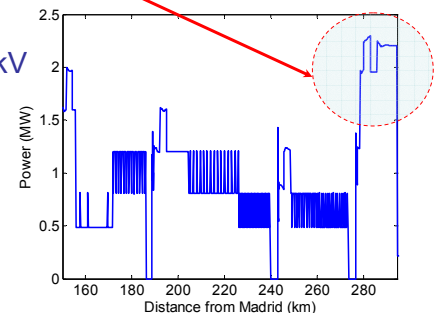
- Option II: Diesel-locomotive stores energy flowing from electrical units or generates energy to supply the start of electric locos.

Locomotive	S-250	S-333	S-250&S-333
Energy (GJ)	5	2.99	5+2.99
Storage (GJ)	0	0	0.15
Res. Braking (GJ)	0.54	0	0
Reg. Braking (GJ)	0	0	0.15+0.39
? Efficiency (%)	0	0	14.8

- More advantages: Substation stress: the diesel loco clips some peaks of demand

Substation: 6MW, 66/3kV
Max Num. Trains: 3

With Generation: 4 to 5
Freight trains (+40%)



Costs (option I)

Capacitors: 750 k€

Fuel savings: 85k€/year

Externalities: ... lower emissions, recover the share of Railways' Transportation in EU, to reduce new investments in G&D resources

Conclusions

- Storage is cost effective
- A better efficiency is achieved in a very important energy segment: Transportation
- The recovery of energy generated by electric units that usually can't be injected from catenaries (DC) to the power system (AC).