

ERGO - modelling the GHG Budget of bioenergy systems

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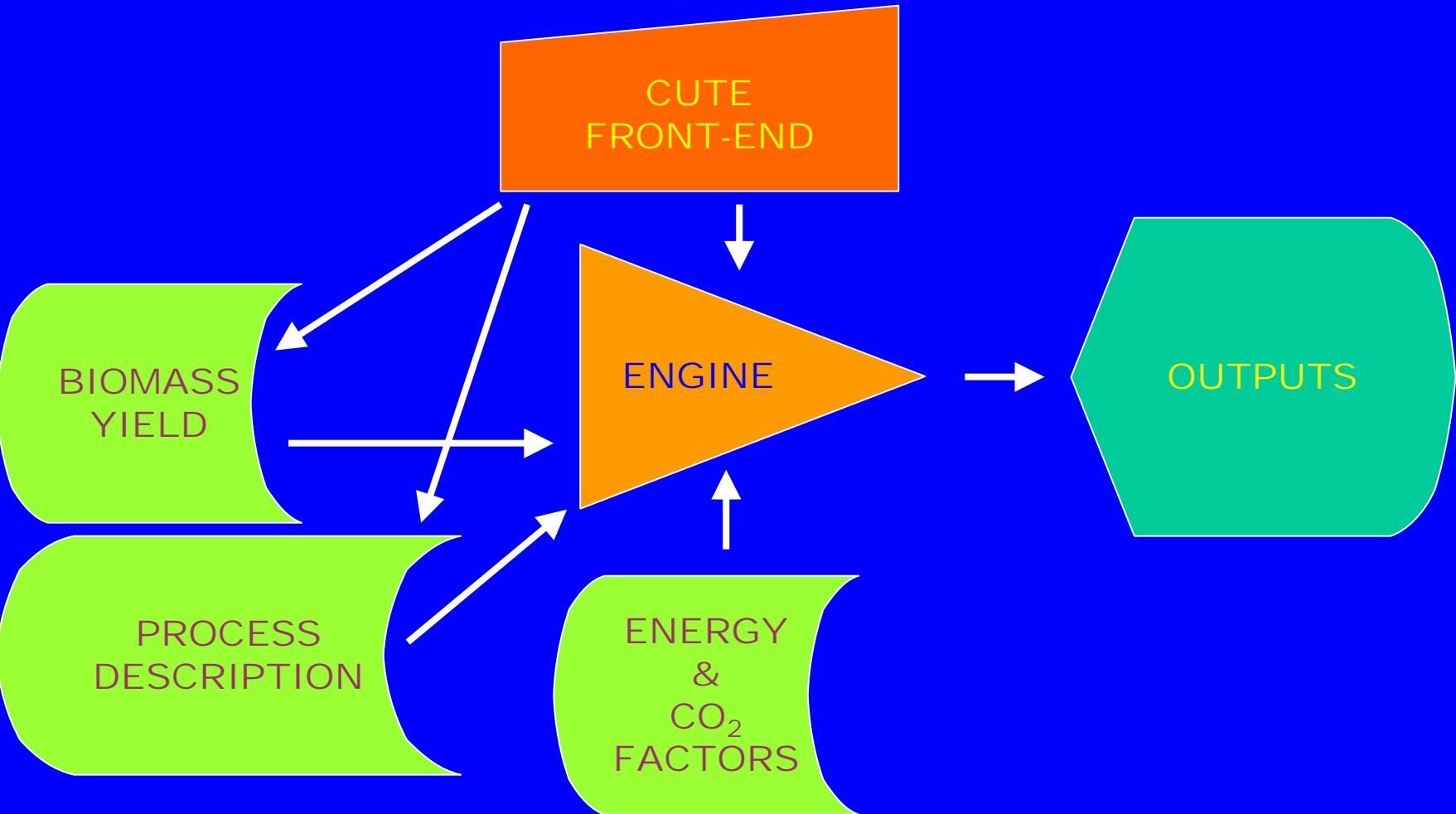
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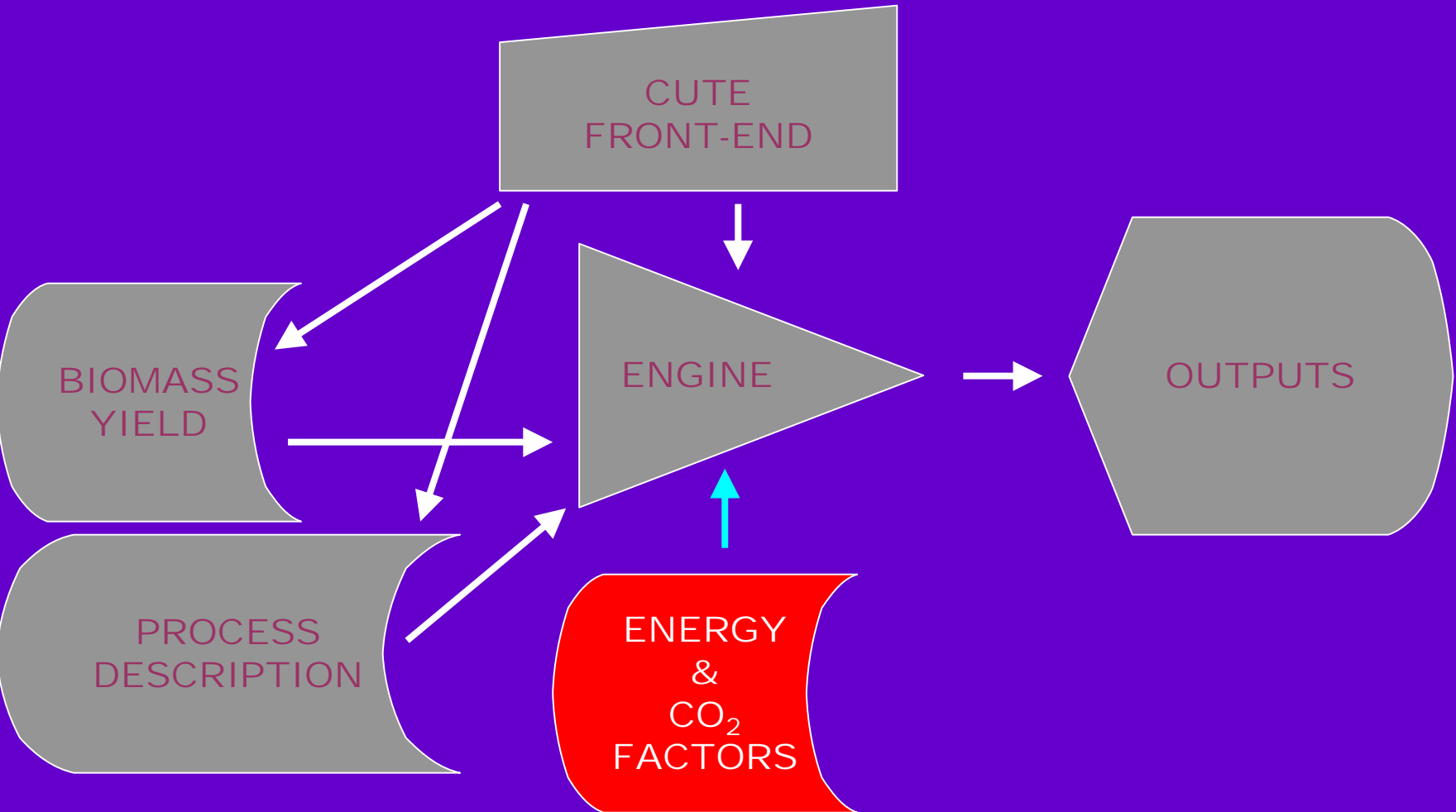
WHY DEVELOP ERGO ?

- Contracted to do it
- Nothing suitable existed
 - Consistency across biofuel systems
 - Work with available rather than ideal data
 - Transparency (self-documenting)
- Budget needed urgently for SRC

STRUCTURE OF ERGO



LET'S TAKE A CLOSER LOOK



ENERGY AND CO₂ FACTORS

DIRECT INPUTS

1	COAL	25.42	0.6596		0.071	0.003170	
2	COKE	28.06	0.7954		0.132	0.003490	
3	GAS OIL	45.46	0.857	litres	0.8532	0.128	0.002210
3	FUEL OIL	42.82	0.850	litres	0.9911	0.128	0.002210
4	DIESEL OIL	45.46	0.857	litres	0.8532	0.128	0.002210
6	MOTOR SPIRIT	46.91	0.855	litres	0.7407	0.128	0.002210
7	LPG	49.57	0.88078	therms	2.1262	0.128	0.002210
8	NATURAL GAS	52.86	0.75753	therms	1.996	0.138	0.003660
9	ELECTRICITY	1.0	0.0928	kWh	3.6	2.783	0.092800
10	LUBR OIL	42.00	0.850	litres	0.8850	0.128	0.002210

FUEL TYPE

CALORIFIC VALUE (MJ kg⁻¹)

TYPE OF ENERGY INPUT

DIRECT CARBON EMISSIONS FACTOR (kgC kg⁻¹)

ENERGY AND CO₂ FACTORS

DIRECT INPUTS

1	COAL	25.42	0.6596		0.071	0.003170
2	COKE	28.06	0.7954		0.132	0.003490
3	GAS OIL	45.46	0.857	litres	0.8532	0.128 0.002210
3	FUEL OIL	42.82	0.850	litres	0.9911	0.128 0.002210
4	DIESEL OIL	45.46	0.857	litres	0.8532	0.128 0.002210
	MOTOR SPIRIT	46.94	0.855	litres	0.7407	0.128 0.002210
	LPG	49.57	0.88078	therms	2.1262	0.128 0.002210
	NATURAL GAS	52.86	0.75753	therms	1.996	0.138 0.003660
	ELECTRICITY	1.0	0.0928	kWh	3.6	2.783 0.092800
10	LUBR. OIL	42.00	0.850	litres	0.8850	0.128 0.002210

ALTERNATIVE UNIT

CONVERSION FACTOR TO kg

SUPPLY ENERGY REQUIREMENT (MJ MJ_{dir}⁻¹)

SUPPLY CARBON EMISSIONS FACTOR [kgC MJ_{dir}⁻¹]

NUMBER FOR
HOUSEKEEPING

ENERGY AND CO₂ FACTORS

DIRECT INPUTS

1	COAL	25.42	0.6596			0.071	0.003170
2	COKE	28.06	0.7954			0.132	0.003490
3	GAS OIL	45.46	0.857	litres	0.8532	0.128	0.002210
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10	LUBR. OIL	42.00	0.850	litres	0.8850	0.128	0.002210

A JOB FOR TASK 25 ?

FACTORS FOR MATERIALS

INDIRECT INPUTS

1	PRIMARY ALUMINIUM	312.	0.070
2	SECONDARY ALUMINIUM	11.	0.070
201	PHOSPHORUS	255.	0.032
.			
202	RECRYSTALLISED BRINE SALT	5.17	0.032
206	NITROGEN FERTILISER	59.7	0.078
.			
403	POPLAR/WILLOW CUTTINGS	0.0491	0.041
.			
421	SPARES # 0.001	0.001	0.052
.			
500	ENERGY	1.0	0.04

DESCRIPTION OF MATERIAL

NET EMISSIONS FACTOR [kgC MJ_{net}⁻¹]

NET ENERGY REQUIREMENT [MJ kg⁻¹]

NUMBER FOR HOUSEKEEPING

FACTORS FOR MATERIALS

INDIRECT INPUTS

1	PRIMARY ALUMINIUM	312.	0.070
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.			
.			
421	SPARES # 0.001	0.001	0.052
.			
.			
500	ENERGY	1.0	0.04

A JOB FOR TASK 25 ?

FACTORS FOR MACHINERY

MACHINERY AND CONSTRUCTIONS

1	MACHINE MILD STEEL COMPONENT	59.5	0.047
2	HEAVY MILD STEEL COMPONENT	66.1	0.047
.			
.			
5	MOTOR VEHICLE	115.	0.047
1	EARTH MOVING MACHINE	86.0	0.047

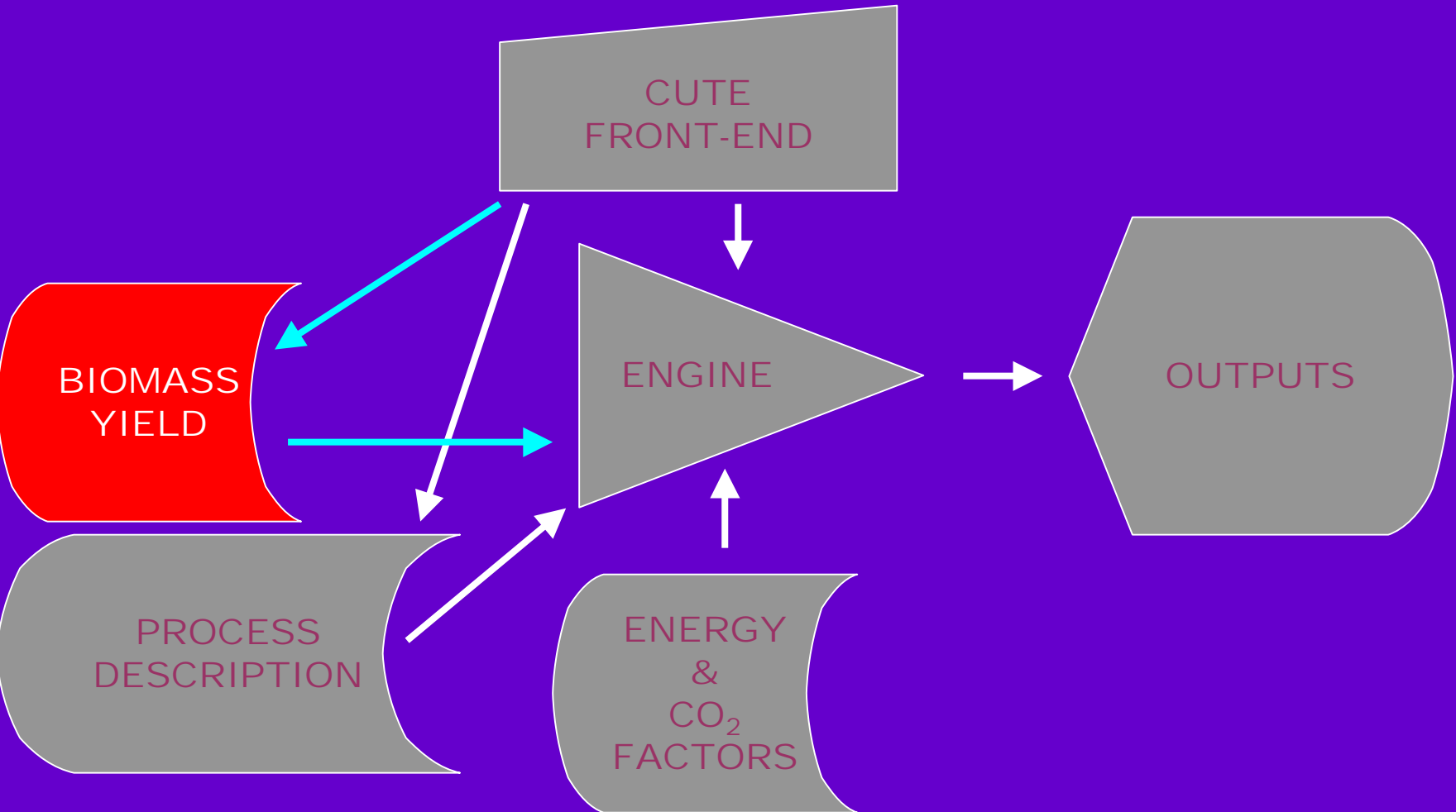
NET ENERGY REQUIRMENT [MJ kg⁻¹]

DESCRIPTION OF MACHINE

NUMBER FOR HOUSEKEEPING

NET EMISSIONS FACTOR [kgC MJ_{net}⁻¹]

LET'S TAKE A CLOSER LOOK



BIOMASS YIELD

CARBON CONTENTS

0.00

0.46

0.46

0.46

YIELD DATA

0	0.0000	0.0000	0.0000	0.0000
1	0.0000	1.4953	4.3682	0.0000
2	0.0000	2.3175	7.4376	0.0000
3	0.0000	3.0736	14.3698	0.0000
4	0.0000	3.7700	21.2159	18.0000
5	0.0000	4.4124	14.0211	0.0000
6	0.0000	5.0057	24.7852	0.0000
7	0.0000	5.5544	35.5005	30.0000

SOIL

ROOTS

ABOVE-GROUND

HARVESTED

UNITS ARE kgC per kg ORGANIC MATTER

BIOMASS YIELD

CARBON CONTENTS

0.00

0.46

0.46

0.46

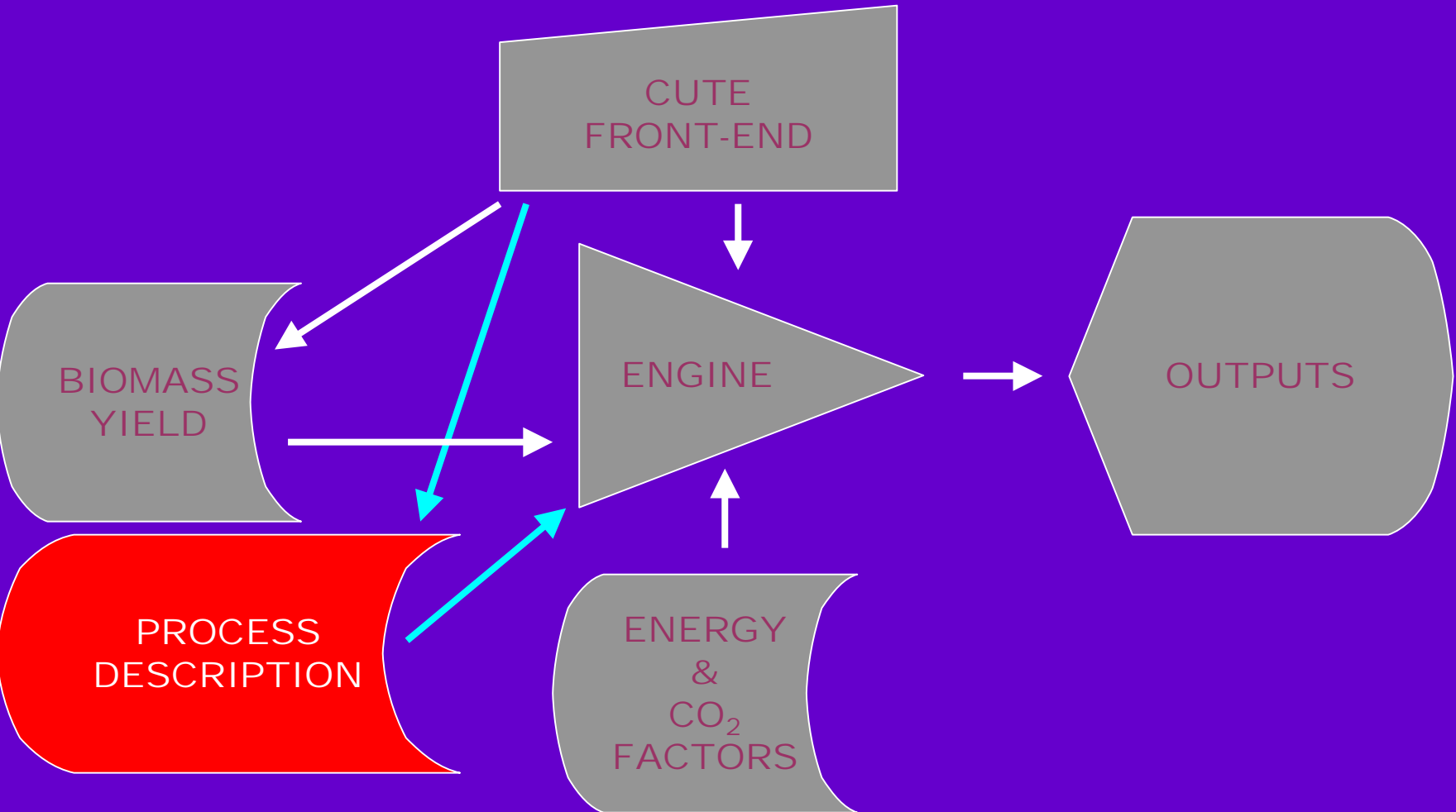
YIELD DATA

0	0.0000	0.6000	0.0000	0.0000
1	0.0000	1.4953	4.3682	0.0000
2	0.0000	2.3175	7.4376	0.0000
3	0.0000	3.0736	14.3698	0.0000
4	0.0000	3.7700	21.2159	18.0000
5	0.0000	4.4124	14.0211	0.0000
6	0.0000	5.0057	24.7852	0.0000
7	0.0000	5.5544	35.5005	30.0000

YEAR SOIL ROOTS ABOVE-GROUND HARVESTED

UNITS ARE tonnes MATTER per hectare

LET'S TAKE A CLOSER LOOK



PROCESS DESCRIPTION

PLOUGH									
2									
DIESEL OIL	100	85	0.25	A hours					1.5
LUBR. OIL	100	85	0.0005	A hours					1.5
2									
SPARES#1	SPARES #	0.005		A hours					1.5
SPARES#2	SPARES #	0.001		A hours					1.5
2									
PLOUGH	EARTH MOVING MACHINE			A hours	1000.	5000.			1.5
TRACTOR	MOTOR VEHICLE			A hours	2600.	5000.			1.5

NAME FOR PROCESS

NUMBER OF DIRECT INPUTS
OF FOSSIL ENERGY

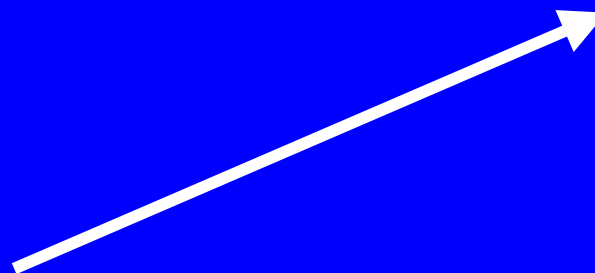
DIRECT ENERGY INPUTS

DIESEL OIL



FUEL TYPE

A MJ



66.4



'A' MEANS 'per unit field Area (hectares)'

'MJ' MEANS ESTIMATE IS IN UNITS OF MJ

THIS NUMBER IS THE ESTIMATE

WHAT DOES IT ALL MEAN ?

PLOUGHING A FIELD CONSUMES 66.4 MJ OF DIESEL FUEL
per hectare OF FIELD

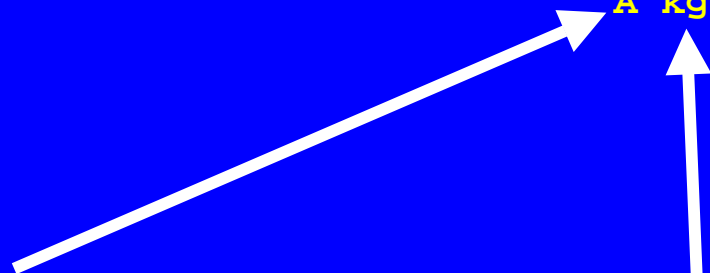
DIRECT ENERGY INPUTS

DIESEL OIL



FUEL TYPE

A kg



0.25



'A' MEANS 'per unit field Area (hectares)'

'kg' MEANS ESTIMATE IS IN UNITS OF kg

THIS NUMBER IS THE ESTIMATE

WHAT DOES IT ALL MEAN ?

PLOUGHING A FIELD CONSUMES 0.25 kg OF DIESEL FUEL
per hectare OF FIELD

DIRECT ENERGY INPUTS

DIESEL OIL

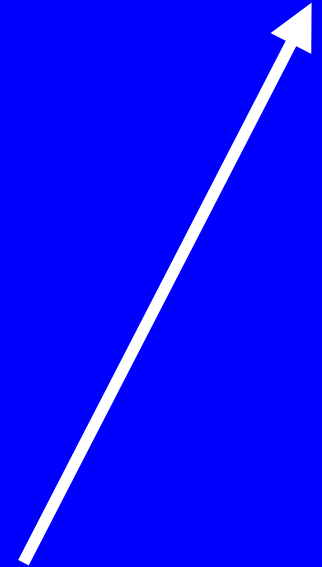


FUEL TYPE

A litres



0.36



'A' MEANS 'per unit field Area (hectares)'

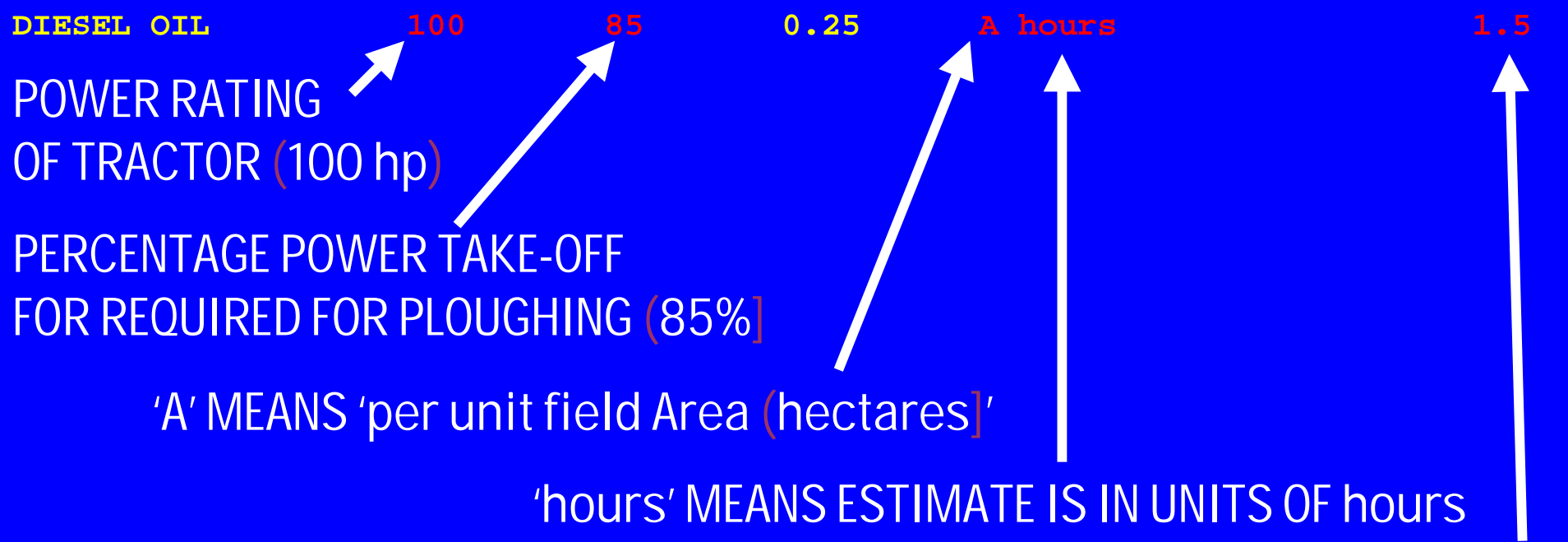
'litres' MEANS ESTIMATE IS IN UNITS OF litres

THIS NUMBER IS THE ESTIMATE

WHAT DOES IT ALL MEAN ?

PLOUGHING A FIELD CONSUMES 0.36 litres OF DIESEL FUEL
per hectare OF FIELD

DIRECT ENERGY INPUTS



WHAT DOES IT ALL MEAN ?

PLOUGHING A FIELD TAKES 1.5 hours per hectare OF FIELD

LET'S DO SOME MATHS

POWER DEVELOPED BY TRACTOR = $100 \text{ hp} \times 85\% = 85 \text{ hp}$

TIME TAKEN BY TRACTOR TO PLOUGH 1 ha = 1.5 hours

WORK DONE BY TRACTOR = $85 \times 1.5 = 127.5 \text{ hp-hours/ha}$

FUEL CONSUMED BY TRACTOR = $k \times 127.5 \text{ litres/ha}$

k is estimated to be 0.25 litres/hp-hour

DIRECT ENERGY INPUTS

DIESEL OIL

100

85

0.25

A hours

1.5



ENTER YOUR FAVOURITE VALUE OF k HERE

DIRECT ENERGY INPUTS

PLOUGH						
2						
DIESEL OIL	100	85	0.25	A hours		1.5
LUBR. OIL	100	85	0.0005	A hours		1.5

WHAT DOES ALL THAT MEAN ?

EUREKA !

PROCESS DESCRIPTION

PLOUGH							
2							
DIESEL OIL	100	85	0.25	A hours			1.5
LUBR. OIL	100	85	0.0005	A hours			1.5
SPARES#1	SPARES #	0.005		A hours			1.5
SPARES#2	SPARES #	0.001		A hours			1.5
2							
PLOUGH	EARTH MOVING MACHINE			A hours	1000.	5000.	1.5
TRACTOR	MOTOR VEHICLE			A hours	2600.	5000.	1.5

NAME FOR PROCESS

NUMBER OF DIRECT INPUTS
OF FOSSIL ENERGY

THERE ARE TWO INDIRECT INPUTS
FROM USE OF MATERIALS (SPARES)

INPUTS FROM MATERIALS

SPARES#1



YOUR NAME FOR
THE MATERIAL

SPARES # 0.005



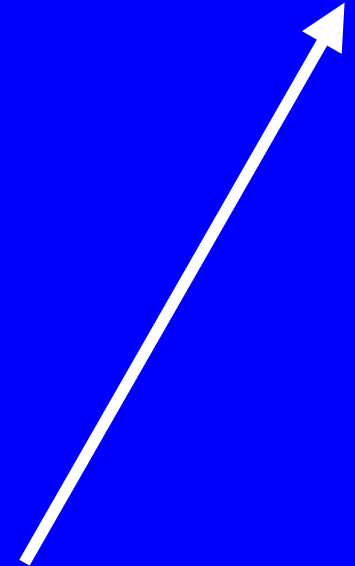
NEAREST AVAILABLE
ENERGY REQUIREMENT
AND EMISSIONS FACTOR

A hours



STUFF DEFINING
HOW MUCH IS
USED

1.5



INPUTS FROM MACHINERY

PLOUGH								
2								
DIESEL OIL	100	85	0.25	A hours				1.5
LUBR. OIL	100	85	0.0005	A hours				1.5
2								
SPARES#1	SPARES # 0.005			A hours				1.5
SPARES#2	SPARES # 0.001			A hours				1.5
2								
PLOUGH	EARTH MOVING MACHINE			A hours	1000.	5000.		1.5
TRACTOR	MOTOR VEHICLE			A hours	2600.	5000.		1.5

THERE ARE TWO INDIRECT INPUTS
FROM USE OF MACHINERY

INPUTS FROM MACHINERY

PLOUGH

EARTH MOVING MACHINE

A hours

1000.

5000.

1.5



YOUR NAME FOR
THE MATERIAL

NEAREST AVAILABLE
ENERGY REQUIREMENT
AND EMISSIONS FACTOR

INPUTS FROM MACHINERY

PLOUGH

EARTH MOVING MACHINE

A hours

1000.

5000.

1.5

'A' MEANS 'per unit field Area (hectares)'

'hours' MEANS ESTIMATE IS IN UNITS OF hours

THIS IS THE MASS OF THE PLOUGH IN kg

THIS IS THE OPERATIONAL LIFE OF THE PLOUGH IN WORKING hours

THIS IS THE ESTIMATE

PROCESS DESCRIPTION

SPRAY FOR COUCH CONTROL

2

DIESEL OIL	100	40	0.25	A hours		0.4
LUBR. OIL	100	40	0.0005	A hours		0.4

4

GLYPHOSATE	AGROCHEMICALS			A litres	1.0	5.0
WATER	IGNORE			A litres	1.0	200.0
SPARES#1	SPARES # 0.005			A hours		0.4
SPARES#2	SPARES # 0.001			A hours		0.4

2

SPRAYER	EARTH MOVING MACHINE			A hours	400.	5000.	0.4
TRACTOR	MOTOR VEHICLE			A hours	2600.	5000.	0.4

PROCESS DESCRIPTION

FENCE

0

8

SUPPORTPOST	HOME-GROWN	SOFTWOOD	P kg	75.0
STRAININGPOST	HOME-GROWN	SOFTWOOD	P kg	0.5
BRACINGSTRUT	HOME-GROWN	SOFTWOOD	P kg	1.0
STRAININGWIRE	STEEL WIRE		P kg	10.0
WIRENETTING	STEEL WIRE		P kg	100.0
STAPLE	MILD STEEL		P kg	1.0
NAIL	MILD STEEL		P kg	1.0
PRESERVATIVE	PAINT		P kg	25.0

0

PROCESS DESCRIPTION

HARVEST AND CHIP

4

DIESEL OIL	300	85	0.25	A hours	1.6
LUBR. OIL	300	85	0.0005	A hours	1.6
DIESEL OIL	100	40	0.25	A hours	3.2
LUBR. OIL	100	40	0.0005	A hours	3.2

3

SPARES#1	SPARES # 0.015			A hours	1.6
SPARES#2	SPARES # 0.005			A hours	3.2
SPARES#3	SPARES # 0.001			A hours	3.2

3

FORAGE HARV.	MOTOR VEHICLE			A hours	7000.	8000.	1.6
TRAILER	EARTH MOVING MACHINE			A hours	1600.	5000.	3.2
TRACTOR	MOTOR VEHICLE			A hours	2600.	5000.	3.2

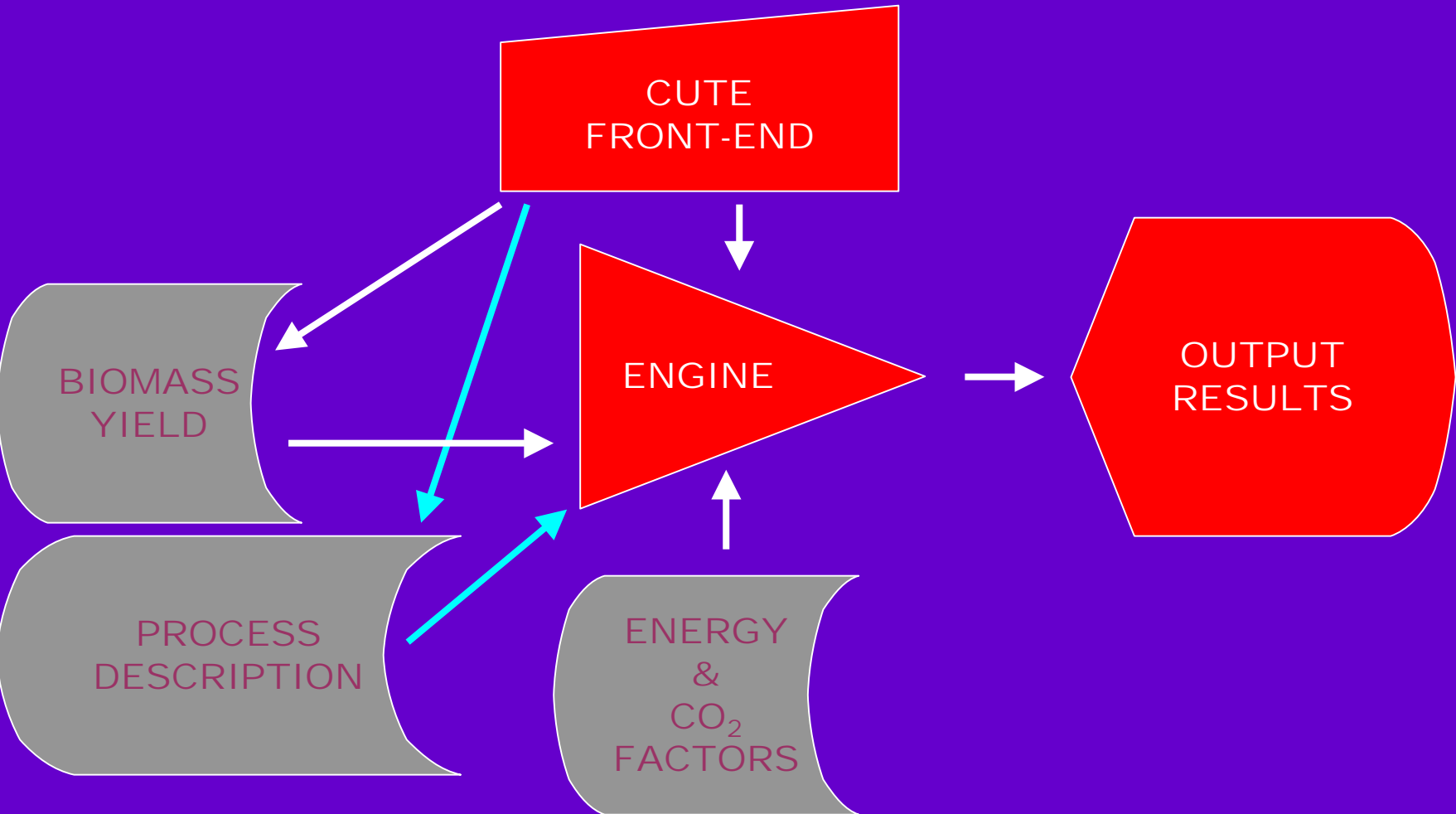
PROCESS DESCRIPTION

TRANSPORT

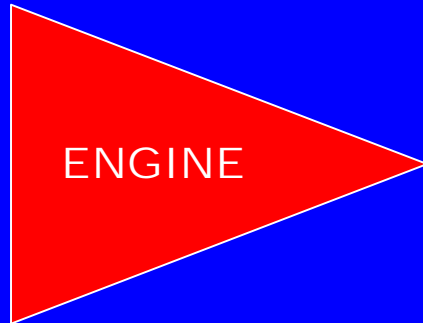
4					
DIESEL OIL	100	40	0.25	T hours	0.04
LUBR. OIL	100	40	0.0005	T hours	0.04
DIESEL OIL	350	55	0.25	T hours	0.0
LUBR. OIL	350	55	0.0005	T hours	0.0
3					
SPARES#1	SPARES #	0.005		T hours	0.04
SPARES#2	SPARES #	0.001		T hours	0.04
SPARES#3	SPARES #	0.015		T hours	0.0
3					
TRAILER	EARTH MOVING MACHINE			T hours	1600. 5000. 0.04
TRACTOR	MOTOR VEHICLE			T hours	2600. 5000. 0.04
BULK CARRIER	MOTOR VEHICLE			T hours	15000. 8000. 0.0

COMPLETE PROCESS DESCRIPTION MADE UP
OF A LONG LIST OF THESE

LET'S TAKE A CLOSER LOOK



CALCULATION ENGINE



- ▶ ANSI STANDARD FORTRAN 77
- ▶ WILL WORK ON MANY PLATFORMS
- ▶ SOURCE CODE PUBLISHED

USER INTERFACE



CUTE
FRONT-END

-  Borland Delphi
-  Microsoft Windows only
-  Cute

OUTPUT RESULTS



OUTPUT AS SIMPLE BUT COMPREHENSIVE ASCII FILE