DYNAMOTIVE

The Evolution of Energy

Biomass into Synthetic Fuels

Key Features Upgrading Process

- Upgrading process uses conventional hydrotreatment equipment and process conditions for rapid implementation at pilot and commercial scale
- Net yield of mobile fuels (UBB) from whole biomass is ~ 25% which to our knowledge is the highest ever reported
- UBA is stabilized so it can be hydrotreated in a standard refinery without the risk of coke formation or blended with diesel fuels used in stationary heat and power applications
- UBA is miscible with biodiesel in any concentration
- UBA can be steered towards diesel/gasoline/jet fuel etc. based on selection of commercial hydrotreating catalyst and hydrotreatment process condition
- Acetic acid and Biochar by-products are valuable and can be easily recovered during different stages of the production process

Biomass to Refiners Input & Finished Fuels Cost Basis

77,000 dry short tons

CONVERSION

Bio Oil s9.4 million gallons

UBA - Fuel 5.3 million gallons

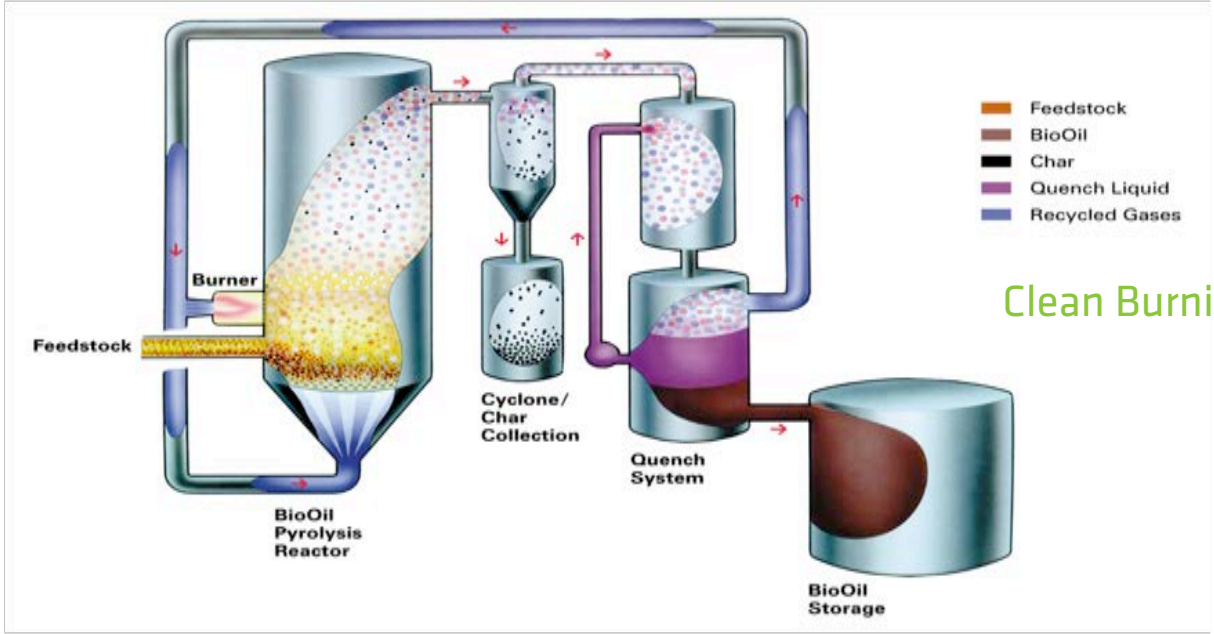
UBB - Mobile Fuel 4.4mm gallons

Dynamotive's Fast PyrolysisTechnology

- Rapid (< 2 sec's) heating of residual cellulosic matter in absence of oxygen.
- Over 120 types of biomass sources tested – forest and agricultural clean residues.

Fuels: Liquid yield 55 – 73% Solid yield 15 – 25%

Non-condensable gases are recycled into the process



Clean Burning, CO_2 Neutral

Dynamotive PyrolysisTechnology Scale Up Path

1996-2000

20 → 100kg/hr

2001-2004

10 → 15 TPD

2005

100 → 130 TPD metric tonnes
West Lorne, Ontario

2007

200 TPD metric tonnesGuelph, Ontario

Production Output

35,000 Tons Dry Input x 38,580 Short Tons		
BioOil	70%	27,006 short tons
Char	18%	6,300 short tons
NCG's	12%	4,200 short tons

70,000 Tons Dry Input x 77,000 Short Tons		
BioOil	70%	53,900 short tons
Char	18%	13,860 short tons
NCG's	12%	9,240 short tons

BioOil® UBA UBB Increases Energy Density vs Raw Biomass

	Volumetric Density	Energy Density	Ratio to BioOil UBA	UBB
Hog Fuel*	100-140kg/m3	2.4mmbtu/01	9	16.7
Sawdust*	100-140kg/m3	2.4mmbtu/M3	9	16.7
Shavings*	50-100kg/m3	1.7mmbtu/M3	12	23.5
BioOil®	1200kg/m3	20.6mmbtu/M3		
UBA	1000kg/m3	40mmbtu/M3		
UBB	870 kg/m3	45mmbtu/M3		

By increasing energy density of biomass on site, Dynamotive allows for efficient transportation

*Approximate oven dry density, softwood. Source: Washington State University

Raw BioOil Overview

Typical Properties

- Viscosity ~ 60-80 cP at 25°C
- Water content ~ 25 – 30 wt%
- pH ~ 2 - 3
- SG ~ 1.2
- HHV ~ 16 MJ/kg
- Elemental stoichiometry: $CH_{1.87}O_{0.75}$
  - 45 -50 wt% Oxygen
  - 4-10 % Acetic Acid

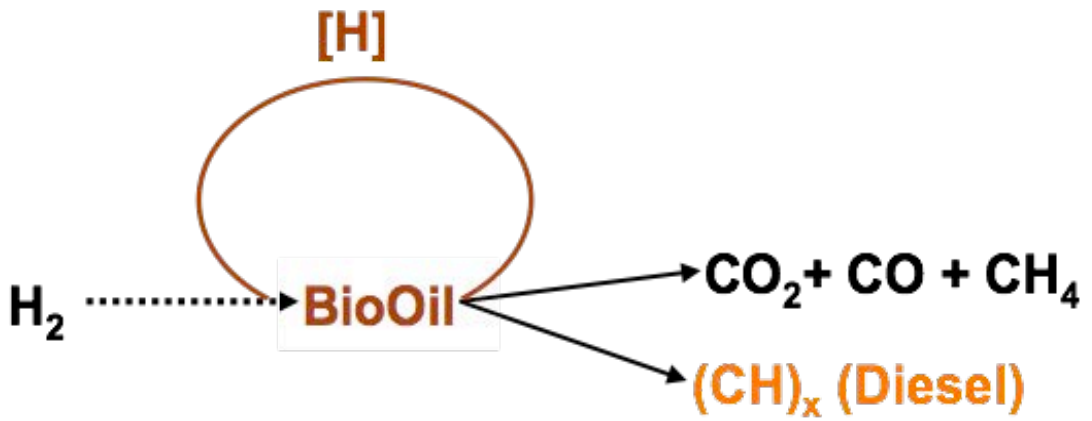
Upgrading Targets

Modify BioOil to:

- Remove acidity
- Make product miscible with hydrocarbons
- Reduce or eliminate propensity to coking
- Maximize carbon conversion to a hydrotreatable product
- Minimize water content (Modified BioOil should preferably be immiscible with water)
- Minimize oxygen content
- Minimize costs:
  - Minimize hydrogen consumption
  - Use as mild conditions as possible

Hydro-Reforming

- Hydrogen is internally generated from the water present by reforming a portion of the BioOil to CO2 and H2.
- Most of the oxygen is released as carbon dioxide so the net hydrogen requirement is small.
- Product is substantially deoxygenated .
- Ideally pure hydrocarbons would be produced in one step:



BioOil® Upgrading
Stage 1: HydroReforming - Phase Separation+Deoxygenation

UBA Bench Scale Lab Run

Temperature	330 °C
Pressure	~1800 psi
Weight Hourly Space Velocity	~1.5g BioOil/(g-catalyst-hr)
Catalyst	xxxxxxxx

Yields (based on raw biooil)
(Mass balance closure – 98%)

UBA	45%
Total Gas (~80% CO2 + 20% CH4)	8.1%
Water content of Aqueous phase (81% water)	37.9%
Organics dissolved in Aqueous Phase (~ 38% Methanol + 62% Acetic Acid)	8.9%
H2 consumption	+ 1.4%

UBA Properties

Water Content	0.84%
Oxygen Content	~10%
HHV	39.5 MJ/Kg
Specific Gravity	0.97
TAN mg KOH/g	37

BioOil® Upgrading
Stage 2: Mild Hydrotreating to Diesel-like Product

UBB Bench Scale Lab Run

Temperature	350 °C
Pressure	~1700 psi
Weight Hourly Space Velocity	~2.5g UBA/(g-catalyst-hr)
Catalyst	Commercial Hyrdotreating Catalyst

Yields (based on UBA)

(Mass balance closure ~ 93%)

UBB	83%
Total Gas (~43% CO2 + 27% CH4 + 30% CO, C2)	9.6%
Water content of Aqueous phase (95% water)	8.6%
H2 consumption	+ 2%

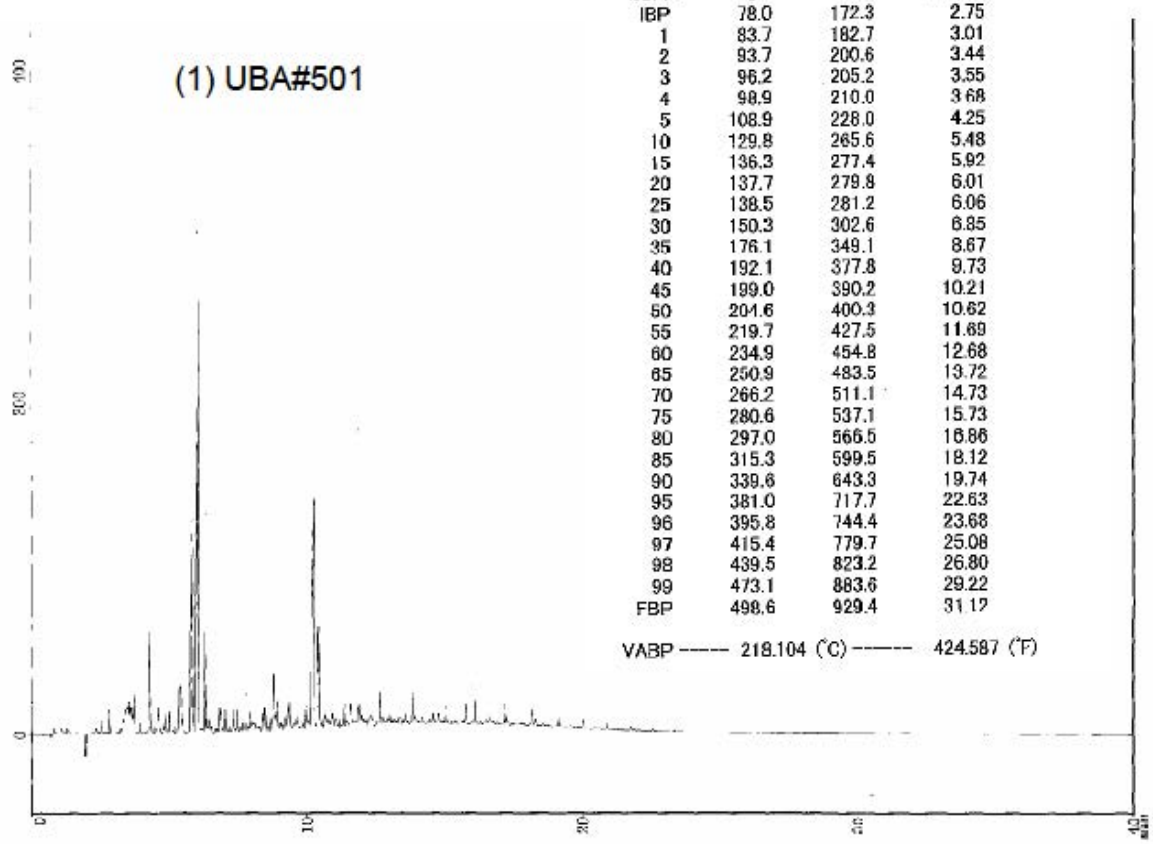
UBB Properties

Water Content	0.05%
Oxygen Content	~1%
HHV	45 MJ/Kg
Specific Gravity	0.87
TAN mg KOH/g	0.9

Elemental analyses, mass%

Sample	(1) UBA#501		(2) UBB#498		(3) UBB#506
C	81.8		87.6		87.7
H	10.9		11.9		12.2
O	7.2		0.4		0.1
N	0.06		<0.01		<0.01
S	0.031	0.014		0.0001	

GC Distillation UBA # 501

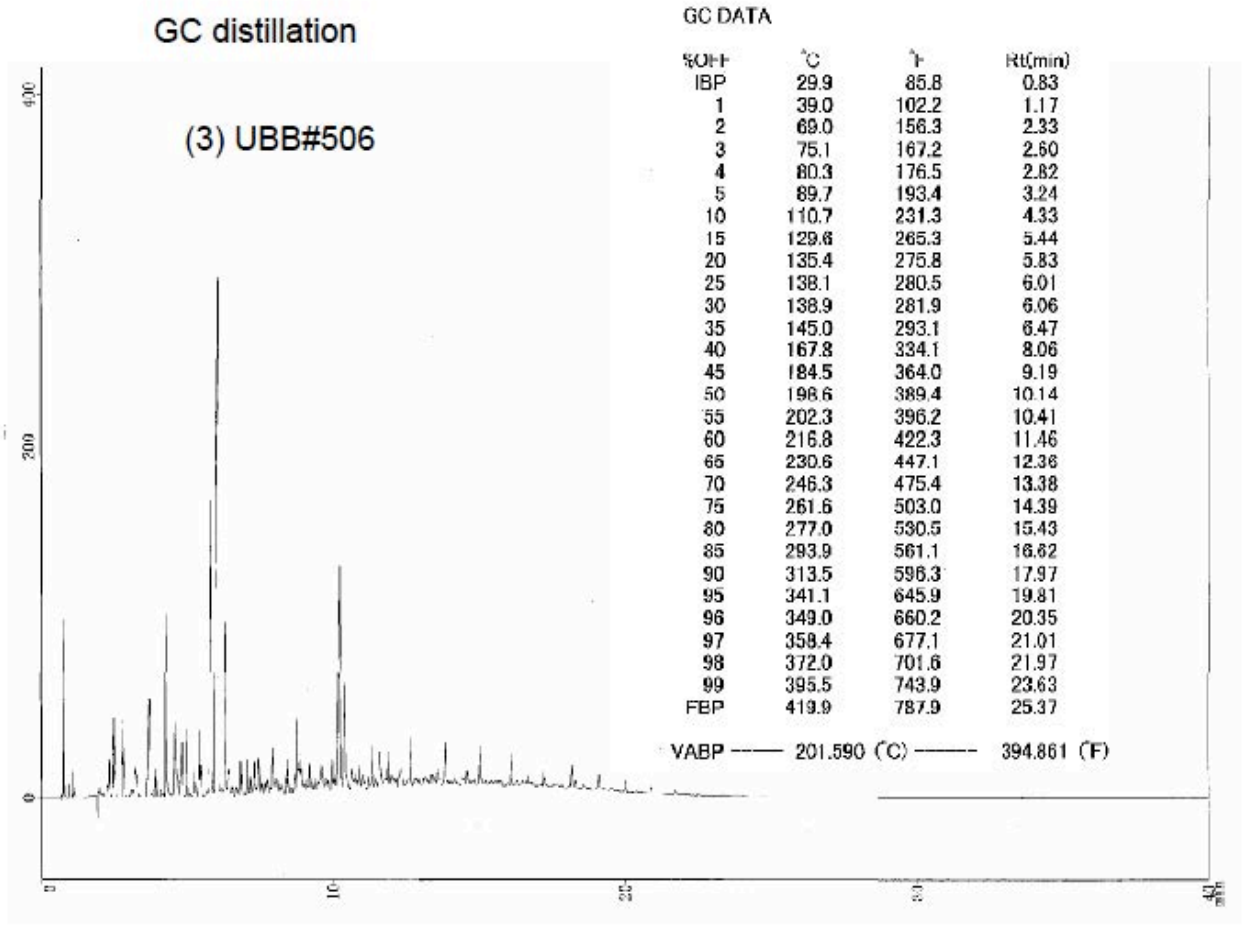


GC DATA

%OFF	°C	°F	Rt(min)
IBP	78.0	172.3	2.75
1	83.7	182.7	3.01
2	93.7	200.6	3.44
3	96.2	205.2	3.55
4	98.9	210.0	3.68
5	108.9	228.0	4.25
10	129.8	265.6	5.48
15	136.3	277.4	5.92
20	137.7	279.8	6.01
25	138.5	281.2	6.06
30	150.3	302.6	6.85
35	176.1	349.1	8.67
40	192.1	377.8	9.73
45	199.0	390.2	10.21
50	204.6	400.3	10.62
55	219.7	427.5	11.69
60	234.9	454.8	12.68
65	250.9	483.5	13.72
70	266.2	511.1	14.73
75	280.6	537.1	15.73
80	297.0	566.5	16.86
85	315.3	599.5	18.12
90	339.6	643.3	19.74
95	381.0	717.7	22.63
96	395.8	744.4	23.68
97	415.4	779.7	25.08
98	439.5	823.2	26.80
99	473.1	883.6	29.22
FBP	498.6	929.4	31.17

VABP ----- 218.104 (°C) ------ 424.587 (°F)

GC Distillation UBB # 506

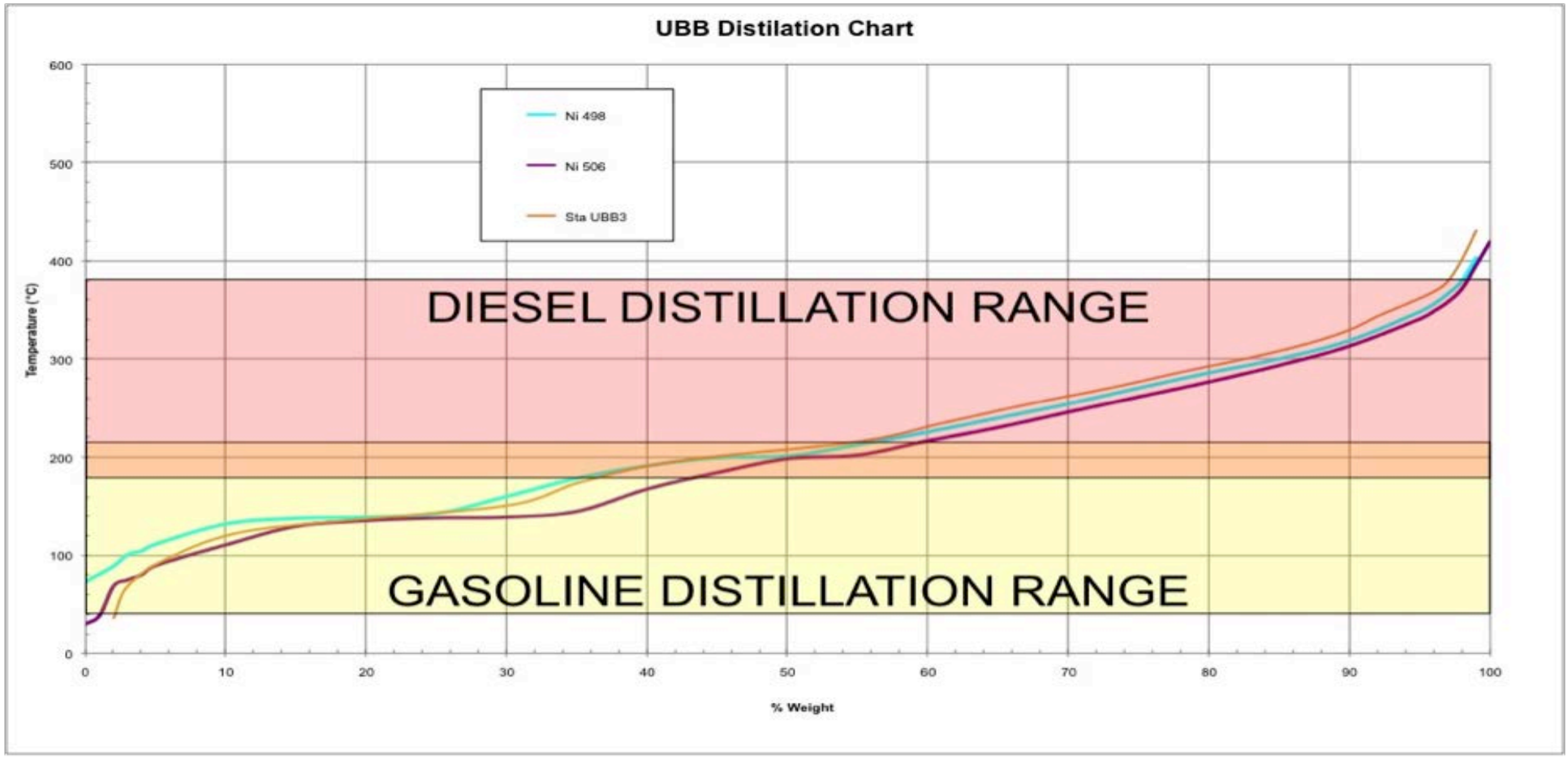


GC DATA

%OFF	°C	°F	Rt(min)
IBP	29.9	85.8	0.83
1	39.0	102.2	1.17
2	69.0	156.3	2.33
3	75.1	167.2	2.60
4	80.3	176.5	2.82
5	89.7	193.4	3.24
10	110.7	231.3	4.33
15	129.6	265.3	5.44
20	135.4	275.8	5.83
25	138.1	280.5	6.01
30	138.9	281.9	6.06
35	145.0	293.1	6.47
40	167.8	334.1	8.06
45	184.5	364.0	9.19
50	198.6	389.4	10.14
55	202.3	396.2	10.41
60	216.8	422.3	11.46
65	230.6	447.1	12.36
70	246.3	475.4	13.38
75	261.6	503.0	14.39
80	277.0	530.5	15.43
85	293.9	561.1	16.62
90	313.5	596.3	17.97
95	341.1	645.9	19.81
96	349.0	660.2	20.35
97	358.4	677.1	21.01
98	372.0	701.6	21.97
99	395.5	743.9	23.63
FBP	419.9	787.9	25.37

VABP —— 201.590 (°C) —— 394.861 (°F)

BioOil® Upgrading
Stage 2: Distillation Curve



SIMDIST shows that the crude oil and UBA have heavy ends compared to a regular diesel quality. The heavy end is not present in the UBB samples. Assuming that the distinction between gasoline and diesel is roughly at 210°C. the distribution of UBB between gasoliline and diesel is approximately 50% at each.

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Thank You

Dynamotive Energy Systems Corporation