Possibilities of hybrid drives of forest vehicles

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Main issues

Growing demand for forest machines that cost less to operate, along with regulatory pressures for lower emissions, increase manufacturers' interest in developing electric and hybrid drives compared to traditional hydraulic and mechanical ones.

Pure electric drives of forest machines meet a lot of bottlenecks:

- costs and reliability of the electric components,
- battery durability,
- charging (where, when and how long)
- size of batteries which could ensure enough energy for 8 h working time.

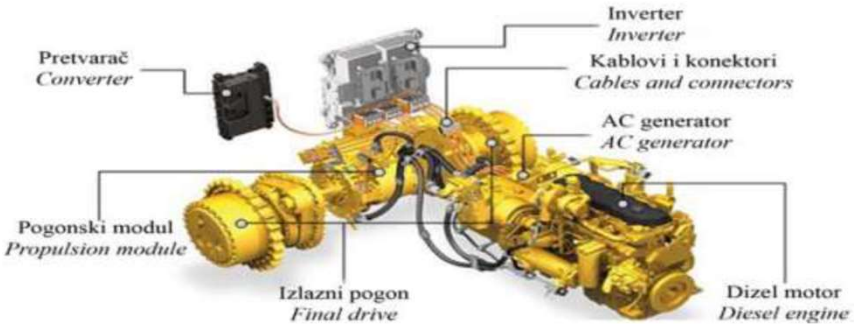
Hybrid solutions were seen as alternative for pure electric vehicle solution.

Forest vehicles offer big possibilities for the use of hybrids.

Main issues

Common drivers of development of hybrid drive solutions in forest vehicles are:

- low emissions and noise,
- high performance,
- fuel efficiency,
- regulation (Emission standards for non-road diesel engines)
- public image.



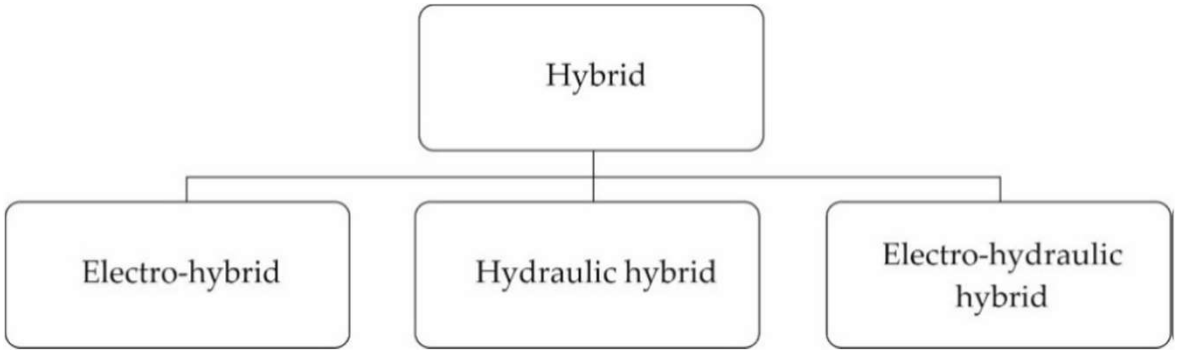
Hybrid drives offer a favorable solution for the propulsion of forestry machinery in terms of:

➢ Possibilities of using a lower power diesel engine (lower fuel consumption)

➢ Additional energy storage system (batteries) and additional energy source (electric motors) for improved efficiency

➢ Possibility of hybrid drive operation with better mechanical performance compared to conventional drive system

Hybrid drive classification



electro-hybrids - generator – inverter- energy storage (battery) – electric motor (series configuration, parallel configuration, power split configuration)

hydraulic hybrids uses a hydrostatic pressure system. Pressure energy of the liquid is converted in the accumulator into the deformation energy of the compressed gas, which is then converted back to the pressure energy at the appropriate moment (crane movement)

electro-hydraulic hybrids = accumulator–hydraulic motor–generator - energy regeneration system

Electro Hybrid forest vehicles

Forwarder Elforest AB F14

Harvester Logset 8H GTE Hybrid
Harvester Logset 12H GTE Hybrid

Hydraulic Hybrid forest vehicles

Ponsse Ergo harvester
Ponsse Caribou S10 forwarder

HSM 208F 12t forwarder
HSM 405H2 harvester

Research aim

The development of hybrid drive of skidder.

Skidder, so far, has not been considered a forest vehicle with hybrid drive capabilities.

The main goal of the research is to develop methods for measuring the energy consumption of skidders

ie. determination of the energy consumption of the skidder at different operating tasks and under different field conditions.

It is necessary to perform field measurements on existing vehicles, then conduct an adequate analysis of the collected data which, after processing, are used as a basis for the development of hybrid drives.

Skidder type

Skidder **Ecotrac 140 V**

- Cummins engine, computer contolled, water cooled engine , 4 cylinders, 140 KS
- Double drum winch (2 x 10t)

Research area

Bjelovar-bilogora County – timber skidding from final fellings on hilly terrains

Lika –Senj County – timber skidding selective fellings on mountainous terrains

Measurements

Mobilisis – measuring equipment (installation)

WIGO-E (Telematic Data collector) gateway

- collecting and storing data from sensors and motor computer via CANBUS
- integrated GPS system
- data transfer of WLAN, LAN and GSM communication to Web platforms (Cloud).

Measurements

Remote measurements

- Fuel consumption (mL)
- position (travelling route) of skidder (lat, lon)
- Detection of winch work (0, 1)
- Engine rpm (min^{-1})
- Engine torgue (% od max)
- Throttle position (%)

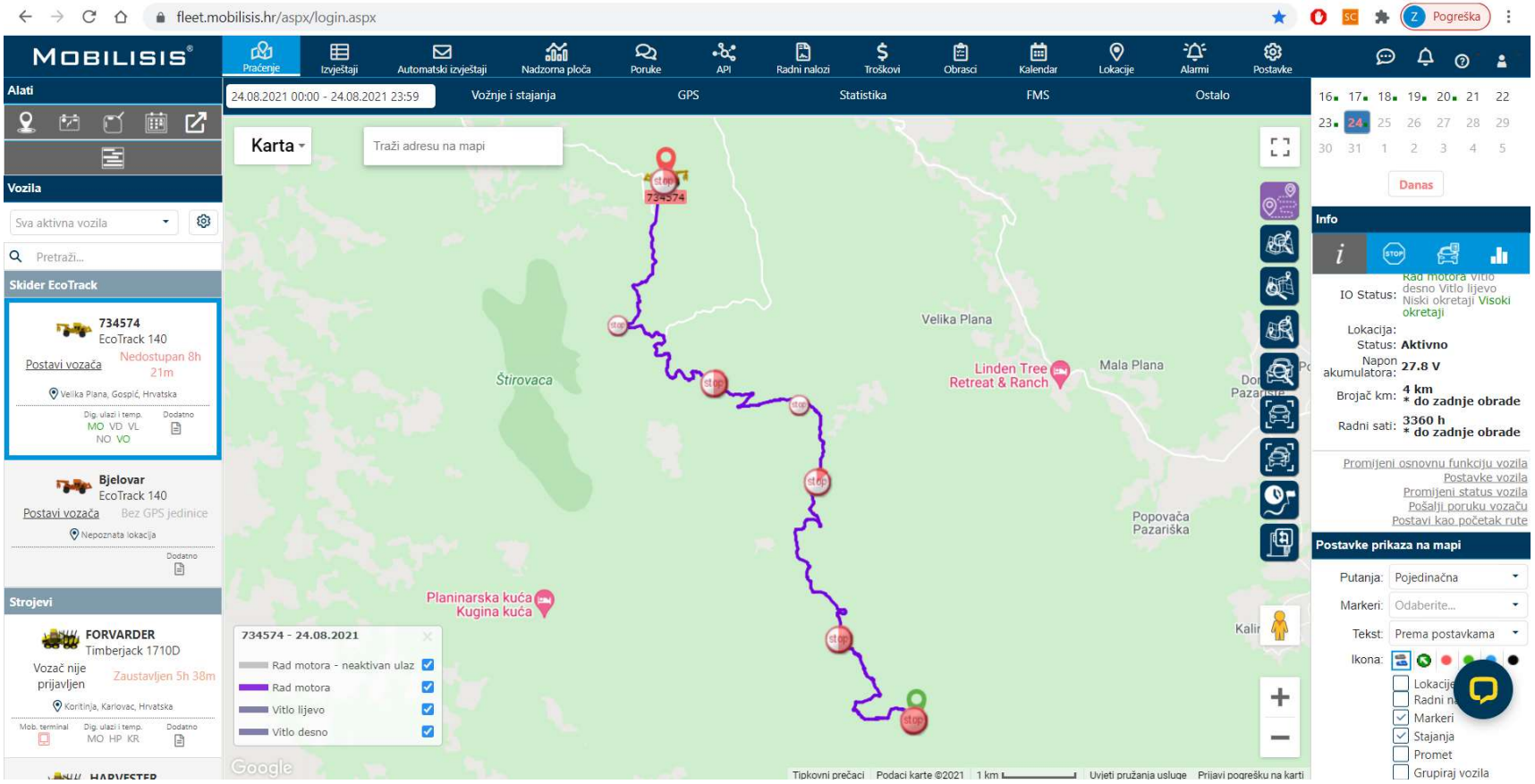
- sampling frequency – 3-5 s

Terrain measurements

- skidder load volumes per cycles
- slopes of skid trails (GNSS)

Data collection

- Web platform
- Mobilisis interface
- Vehicle operation reports (graphic and tabular display, .xlsx, .pdf)



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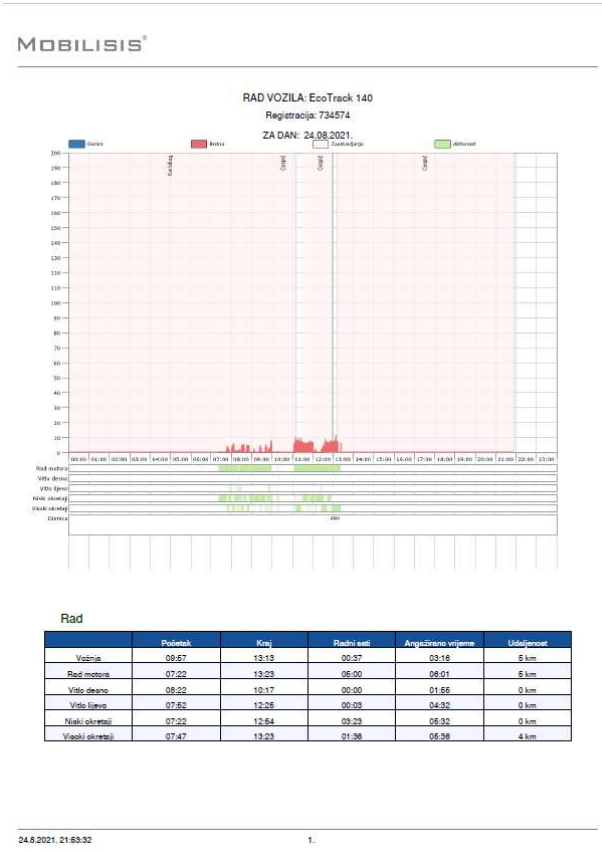

MOBILISIS

RAD VOZILA: EcoTrack 140

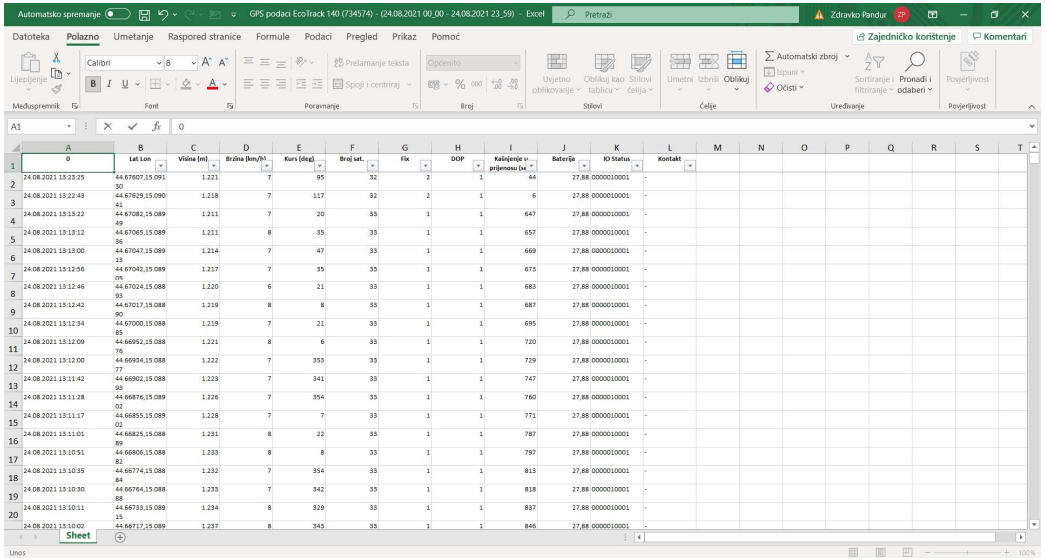
Registracija: 734574

ZA DAN: 24.08.2021.

Rad

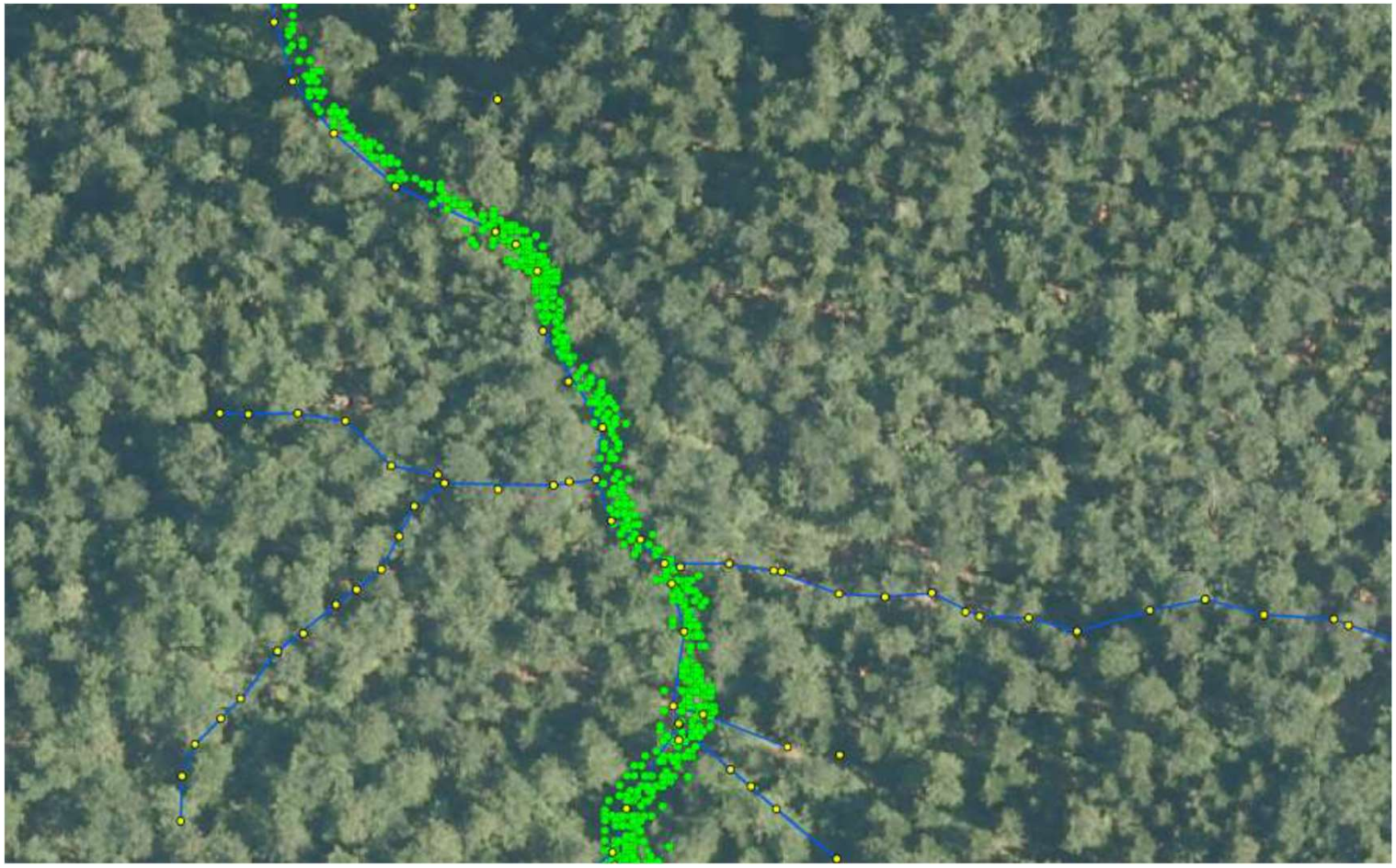
	Početak	Kraj	Radni sati	Angažirano vrijeme	Udaljenost
Vožnja	09:57	13:13	00:37	03:16	5 km
Rad motora	07:22	13:23	06:00	06:01	5 km
Vitlo desno	08:22	10:17	00:00	01:55	0 km
Vitlo lijevo	07:62	12:26	00:03	04:32	0 km
Niski okretaji	07:22	12:64	03:23	06:32	0 km
Visoki okretaji	07:47	13:23	01:36	05:36	4 km

24.8.2021. 21:53:32 1.



Data processing

- overlapping terrain slope and vehicle position measurement data



Data processing

- merging all data into a database

Mjerač protoka goriva | Bjelovar (EcoTrack 140) | 10.02.2022

MOBILISIS

Mobilisis d.o.o.
Varaždinska ul. 8, 42000, Jalkovec
042 311 777
www.mobilisis.hr

Datum	Temperatura goriva	Mod mjer	Trenutna potrošnja goriva (l/	Ukupno izmjerena potrošnja goriva (0.00	Potrošnja goriva u radu na mjestu (0.00	Potrošnja goriva u vožnji (0.00	Potrošnja goriva u radu na maksimalnom protoku (0.00	Potrošnja goriva u radu s manipulacijom dovoda ili povrata goriva (0.00	Vrijeme rada motora prema zabilježenom protoku goriva (hh:n	Vrijeme rada motora u stanju (hh:n	Vrijeme rada motora u vožnji prema optimalnom protoku (hh:n	Vrijeme rada motora s maksimalnim protokom (hh:n	Vrijeme rada motora s manipulacijom dovoda ili povrata goriva (hh:n	Vrijeme rada motora s uočenim problemom s ispravnim mjerenjem mjerača (hh:n
10.02.2022 6:56	47	0	0,02	510,758	67,978	430,585	12,195	4,015	56:04	32:16	23:35	00:00	00:02	00:08
10.02.2022 6:56	-2	1	0,03	510,838	68,028	430,615	12,195	4,015	56:05	32:17	23:35	00:00	00:02	00:08
10.02.2022 6:56	-2	0	0,04	510,858	68,043	430,62	12,195	4,015	56:06	32:18	23:35	00:00	00:02	00:08
10.02.2022 6:56	-1	1	0,16	510,908	68,078	430,635	12,195	4,015	56:06	32:18	23:35	00:00	00:02	00:08

FMS podaci | Bjelovar (EcoTrack 140) | 10.02.2022 00:00 - 23:59

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Varaždinska ul. 8, 42000, Jalkovec
042 311 777
www.mobilisis.hr

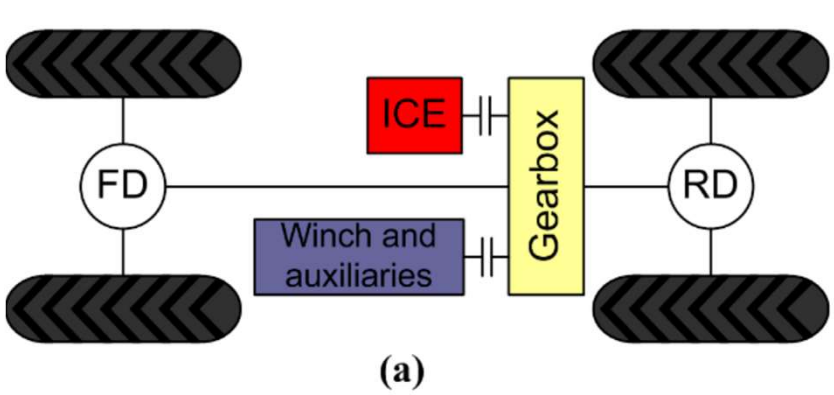
Vrijeme	Stanje brojčanika (l	Brzina (km	Ukupna potrošnja goriva	Količina goriva u spremniku	Razina goriva	Radnih sati	Broj okretaja motora (RP	Okretni moment (% od maksimu	Pozicija papučice gasa	Temperatura motora	Stajanje s upaljenim motorom (hh:n	Broj pritisaka kočn	Broj pritisaka kva
10.02.2022 14:44:58			7.651,0			785,30	748	14			00:00		
10.02.2022 14:44:53			7.651,0			785,30	1.024	0			00:00		
10.02.2022 14:44:48			7.651,0			785,30	1.800	15	58		00:00		
10.02.2022 14:44:43			7.651,0			785,30	1.285	71	48		00:00		
10.02.2022 14:44:39			7.651,0			785,30	1.127	0	4		00:00		

broj	visina	x	y	razmak po x osi,	razmak po y osi, r	horizontalan razmak,	stacionaža, m	Stvaran razmak n	visine,	nagib u	nagib kretanja u stupnjevim	prazan/	tovar, r	vremena	
15	154,336	526881,818	5040010,643	225,18	276,46	22,40	0,00	22,52	154,34	-10,51%	-6,00	pun	4,96	8:03:33	početak
14	151,982	526896,824	5040027,270	37,03	115,69	12,36	22,40	12,49	151,98	-14,68%	-8,35	pun	4,96	8:03:44	
13	150,168	526902,909	5040038,026	176,31	559,28	27,12	34,76	27,22	150,17	-8,41%	-4,81	pun	4,96	8:03:51	
12	147,888	526916,187	5040061,675	361,91	1329,33	41,12	61,88	41,42	147,89	-11,96%	-6,82	pun	4,96	8:04:04	
11	142,970	526935,211	5040098,135	66,39	489,34	23,57	103,00	23,84	142,97	-14,97%	-8,52	pun	4,96	8:04:33	
10	139,440	526943,359	5040120,256	11,53	669,83	26,10	126,58	26,40	139,44	-15,14%	-8,61	pun	4,96	8:04:45	
9	135,487	526946,755	5040146,137	48,16	1560,25	40,11	152,68	40,16	135,49	-5,14%	-2,94	pun	4,96	8:05:00	
8	133,427	526953,695	5040185,637	223,53	867,07	33,02	192,78	33,05	133,43	-4,09%	-2,34	pun	4,96	8:05:26	
7	132,076	526968,646	5040215,083	35,25	534,63	23,87	225,81	23,88	132,08	-2,30%	-1,32	pun	4,96	8:05:50	
6	131,528	526974,583	5040238,205	0,03	258,82	16,09	249,68	16,09	131,53	-2,64%	-1,51	pun	4,96	8:06:00	
5	131,104	526974,755	5040254,293	22,94	848,62	29,52	265,77	29,55	131,10	-4,38%	-2,51	pun	4,96	8:06:11	
4	129,810	526969,965	5040283,424	60,23	477,42	23,19	295,29	23,20	129,81	-3,79%	-2,17	pun	4,96	8:06:29	
3	128,932	526962,204	5040305,274	4,61	212,90	14,75	318,48	14,76	128,93	-4,45%	-2,55	pun	4,96	8:06:56	
2	128,275	526960,058	5040319,865	9,71	335,37	18,58	333,23	18,60	128,28	-4,60%	-2,63	pun	4,96	8:07:06	
1	127,421	526963,174	5040338,178				351,80		127,42				4,96	8:07:22	kraj

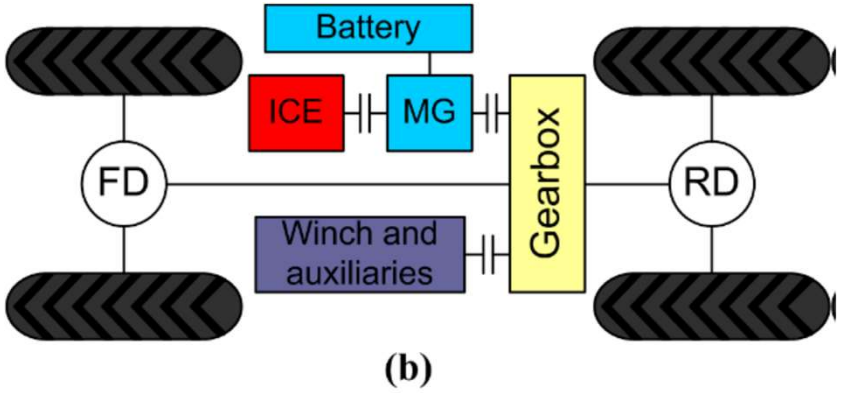
Radilište	Datum	Vrijeme turnusa	Broj turnusa	Broj komada u tovaru	Vrsta drveta	Promjer (cm)	Duljina (m)	Obujam (m^3)
Dišnica - Zobikovac - Petkovača 10c	10.2.2022	7:00	1		Bukva	50	6	1,1775
Dišnica - Zobikovac - Petkovača 10c	10.2.2022		1		Bukva	52	7	1,485848
Dišnica - Zobikovac - Petkovača 10c	10.2.2022		1		Bukva	44	6,4	0,972646
Dišnica - Zobikovac - Petkovača 10c	10.2.2022		1		Bukva	45	5,4	0,858398
Dišnica - Zobikovac - Petkovača 10c	10.2.2022	8:10	1	5	Bukva	43	3,2	0,464469

Data analysis

Using mathematical models of the drive with defined operating cycles obtained by measurement, the structure of the hybrid drive and the dimensions of the elements of the hybrid drive (internal combustion engine, electric motor, batteries…) are determined.



conventional skidder (**a**)



proposed hybrid vehicle configuration (**b**)

Conclusions

Future development of pure electric forest vehicles as well as for hybrid solutions is very important tasks for forest engineering research activities.

We need to define needs for energy of different types of forest machines performing works in different terrain conditions.

Such research results will be basement for future development of electric and hybrid forest machines.

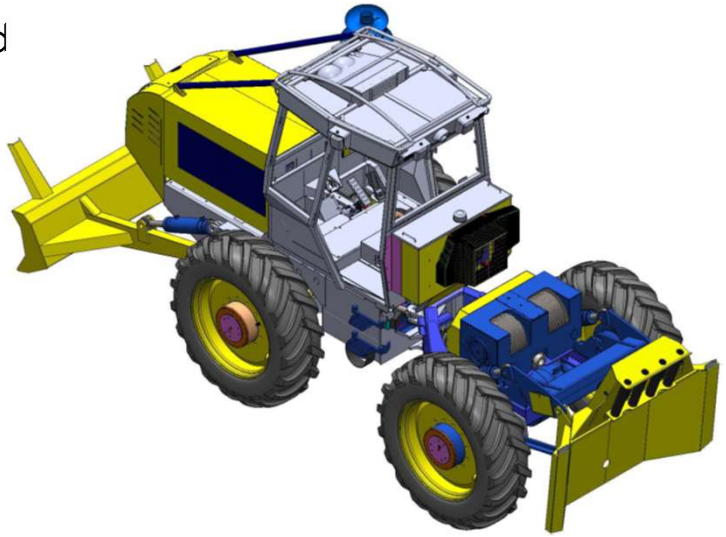
When we will know the energy demands for forest machines than we will know which capacity of battery is needed, where and when application of electric or hybrid drive is possible according to the recent scientific achievements in battery production.

Acknowledgments

This research was co-funded by the European Regional Development Fund, in the scope of the European Union Operational Programme «Competitivness and Cohesion» under the grant KK.01.1.1.04.0010 (Development of hybrid skidder—HiSkid).

The project is implemented in partnership between the Faculty of Forestry and Wood Technology and the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

The final outcome of the project is the conceptual design of a hybrid skidder that will be the basis for the prototype.



www.hiskid.hr

THANK YOU FOR ATTENTION!