ATO-DLO

Appendix half-year report of CEET2005

Presentations held at the meeting on 27 September 1999

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Consortium:
ATO
Carrier Transicold
P&O Nedlloyd
Ecofys
The Greenery International
Shell Solar Energy B.V.

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2252736

Task 1

The Greenery International

Containertransport

CEET 2005

P. Jan Smits,
september 1999

Commercial interest for:

1. tomatoes on the vine
2. bell peppers
3. green beans import
4. nectarines, peaches, mango's import
   * existing boattranport
   * harvested more mature for better flavour
5. not for apples

Bell Pepper I

* Substantial price fluctuations
* Risk of lower productprices next week when airfreight (and better Q in US)
* Supply forecasting is helpfull

* Perfect productquality needed
  * Selected growers
  * Varieties with long shelf life

Bell pepper II

* Container CA or
* MA per box (special boxes) or
* Consumerpacks MA

▷ Total costprice
▷ Quality at retail level

Tomatoes on the vine

* Less price fluctuations
* More quality differences between varieties
* Container CA - Box MA - Cons. Pack MA ?
* Quality of tomatoes <u>and</u> quality of vine
  * different optimal conditions ?

Task 2

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Carrier Transicold

Task 2

Modelling

climatic conditions in container,

and cool/CA unit

to be used in supervisory control algorithm

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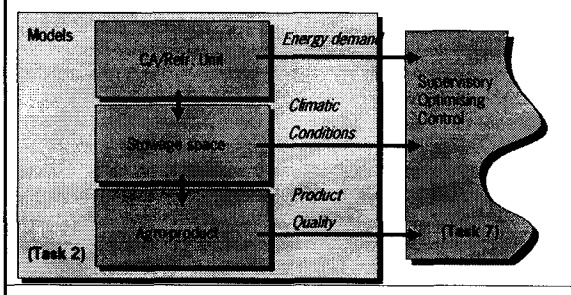
Modeling objective

Reliable, validated model to make predictions for supervisory controller



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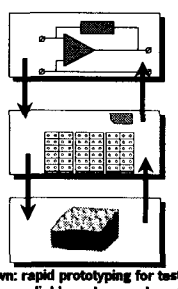
Marching Route



Dual route **top-down: rapid prototyping for testing supervisory controller**
bottom-up: reliable and general model, ciritical points

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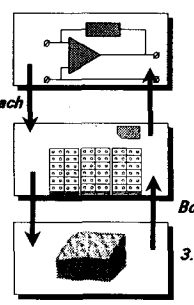
State of modelling

1.Crude model T/RH
2. Model cool-unit



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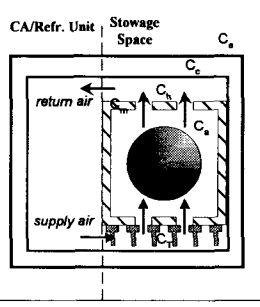
Activity 1: Crude model T/R.H.

- **Objective**:
  model template for supervisory control
  estimation of energy load of product
- **Approach**:
  Identify objects with
  thermal energy storage capacity
  Connect them with
  heat resistances/convective flows



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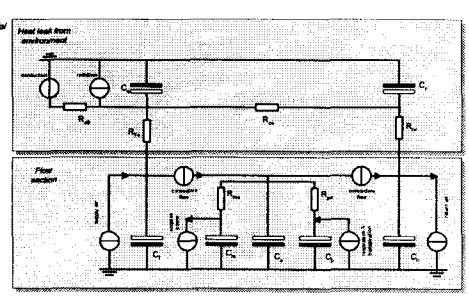
Network model: thermal domain



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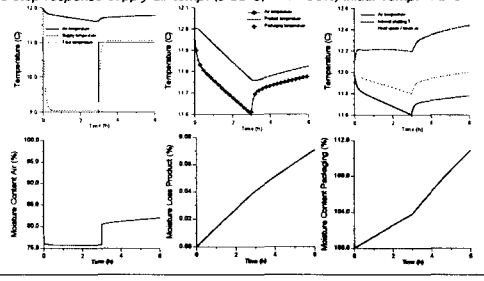
Sample output of thermal model

25 ton tomatoes in container with ambient temperature = 20°C
Double step response supply air temp. (9-11°C) R.H.=90%, initial Temp.=12°C



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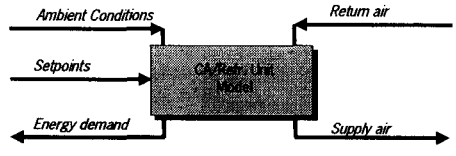
Activity 2: Refrigerating unit model

- Mapping of return air conditions to supply air conditions, given setpoints and ambient conditions.
- Predicts energy demand.



Prediction to be used in supervisory control algorithm, needs simple input/output mapping for on-line computation

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First indication power requirements

Electrical current of various components

- **Heater** = **10 A**
- **Evap. high on (fans high)** = **1.5 A**
- **condenser fan** = **1 A**
- **Compressor** = **20 - 35 A**

Highest power usage by compressor,
Energy reduction possible by power cycling of compressor,
Effects on product quality will be investigated
(experimentally and by means of 'crude' model)

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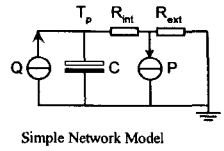
Activity 3: Cooling at product level

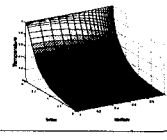
Example of bottom-up approach: simplification of models

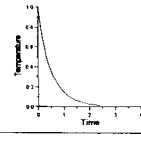
Detailed Finite Element Model

Volume Averaging



Simple Network Model





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Next actions

- Product model of respiration heat and transpiration
- Airflow through package
- Airflow in container
- Identification and modeling refrigeration/CA unit.

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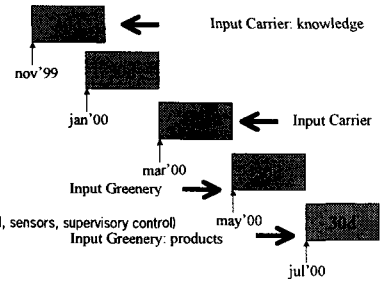
Container Experiments

- Identification Cool unit
- Airflow
- Identification CA-unit
- Temperature/R.H.
- Gas conditions
- ('01: Testing macromodel, sensors, supervisory control)



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Conclusions

- Model template for supervisory control is ready
- Method available for model simplification (bottom-up)

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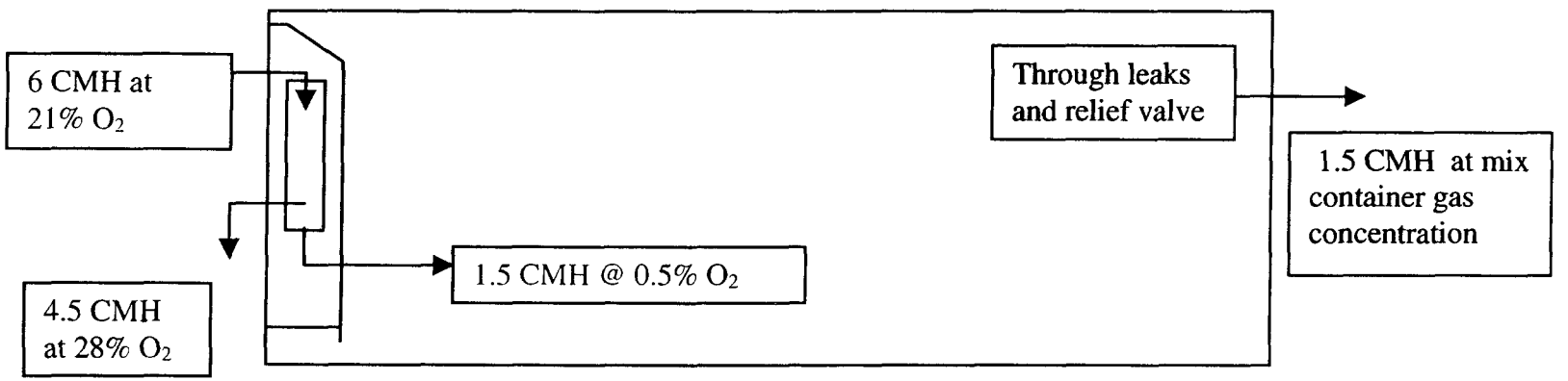
I. Review of Current EverFresh System Function

Today's system requires membrane feed flow of approximately 4 times the Nitrogen rich output.

When Compressor on and OSV closed:



O2 Pull Down

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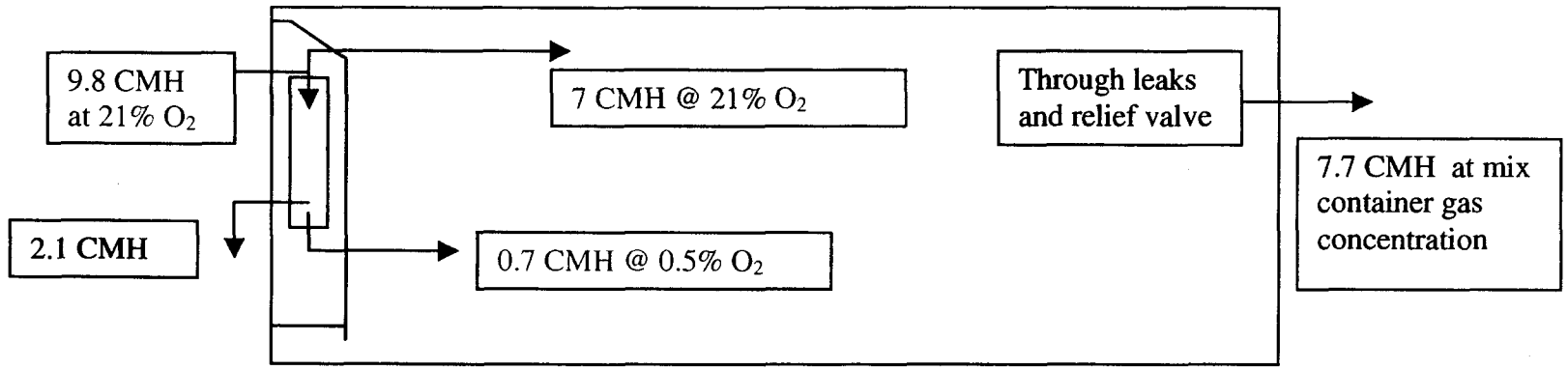
When OSV open, bypass membrane,



O2 Pull Up

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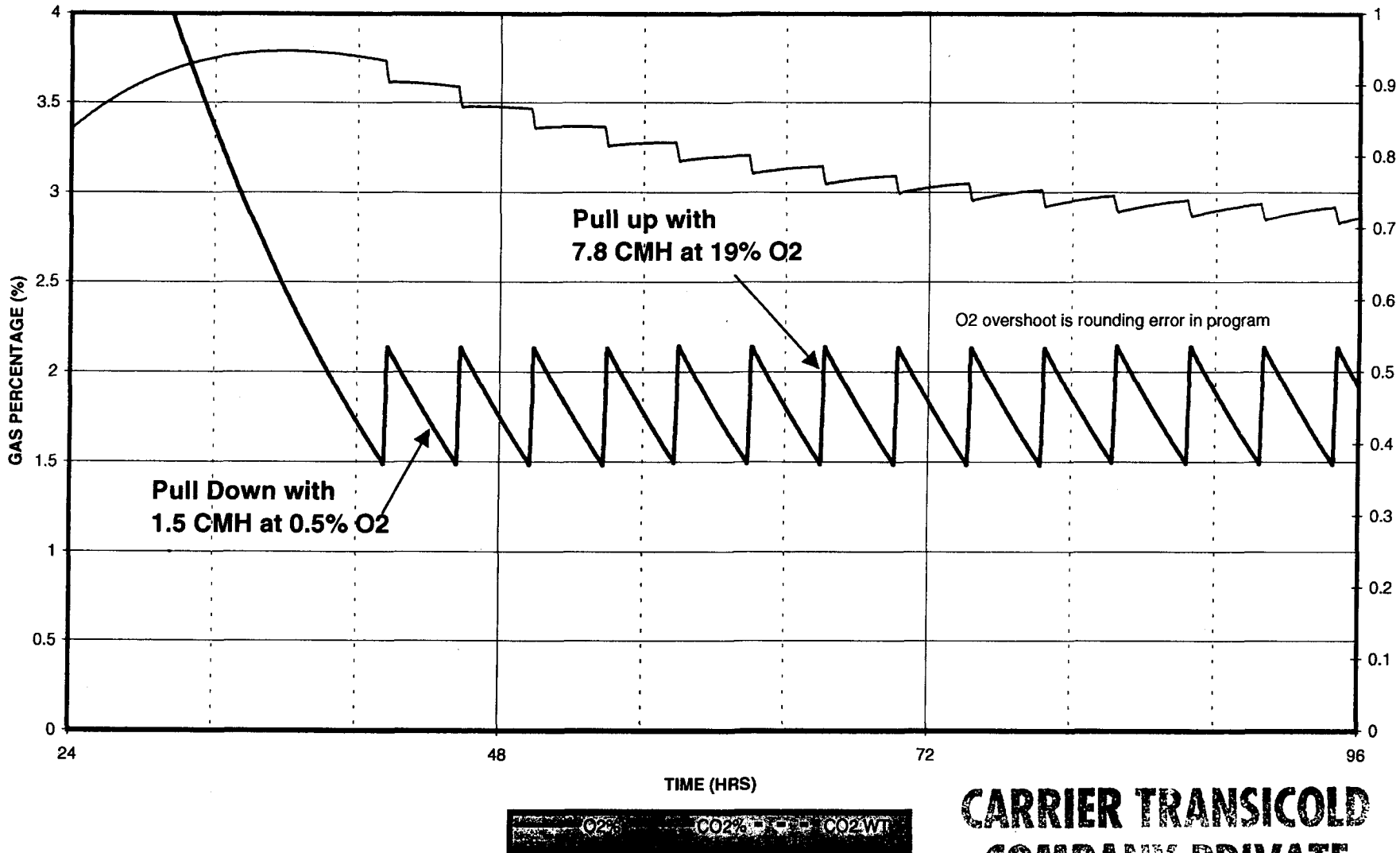
O2 Primary control; CO2 Secondary Control



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II. Causes of Inconsistent Control

Combination Low O_2 set point
Low CO_2 set point

Result: Need for increased flow to dilute CO_2 to desired SP

Early Assumptions:

1. Respiration rate linearly proportional to O_2 level
   Problem:
   Respiration rate at low O_2 not completely known for all products
   Respiration rate reduction may not begin until O2 less thatn 6%
   Respiration rate may not ever be less than 50%

2. OSV, high flow = enough to dilute CO_2
   Problem:
   21% O_2 raises O_2 level rapidly and shuts off

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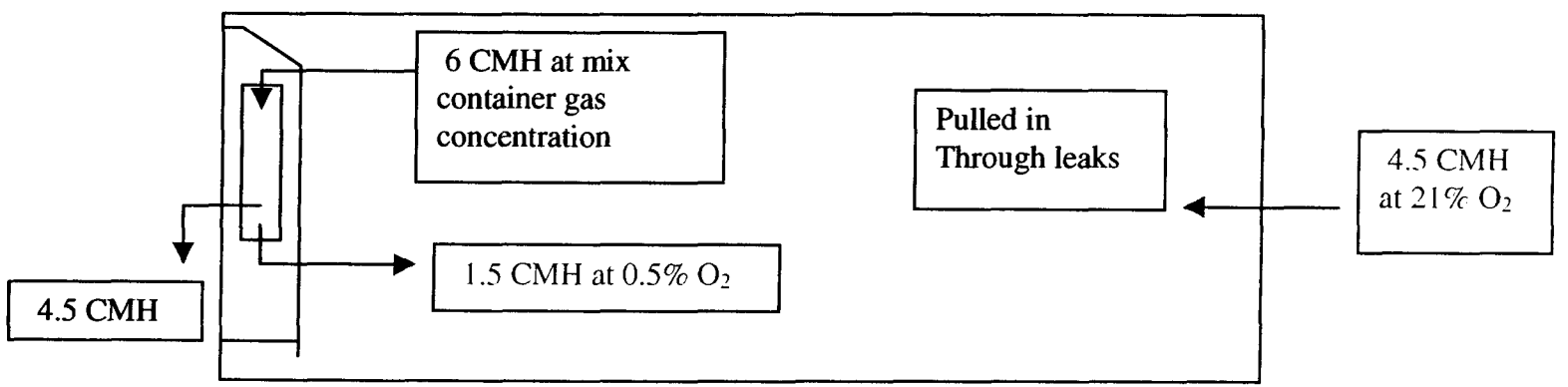
III Options

Option #1 Recycle container air through membrane
Recycle 100% of membrane feed flow



Result: Pulls air from outside container to balance pressure - Loses O_2 control

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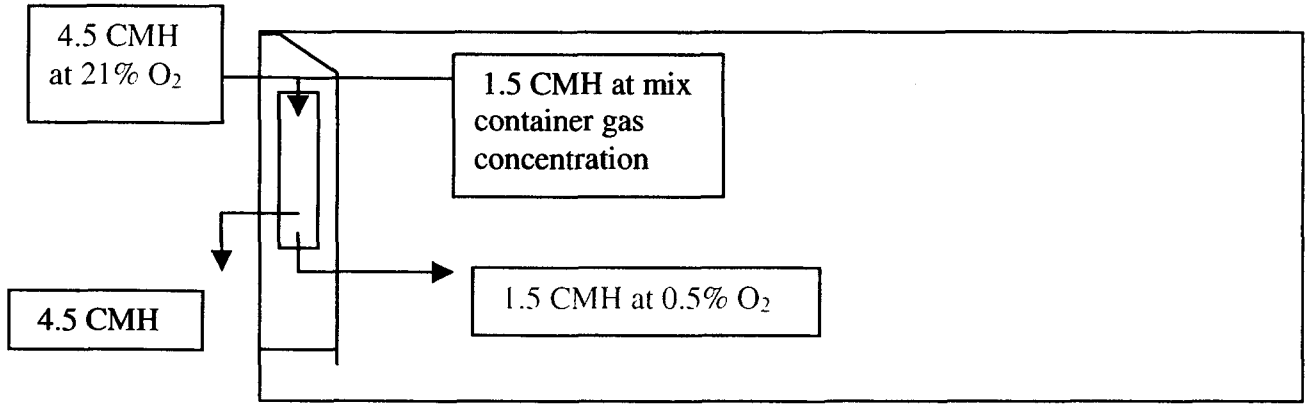
III Options (continued)

Option #2 Balance the amount recycled to equal the membrane output



Result: Same as original design – No contribution over current system

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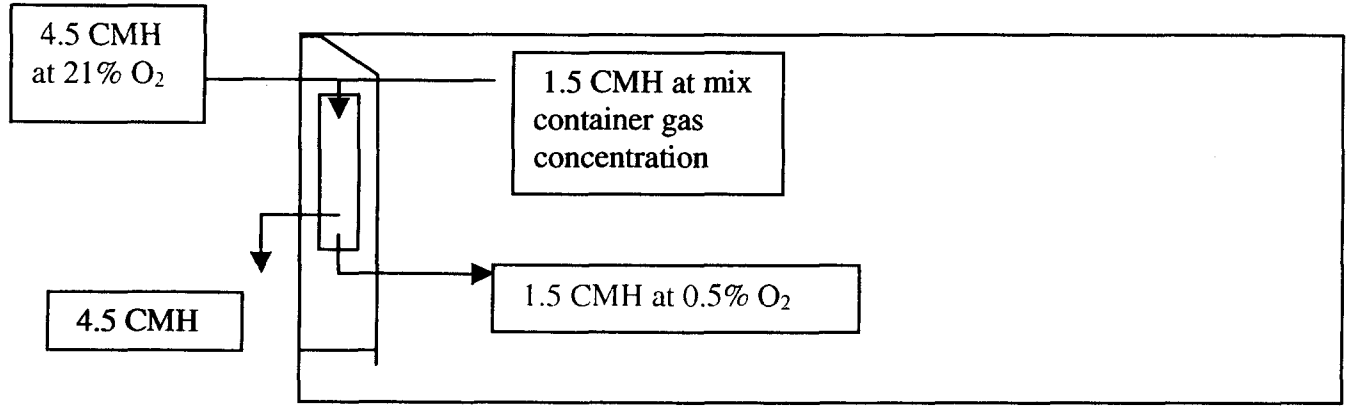
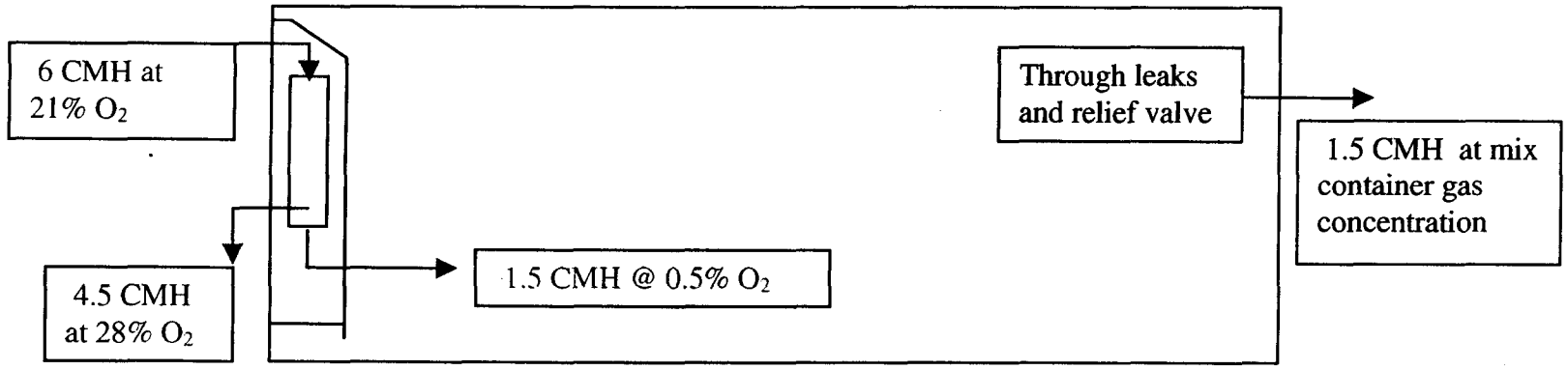
RECYCLE COMPARISON



ORIGINAL SYSTEM



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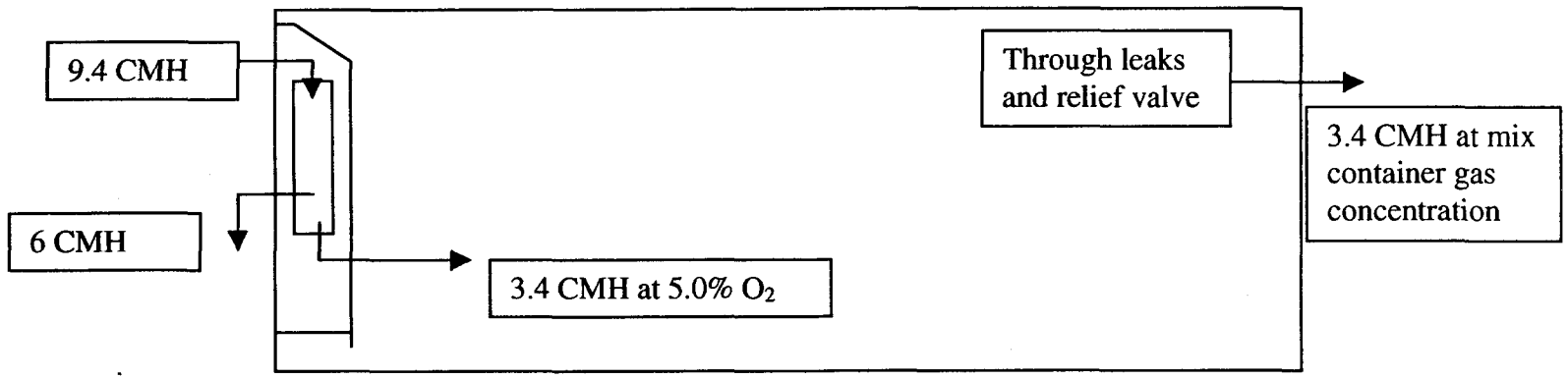
III Options (continued)

Option #3

Allow higher flow through membrane (open membrane outlet restriction)

Result: Higher flow, Lower purity approx 3.4 CMH at 5% O_2

Lower system pressure higher feed flow from compressor



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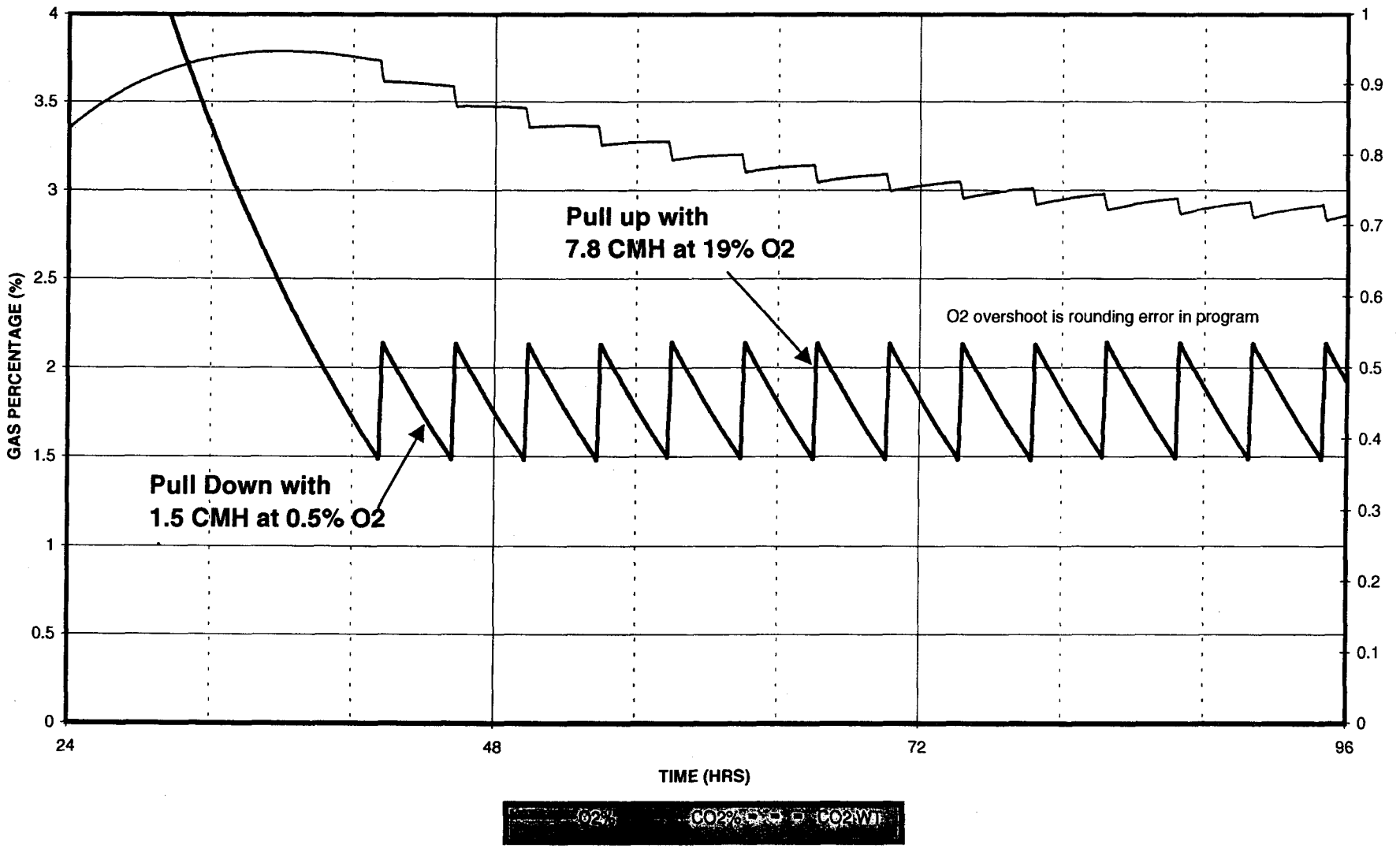
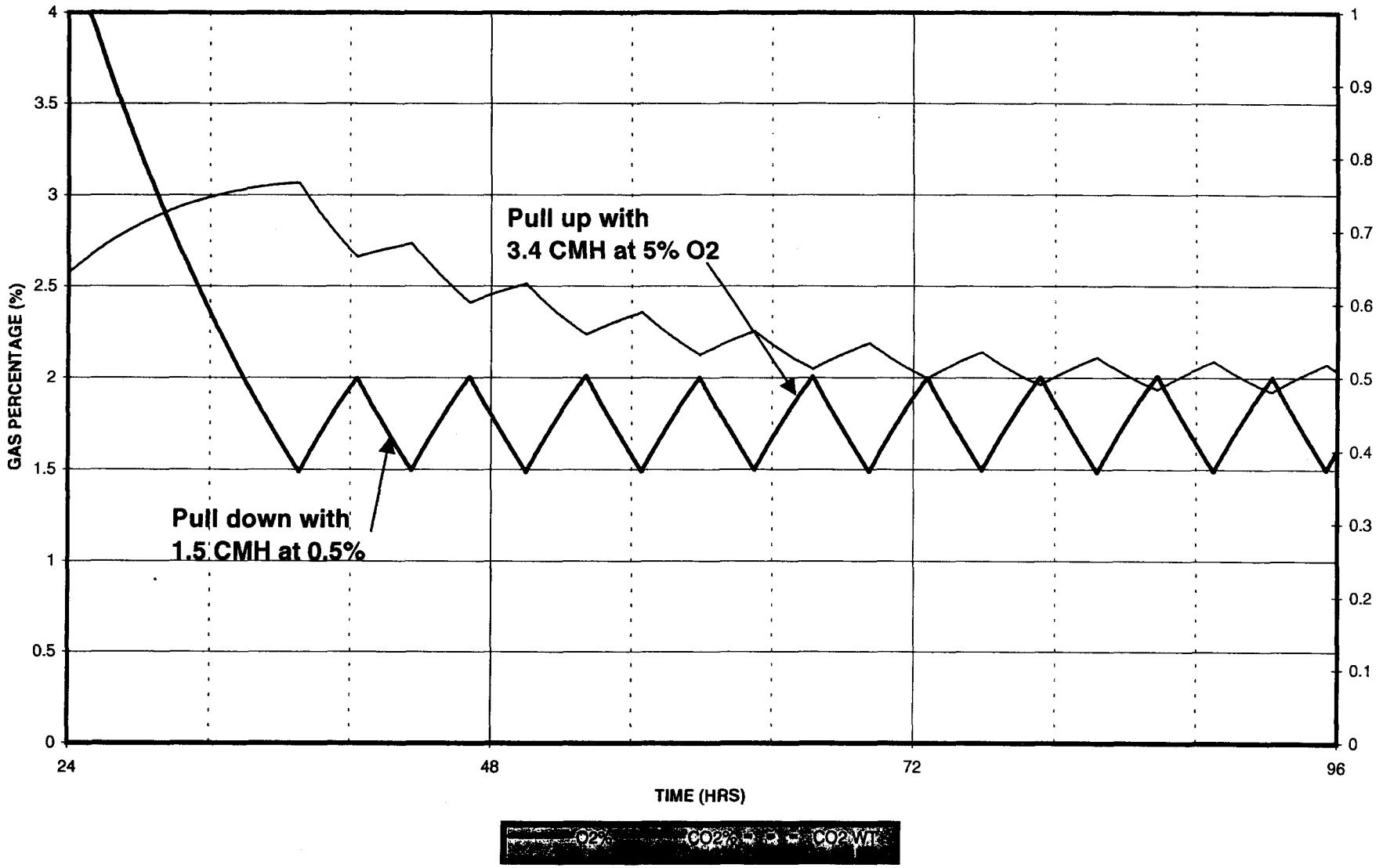
1 purity - Cox Apple



2 purity -Cox Apple



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Options Summary

1. Recycle 100% of membrane feed flow
   Lose O_2 control

2. Recycle exact membrane delivery – Balance
   No contribution over current system
   Complex system

3. Increase system flow
   Improved CO_2 control

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Required flow for a given CO_2 setpoint

A steady state Example

Respiration at O_2 set point = 0.04CMH

Desired CO_2 Set Point = 5.0%

Required flow = Respiration / CO_2 set point
0.04/.05 = 0.8CMH

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- What is respiration rate at O2 set point?
  - When does the cargo go to "sleep"?
    - How deep a "sleep"?

Theoretical design consideration
worst case

Respiration at O2 Set point is **50%** of respiration in Atmosphere of 21% O2

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CA Commodoties shipped
calculated flow required
to dilute atmosphere to desired CO2 set point

Current 1 purity system capability to maintain Range of CO2 set point

Commodity	Temperature Set Point Deg C	Recommended O2 % Set Point		Recommended CO2% Set Point		CMH Flow required to dilute CO2 to in range at 50% respiration
		min	max	min	max	
Blueberry	-0.5	2	5	12	20	**0.18**
Pineapples	10	2	5	5	10	**0.21**
Plums	-0.5	2	2	1	5	**0.27**
Kiwi Fruit	0	2	2	3	5	**0.35**
Nectarines & Peaches	-0.5	2	2	3	5	**0.47**
Spinach	0	5	10	5	10	**0.51**
Apple Others	0	2	3	1	5	**0.51**
Broccoli	0	2	3	5	10	**0.64**
Peppers, Bell	10	2	5	2	5	**1.04**
Pears	-0.5	2	3	1	3	**1.13**
Lettuce	0	2	3	1	2	**1.86**
Apple Cox	3	2	3	1	2	**1.89**
Mangos						
Tomatoes						
Avocados						
Banana						
Beans, green						
Asparagus						
Cucumbers						
Artichoke						
Peas						

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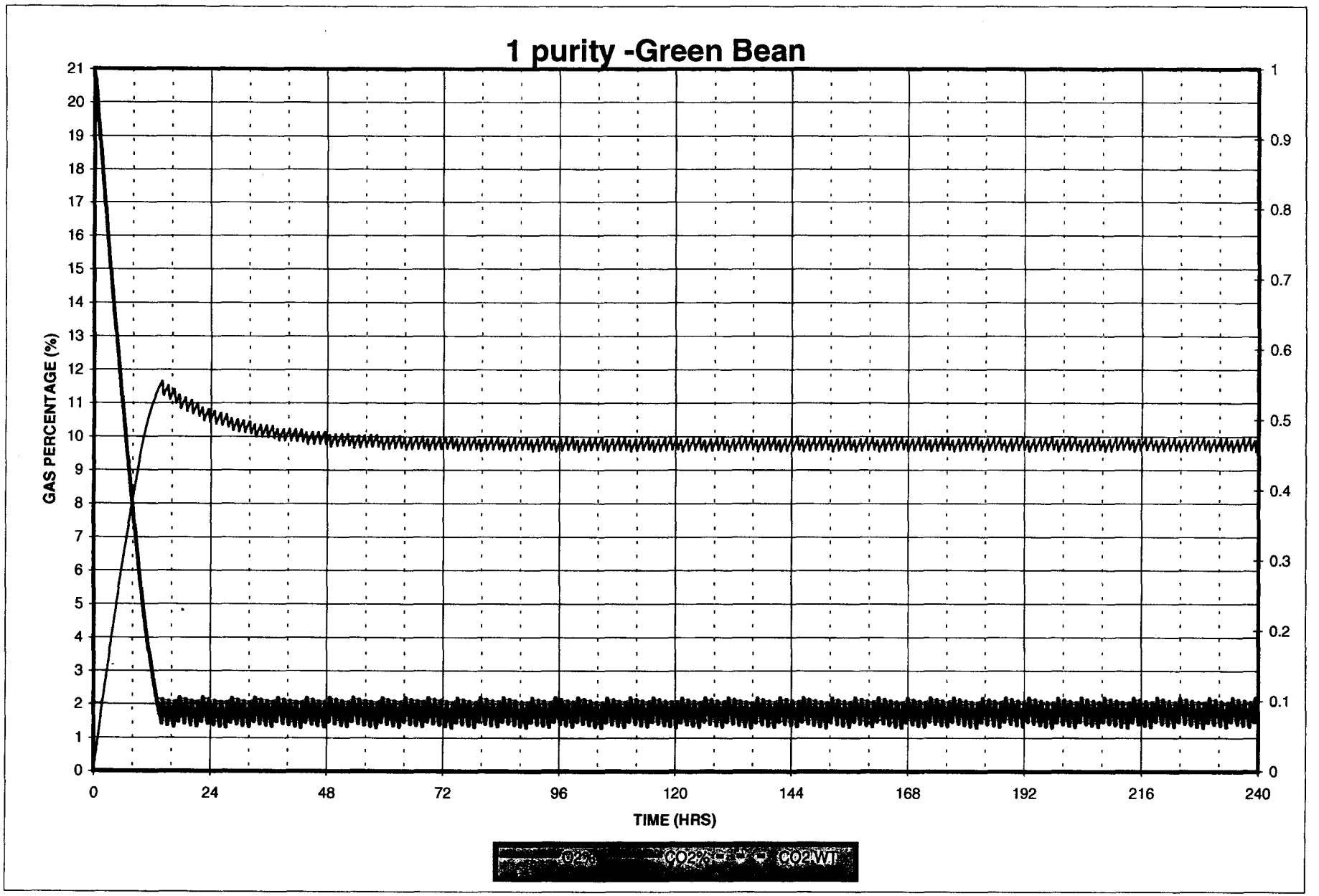
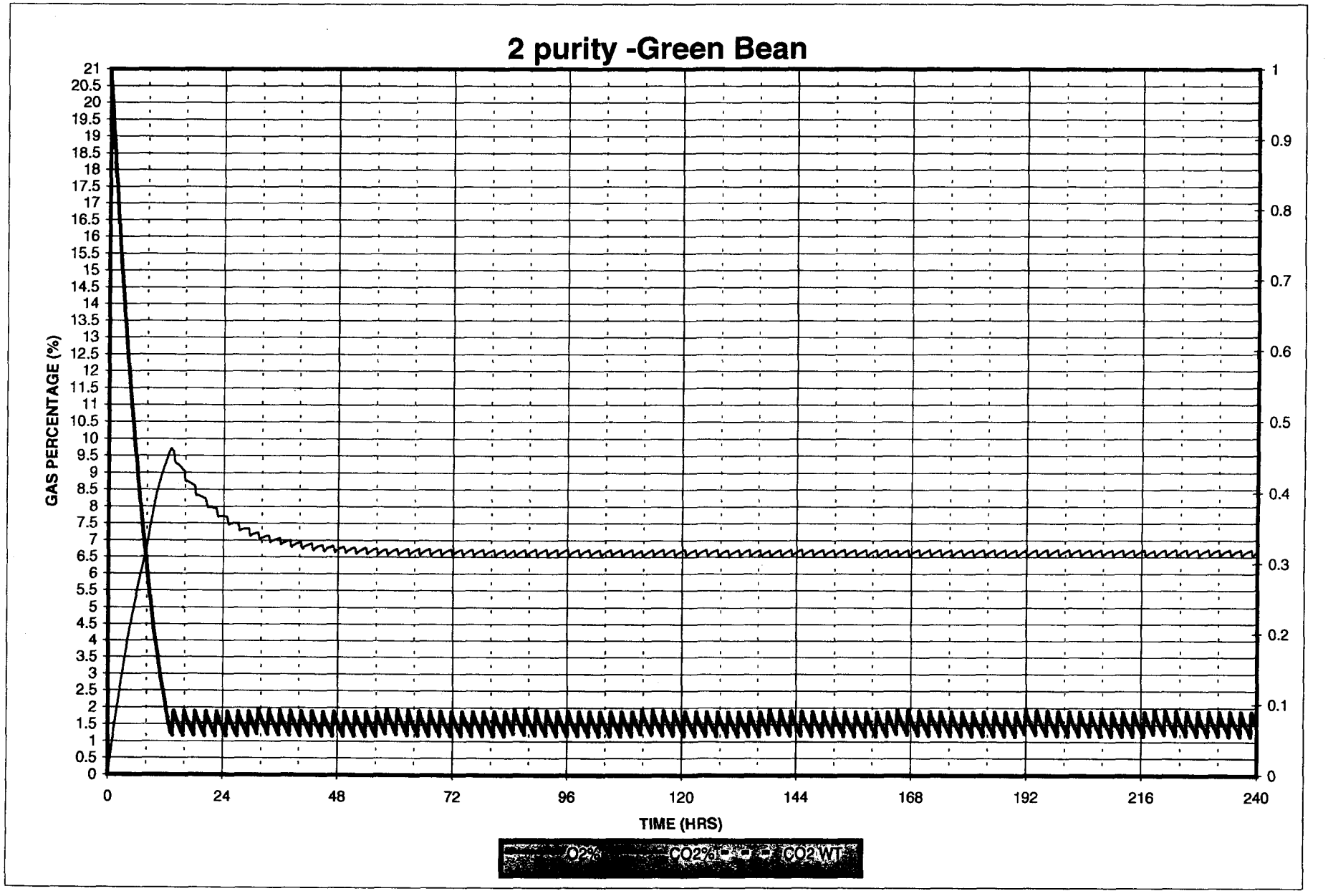
CA Commodoties shipped
calculated flow required
to dilute atmosphere to desired CO2 set point

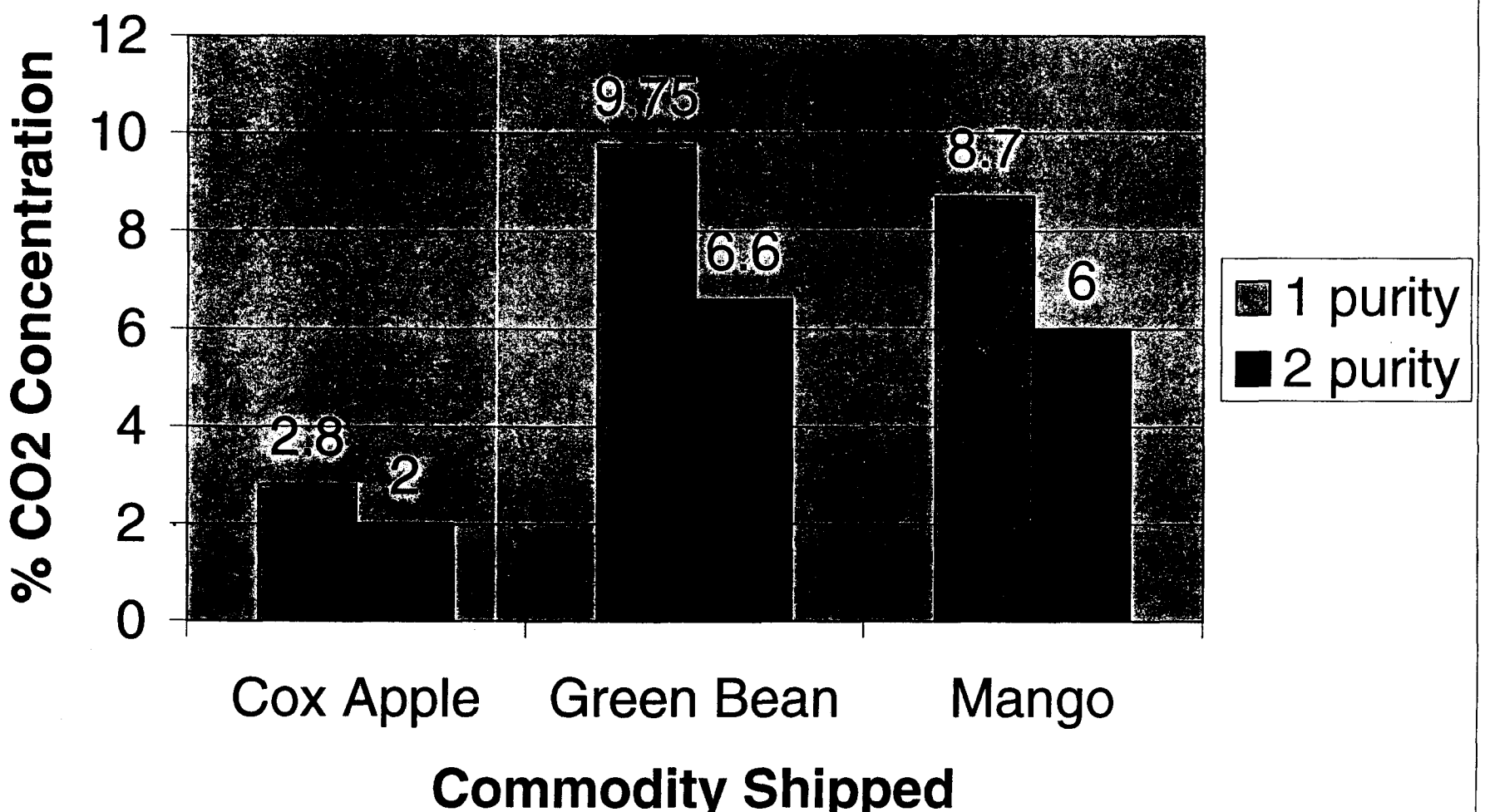
Proposed 2 purity system capability to maintain Range of CO2 set point

Commodity	Temperature Set Point Deg C	Recommended O2 % Set Point		**Recommended CO2% Set Point**		**Flow required to dilute CO2 to in range at 50% respiration**
		min	max	min	**max**	
Blueberry	-0.5	2	5	12	**20**	**0.18**
Pineapples	10	2	5	5	**10**	**0.21**
Plums	-0.5	2	2	1	**5**	**0.27**
Kiwi Fruit	0	2	2	3	**5**	**0.36**
Nectarines & Peaches	-0.5	2	2	3	**5**	**0.47**
Spinach	0	5	10	5	**10**	**0.51**
Apple Others	0	2	3	1	**5**	**0.51**
Broccoli	0	2	3	5	**10**	**0.64**
Peppers, Bell	10	2	5	2	**5**	**1.04**
Pears	-0.5	2	3	1	**3**	**1.13**
Lettuce	0	2	3	1	**2**	**1.86**
Apple Cox	3	2	3	1	**2**	**1.89**
Mangos	10	3	7	5	**8**	**2.07**
Tomatoes	10	3	5	2	**5**	**2.44**
Avocados	4	3	10	2	**5**	**2.96**
Banana	14	2	5	2	**5**	**2.96**
Beans, green	7	2	3	4	**7**	**3.05**
Asparagus	1- 3	11	21	5	**13**	**3.19**
Cucumbers	10	2	5	2	**5**	**3.38**
Artichoke						
Peas						


1 purity -Green Bean
GAS PERCENTAGE (%)
TIME (HRS)
0
24
48
72
96
120
144
168
192
216
240
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
O2%
CO2%
CO2WT


2 purity -Green Bean
GAS PERCENTAGE (%)
21
20.5
20
19.5
19
18.5
18
17.5
17
16.5
16
15.5
15
14.5
14
13.5
13
12.5
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
24
48
72
96
120
144
168
192
216
240
TIME (HRS)
O2%
CO2%
CO2 WT

CO2 steady state system simulation



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Option #3 Implementation

- Retrofit a valve in parellel with the existing capillary
- Wire into controller
- Upgrade software

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CO_2 Control

I. Review Of Current EverFresh System Function

II. Cause Of Inconsistent Control

III. Options

IV. Future Considerations

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Task 3

Ecofys
Shell Solar Energy B.V.

ECOFYS

CEET-Container Task 3

Energy supply

ECOFYS, September 1999

ECOFYS

Contents

- Options
  - What energy suppliers are we looking at?
- Criteria
  - What is needed to obtain the optimal energy supplier?
- Situations
  - Which different situations can we distinguish?
- Conclusions
  - What is the optimal supplier in all situations?

ECOFYS

Options

- Electricity
- Photo voltaic
- Diesel genset
- Bio diesel genset
- Hydrogen / LPG / LNG genset
- Fuel cells
- Absorption heat pump
- Electric buffer
- Thermal buffer

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Electricity

- Only available on board
- High reliability
- Sustainability depends on production
- No investment or maintenance cost
- Fuel cost approx. 0.10 $/kWh?

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Photo Voltaic

- Limited power
- No maintenance or fuel cost
- Autonomous and sustainable
- Logistics hard to combine with reefer transport
- High investment cost (approx. 5000 $/kW)

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Diesel Genset

- Fuel sufficiently available
- Not sustainable
- High maintenance cost (1500 $/year?)
- Investment ± 1000 $/kW
- Fuel cost approx. 0.15 $/kWh

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Bio Diesel Genset

- Fuel poorly available
- Sustainable
- High maintenance cost (1500 $/year?)
- Investment ± 1000 $/kW
- Fuel cost approx. 0.30 $/kWh

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Hydrogen / LPG / NPG

- Fuel poorly available
- Sustainability depends on source
- High maintenance cost
- High fuel cost

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Fuel Cells

- Availability depends on fuel
- Sustainability depends on fuel
- High investment cost (2000 $/kW, General Electrics)
- Technology under development

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Absorption heat pump

- Only for transport on truck
- Availability depends on waste heat and fuel
- Known technology and economy

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Electric buffer

- Low capacity
- High weight (approx. 40 kg/kWh)
- High investment cost (300 $/kWh)

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Thermal buffer

- Low capacity
- Extra heat exchanger needed
- High volume (15 l/kWh)
- and weight (12 kg/kWh)

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Criteria

- Power
- Autonomy
- Availability (fuel source)
- Reliability
- Sustainability
- Investment cost
- Maintenance cost
- Fuel cost
- Built-in

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Overview

	Electricity	Photo voltaic	Diesel genset	Bio diesel genset	Hydrogen/LPG/LNG genset	Fuel Cells	Absorption heat pump	Electric buffer	Thermal buffer
Power	++	≈ 2.2 kW	++	+	++	++	+	-	- -
Autonomy	- -	++	+	+	+	+	+	++	++
Availability (fuel source)	++	-/+	+	0	?	-/+	+	++	++
Reliability	++	++	+	+	+	?	+	++	++
Sustainability	-	+	-	+	-/+	-/+	-/+	-/+	-/+
Investment cost	++	- -	+	+	+	-	?	- -	-
Maintenance cost	++	++	-	-	-	?	+	++	++
Fuel cost	+	++	-	- -	0	-	+	+	+
Built-in	- -	- -	-	-	-	?	-	+	-

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Situations

- Initial cooling
  - The optimal energy supplier during the initial cooling after stowage
- Shipment
  - The optimal energy supplier during a six week over sea shipment
- Transfer
  - The optimal energy supplier during transfer in harbours and other temporarily autonomous operation
- Continental transport
  - The optimal energy supplier during transport on trucks and trains

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Initial cooling

- Main criteria
  - Power
  - Investment
- Best option
  - Electricity
  - Diesel genset

	Electricity	Photo voltaic	Diesel genset	Bio diesel genset	Hydrogen/LPG/LNG genset	Fuel Cells	Absorption heat pump	Electric buffer	Thermal buffer
Power	++	≈ 2.2 kW	++	+	++	++	+	-	- -
Autonomy	- -	++	+	+	+	+	+	++	++
Availability (fuel source)	++	-/+	+	0	?	-/+	+	++	++
Reliability	++	++	+	+	+	?	+	++	++
Sustainability	-	+	-	+	-/+	-/+	-/+	-/+	-/+
Investment cost	++	- -	+	+	+	-	?	- -	-
Maintenance cost	++	++	-	-	-	?	+	++	++
Fuel cost	+	++	-	- -	0	-	+	+	+
Built-in	- -	- -	-	-	-	?	-	+	-

ECOFYS

Shipment

- Main criteria
  - Power
  - Reliability
  - Fuel cost
- Best option
  - Electricity

	Electricity	Photo voltaic	Diesel genset	Bio diesel genset	Hydrogen/LPG/LNG genset	Fuel Cells	Absorption heat pump	Electric buffer	Thermal buffer
Power	++	≈ 2.2 kW	++	+	++	++	+	-	- -
Autonomy	- -	++	+	+	+	+	+	++	++
Availability (fuel source)	++	-/+	+	0	?	-/+	+	++	++
Reliability	++	++	+	+	+	?	+	++	++
Sustainability	-	+	-	+	-/+	-/+	-/+	-/+	-/+
Investment cost	++	- -	+	+	+	-	?	- -	-
Maintenance cost	++	++	-	-	-	?	+	++	++
Fuel cost	+	++	-	- -	0	-	+	+	+
Built-in	- -	- -	-	-	-	?	-	+	-

ECOFYS

Transfer

- Main criteria
  - Autonomy
  - Built-in
- Best options
  - Electric buffer

	Electricity	Photo voltaic	Diesel genset	Bio diesel genset	Hydrogen/LPG/LNG genset	Fuel Cells	Absorption heat pump	Electric buffer	Thermal buffer
Power	++	≈ 2.2 kW	++	+	++	++	+	-	- -
Autonomy	- -	++	+	+	+	+	+	++	++
Availability (fuel source)	++	-/+	+	0	?	-/+	+	++	++
Reliability	++	++	+	+	+	?	+	++	++
Sustainability	-	+	-	+	-/+	-/+	-/+	-/+	-/+
Investment cost	++	- -	+	+	+	-	?	- -	-
Maintenance cost	++	++	-	-	-	?	+	++	++
Fuel cost	+	++	-	- -	0	-	+	+	+
Built-in	- -	- -	-	-	-	?	-	+	-

ECOFYS

Continental transport

- Main criteria
  - Power
  - Autonomy
  - Availability
- Best options
  - Diesel genset
  - Photo voltaic?
  - Fuel Cells?
  - Absorption heat pump?

	Electricity	Photo voltaic	Diesel genset	Bio diesel genset	Hydrogen/ Methanol genset	Fuel Cells	Absorption heat pump	Electric buffer	Thermal buffer
Power	++	2.2 kW	++	+	++	++	+	-	--
Autonomy	--	++	+	+	+	+	+	++	++
Availability (fuel source)	++	-/+	+	0	?	-/+	+	++	++
Reliability	++			+	+		+	++	++
Sustainability	-	+	-	+	-/+	-/+	-/+	-/+	-/+
Investment cost	++	--	+	+	+	-	?	--	-
Maintenance cost	++	++	-	-	-	?	+	++	++
Fuel cost	+	++	-	--	0	-	+	+	+
Built-in	--	--	-	-	-	?	-	+	-

ECOFYS

Choice #1 (conventional)

- On ship
  - electricity
- Off ship
  - genset
- Cost
  - Investment: 1000 $ / kW (per truck)
  - Maintenance: 1500 $ / year
  - Fuel on ship: 0.10 $ / kWh
  - Fuel on land: 0.15 $ / kWh

ECOFYS

Choice #2

- On ship
  - electricity
- Off ship
  - electric buffer + genset / fuel cell
- Extra cost
  - Fuel cell: 1000 $ / kW (per truck)
    + battery: 300 $ / kWh
  - Maintenance: ? $ / year

ECOFYS

Alternatives

- On ship
  - cooling of storage room to improve SPF
- On truck
  - extra generator on truck to supply container and electric buffer (battery)

State of the Art in Photovoltaics

Ruud van der Zanden
Shell solar Energy BV
Technology- & Product development

The Shell Solar Solar Panel

Sandwich:

- Glass (thermally tempered), 3-4 mm
- Rubber, UV-resistance
- Solar cells
- Glassfiber for reinforcement
- Rearside foil: PVF/Al/PET

Reliability and Environmental testing

IEC61215:

- Damp Heat test: 1000h 85 °C/85% RH
- Temperature cycling test: -40 ↔ +85 °C
- Hail impact test: ∅ 25 mm, 23 m/s, 11 impact locations
- Mechanical load test: 2400 Pa (=windforce 13 (800 Pa) with safety factor 3)
- Twist test: Deformation angle 1.2 °

Reliability and Environmental testing

Salt Spray test IEC68

- Spraying of salty water ([NaCl]=90 g/l) of about 85 °C

Water Proof Test

- Diluting of panels in tap-water of 85 °C

Electrical Properties

- Power = 50 W
- Voltage = 17 V
- Current = 3 A
- Efficiency = 13.5%

Task 4

ATO

CEET 2005 *task 4, introduction*

- Development of slow-release systems for *green* chemicals
- Input per phase
  - 1: 6 months, 04 man year
  - 2: 18 months, 055 man year
  - 3: 12 months, 0.65 man year
- Partners in task 4
  - Transicold
  - P&O Nedlloyd
  - ATO-DLO
    - task 5 (monitoring systems)
    - task 7 (system control)

CEET 2005 *task 4*, objectives:

- The goal of task 4 is to implement the use of *green* chemicals in the climate control system of the container.
- In principle this is an energy efficient means of preventing deterioration of the perishable product, since the requirements for temperature and humidity control can become less strict.

CEET 2005 *task 4*, workpackage

- task 4.1
  - selection of green chemicals for differentproducts
- task 4.2
  - *In situ* activity of selected plantderived antifungal compounds
- task 4.3
  - phytobicity of the selected antifungal compounds
- task 4.4
  - innovatiove technology for application and distribution oânntifungal volatiles

CEET 2005, *task 4*

Deliverables task 4

- Task 4.1
  - Selection of (product derived) aromatic volatileswith antifungal activity against the major postharvestpathogens of apple, tomato and chicory
- Task 4.2
  - The *in situ* screening will provide information about the efficacy of the selected antifungal volatileswhen applied on the product. The minimal dose at which full suppression of fungal spoilage occurs will be determined for three porductsat two different temperatures
- Task 4.3
  - Execution of task 4.3 will show the dosing levels at which at the selected antifungal compounds can be safely used with respect to phytoxicity
- Task 4.4
  - An injection system for green chemicals, and eventually for controlled release, will be obtained

CEET 2005, *target organisms*

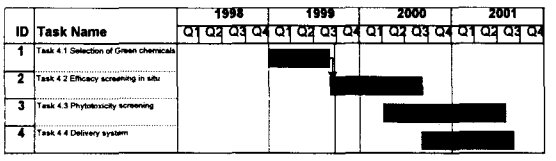
	Optimum (°C)	*Minimum* (°C)	*Maximum* (°C)
Pseudomonas marginalis	25-30	0-1	38-40
Botrytis cinerea	22-25	0-3	35-38
Penicillium expansum	20-25	0-1	
Monilinia fructigena			
Alternaria alternata	25-28	2.5-0.5	31-32
Rhizopus stolonifer	25-26	5	32-33

CEET 2005, *selection green chemicals*

	Chicory	*Tomato*	*Apple*
Carvacrol	X	X	
Thymol	X		
Trans-2-Hexenal	X	X	X
Decanal			X
Hexyl acetate			X
Ethyl hexanoat			X
Geraniol			X
Trans-2-pentenal		X	X

CEET 2005, *planning*

ato-dlo



CEET 2005, *results first year*

ato-dlo

- Screening green chemicals
- Effect of vapour on viability of spores
- Effect of vapour on mycelial growth
- Metabolism of decanal administered via gasphase
- Conclusions task 4.1

CEET 2005, *results first year*

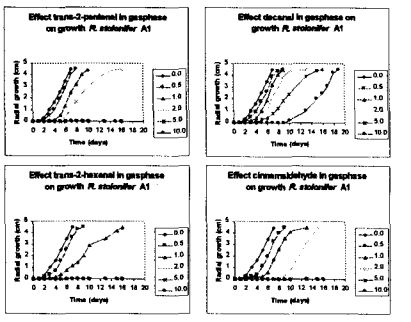
ato-dlo

Screening programme completed d.d. September 99

	Botrytis cinerea	*Rhizopus stolonifer*	*Penicillium expansum*
E-2-hexenal	X	X	X
E-2-pentenal	X	X	X
Decanal	X	X	X
Cinnamaldehyde		X	
Geraniol	X		X
Thymol			
Carvacrol			
Ethylhexanoate	X		X
Hexylacetate	X		X

CEET 2005, *results first year*

ato-dlo



CEET 2005, *results first year, Rhizopus*

ato-dlo

De vertraging op de ontkieming en de lineaire groei van *R. stolonifer* A1 t.o.v. de controle bij behandeling met verschillende concentraties etherische oliën

Olie	Volume (µl)	Ontkieming (dagen)	Lineaire groei (dagen)
trans-2-Hexenal	0.5	0	1
	1	0	2
	2	> 23	> 23
	5	> 23	> 23
	10	> 23	> 23
Cinnamaldehyde	0.5	0	2
	1	1	3
	2	6	7
	5	> 23	> 23
	10	> 23	> 23
trans-2-pentenal	0.5	0	1
	1	1	2.5
	2	2	3
	5	> 23	> 23
	10	> 23	> 23
Decanal	0.5	0	1
	1	0	2
	2	1	2.5
	5	3	3
	10	8	9

CEET 2005, *results first year, Botrytis*

ato-dlo

De vertraging op de ontkieming en de lineaire groei van *B. cinerea*A2 t.o.v. de controle bij behandeling met verschillende concentraties etherische oliën

Olie	Volume (µl)	Ontkieming (dagen)	Lineaire groei (dagen)
trans-2-Hexenal	0.5	7	7
	1	> 23	> 23
	2	> 23	> 23
	5	> 23	> 23
	10	> 23	> 23
Decanal	0.5	> 23	> 23
	1	> 23	> 23
	2	> 23	> 23
	5	> 23	> 23
	10	> 23	> 23
trans-2-pentenal	0.5	2	2
	1	4	5
	2	> 23	> 23
	5	> 23	> 23
	10	> 23	> 23
Geraniol	0.5	0	1
	1	0	2
	2	0	3
	5	> 23	> 23
	10	> 23	> 23
Ethyl hexanoate	0.5	0	1
	1	0	0
	2	0	1
	5	3	8
	10	> 23	> 23
Hexyl acetate	0.5	0	1
	1	0	2
	2	0	2.5
	5	6	11
	10	> 23	> 23

CEET 2005, *results first year, Penicillium*

Stof	Volume (µl)	Ontkieming (dagen)	Lineaire groei (dagen)
Decanal	0.5	1	-
	1	> 23	-
	2	> 23	-
	5	> 23	-
	10	> 23	-
2-trans-2-hexenal	0.5	2	-
	1	4	-
	2	> 23	-
	5	> 23	-
	10	> 23	-
trans-2-pentenal	0.5	6	-
	1	2	-
	2	4	-
	5	> 23	-
	10	> 23	-
Geraniol	0.5	0	-
	1	2	-
	2	2	-
	5	17	-
	10	> 23	-
Hexyl acetaat	0.5	0	-
	1	0	-
	2	0	-
	5	2	-
	10	10	-
Ethyl hexanoaat	0.5	0	-
	1	0	-
	2	0	-
	5	0	-
	10	1	-

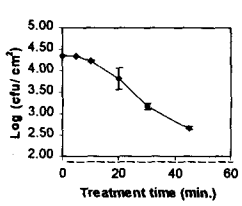
CEET 2005, *results first year*

Conclusions screening green chemicals

- *Botrytis cinerea*;
  - **decanal=E-2-hexenal>E-2pentenal>geraniol>hexylacetate>ethylhexanoate**
- *Rhizpus stolonifer;*
  - **E-2-hexenal>cinnamaldehyde>E-2pentenal>decanal**
- *Penicillium expansum*
  - **decanal=E-2-hexenal>E-2pentenal>geraniol>hexylacetate>ethylhexanoate**

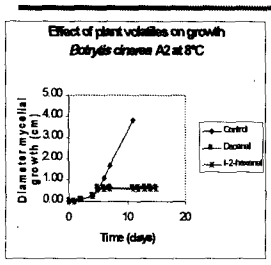
CEET 2005, *results first year*

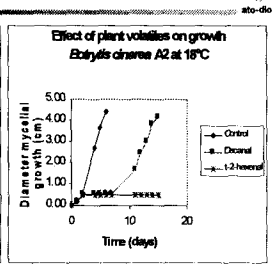
Effect of decanal in the gas phase on the viability of spores of *Botrytis cinerea* A2 at 18°C



- Decanal reduces the viable count of Botrytis cinerea conidia
- Decimal reduction is obtained in 20 min exposure to decanal vapor

CEET 2005, *results first year*

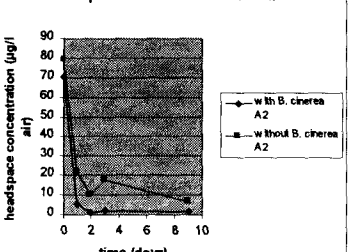




- Decanal and E-2-hexenal inhibit radial growth of mycelial mat *Botrytis*
- At 18°C complete inhibition by decanal lasts only 8 days

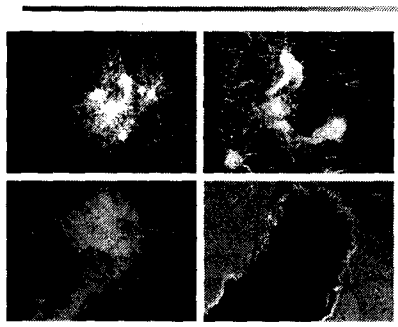
CEET 2005, *results first year*

Headspace concentration decanal



- Headspace concentration decanal drops in two days to 12% of initial value
  - **chemical oxidation**
- In the presence of *B. cinerea* the headspace concentration drops to almost zero two days
  - **bio-conversion**

CEET 2005, *results first year*



- *Rhizopus* has a reduced sensitivity towards decanal
- The fungus forms special survival structures in the presence of decanal which may help the organism to overcome this stress-factor

CEET 2005, task 4 *conclusions*

- Decanal, E-2-hexenal and E-2-pentenal are the most potent antifungal agents for postharvest control of *Penicillium expansum*, *Rhizopus stolonifer* and *Botrytis cinerea*
- Decanal in the headspace is sensitive for chemical and biological degradation
- Decanal induces the formation of survival structures on *Rhizopus stolonifer*

CEET 2005, task 4 *planning phase 2*

- Screening of natural antimicrobials on *Pseudomonas marginalis*, *Monilinia fructigena* and *Alternaria alternata*
- *In situ* activity testing of selected plant derived antifungal compounds

Task 5

ATO

Phase 2: Tasks

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Main tasks

- CO_2/O_2 sensor: product environment
- Volatiles detection: signs of product deterioration, anaerobiosis, ripening or levels of green chemicals
- Particulates detector: presence of fungal spores

Subsiduary task

- Heat production in products: instrumentation to provide data for models

Task 1: CO_2 and O_2 sensor

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Two detectors in one housing

- CO_2 : infrared absorption, sensitivity 0-5%
- O_2: singlet/triplet lifetime measurement,

  any desired sensitivity

Task 2: Volatiles

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Volatiles detection: signs of product deterioration, anaerobiosis, ripening or levels of green chemicals

- ethanol/ethylene: heated metal oxide sensor under development, required increase of sensitivity: 100 fold
- microbalance sensors: adsorption of volatiles onto coated SAW or quartz crystal, changes in resonance frequency, choice of metallated substituted tetraphenylporphyrins and phthalocyanines as coatings
- characterisation and analysis of signals

Task 3: Particulates & Task 4: Heat production

ato-dlo

Particulates indicative of fungal spores, indicating pathogen or saprotroph attack, timing the use of green chemicals

- detection of light scatering by particulates when passing an LED or laser diode light beam
- characterisation and analysis of signals

Measurement of heat production of products in different environments to support models

- calorimitry combined with measurements of gas composition

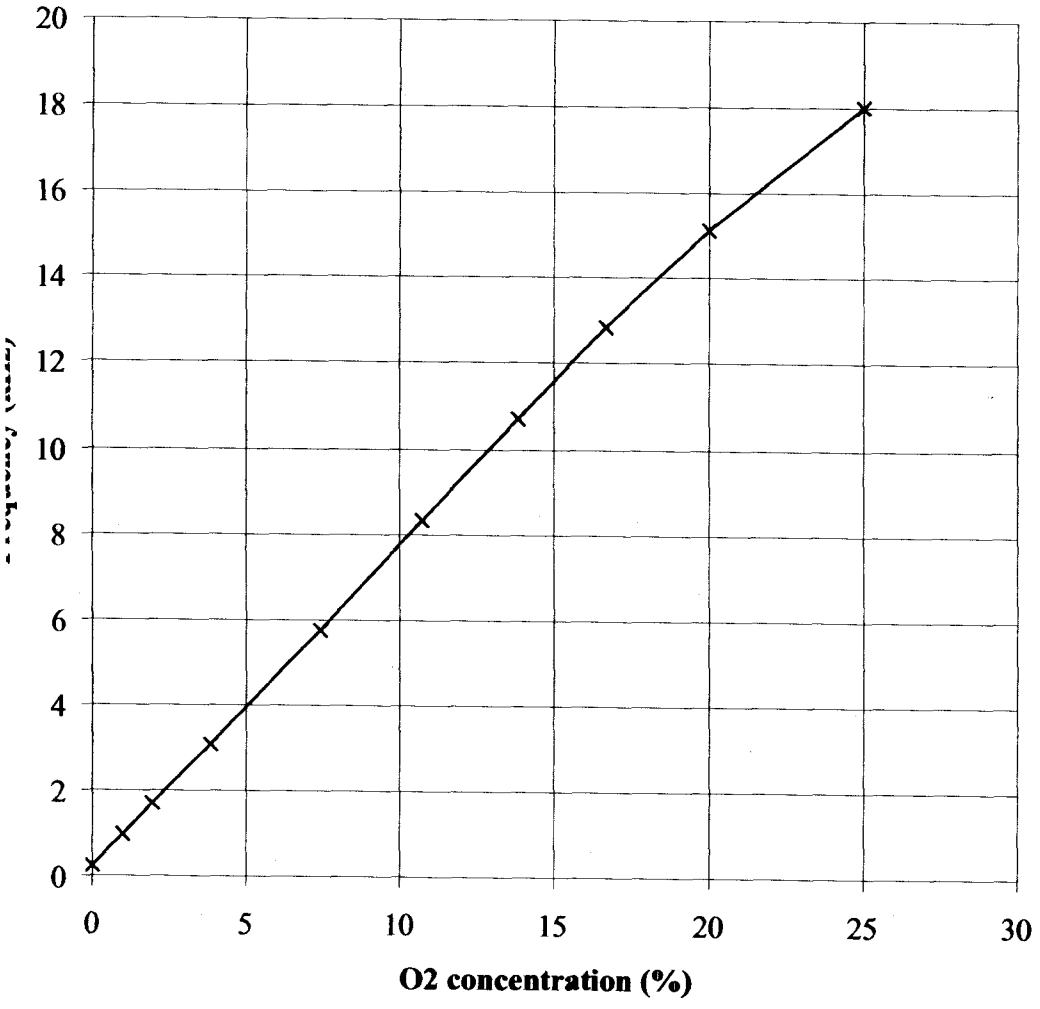
CO_2 sensor available commercially "made-up"; Ca-Tec

O_2 sensor: dye triplet lifetime measurement being developed "in-house"

Ethanol sensors from Italy via an EU project

Fuel cell sensors using Nafion electrodes - look promising: selectivity and sensitivity increased by means of selective absorbents

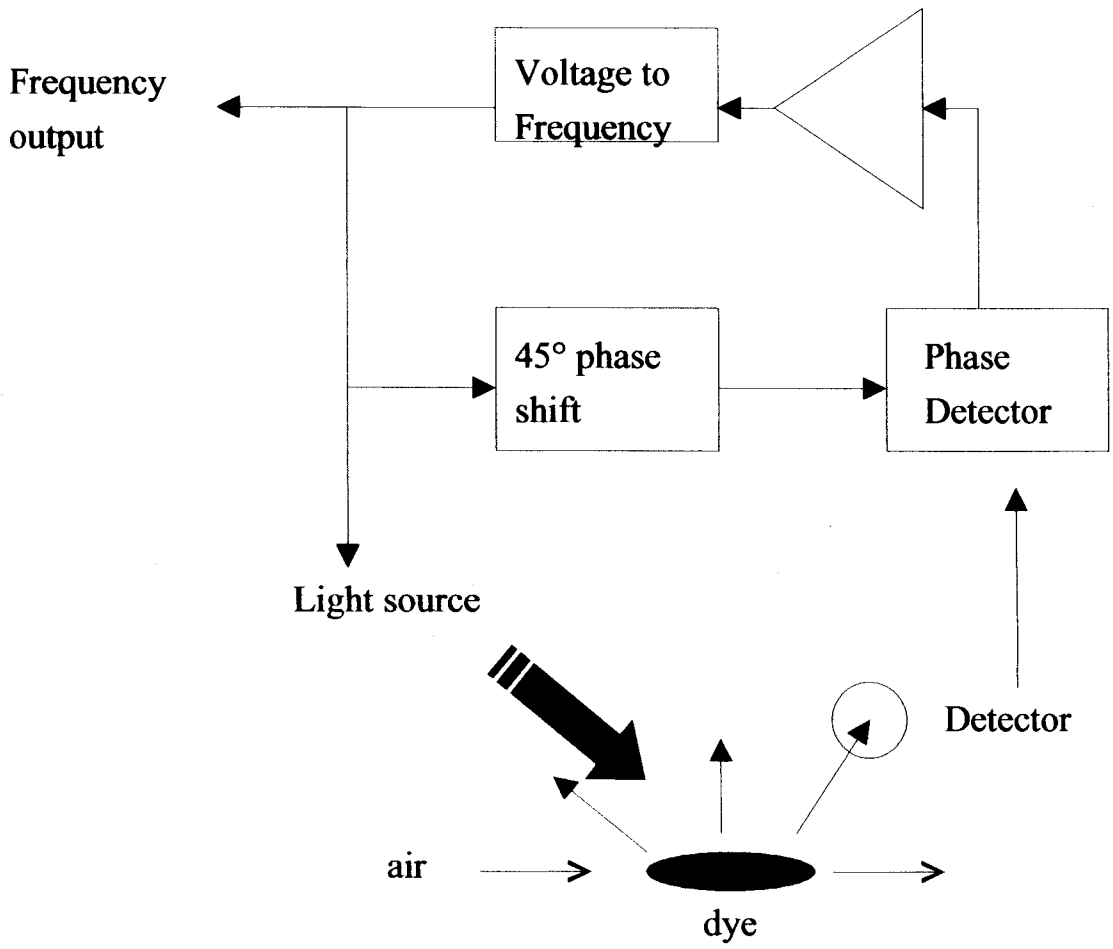
'gen sensor linearity

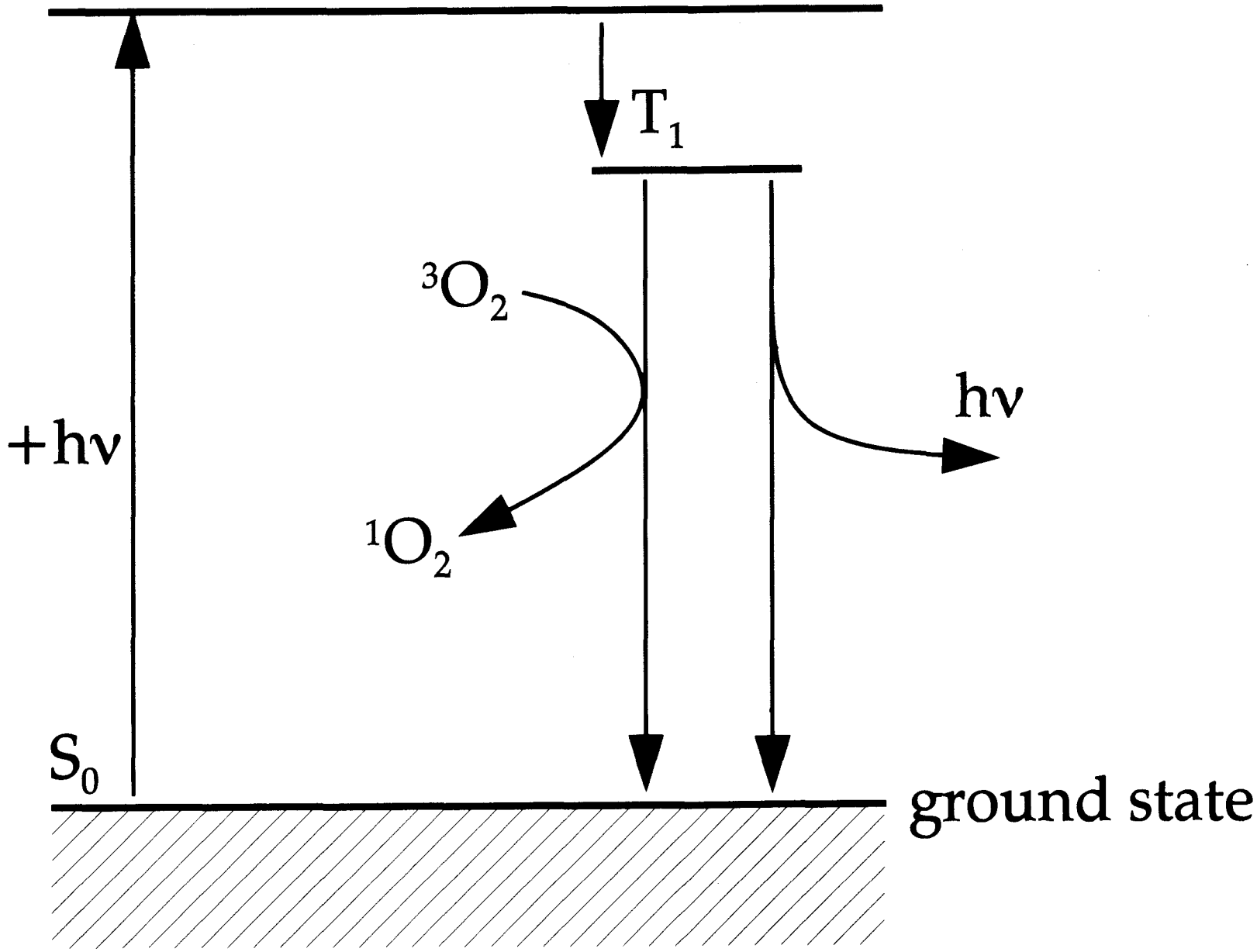


gen sensor - detection system

locked loop

ency varies while maintaining constant phase shift




T_1
$^3O_2$
$h\nu$
$+h\nu$
$^1O_2$
S_0
ground state

Microbalance volatile detection system:

electronics and software for testing built,

porphyrins and phthalocyanines obtained,

next - start coating experiments.

Task 6

ATO
P&O Nedlloyd
Eteca B.V.

Task 6: developing a cost benefit model for the CEET container

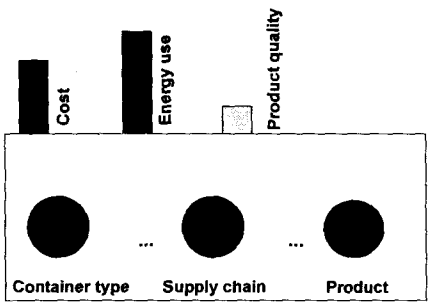
Seth Tromp & Erik de Jonge
Dept. of Packaging, Transport and Logistics
ATO

Future decision problems

- **Market implementation of the container**
  - Who is interested in being the container owner? (E.g. shipping company, third party, shipper, retailer, consortium of interested parties)
  - How many containers to buy?
  - Where to locate them and how to set up a planning?
  - Which price setting?
  - ...
- **Shipper**
  - Which type of container to use for a certain cargo?

A cost/benefit model may help to solve these problems.

Cost benefit model



Model functionality

- **To quantify the cost, quality loss, and energy use when using a variable type of container along a supply chain.**
- **Performance indicators**
  - Cost
  - Product quality loss
  - Energy use
- **Model input**
  - Supply chain
  - Container type
  - Type and volume of product

Modeling approach

- **A supply chain will be modeled by describing its activities (stuffing and stripping, handling, transport, maintenance, planning,...). These activities can be different when using different types of containers.**
- **For each activity its performance is quantified on the indicators cost, quality loss and energy use. This performance is expected to be different for different types of containers.**

Fictive output with respect to cost

Container type	Truck transport to port	Stuffing at shipper	Container Transport to port	Stuffing at the port	...
Reefer	40	x	x	8	...
CEET	x	10	60	x	...
...					

However, quantifying the benefits is not easy

- **For example, a higher product quality after distribution may induce**
  - less waste
  - a higher price
  - less claims
  - opportunities for price speculation
  - more flexibility in distribution
- **These benefits are difficult to quantify**

Future approach

- **To use the proposed model as a framework that will be filled in more and more during the project**
- **To start with focus on the performance indicator 'cost':**
  - Operating cost of different types of container (Reefer, CA, CEET, ...)
  - Cost on the primary activities in the chain: stuffing, transporting, handling, stripping,...
- **To work in close cooperation with P&O and Eteca**

The Agro-container of the 21st century

CEET 2005
Task 6

28-10-99 1

Presentation 27/09/99

- Task 6 - main participants
- *Task 6 - key issues, objectives and deliverables and approach*
- *Some facts and figures*

28-10-99 2

Task 6 - main participants

- P&ONedlloyd
- ATO-DLO
- Erasmus University Rotterdam through Eteca bv

28-10-99 3

Presentation 27/09/99

- *Task 6 - main participants*
- Task 6 - key issues, objectives and deliverables and approach
- *Some facts and figures*

28-10-99 4

Task 6 - key issues

- Chain optimization
- Market developments and opportunities

28-10-99 5

Task 6 - objectives/deliverables

- Quantitative analysis of the logistical chain
- Container design versus requirements of the chain concept

28-10-99 6

Task 6 - objectives/deliverables

- Qualitative analysis of the reefer industry
- Container design versus economical and other market criteria
- Marketing and implementation strategies

Task 6 - approach

- Market analysis
- Marketing methodology - client profiles
- Marketing methodology - concepts
- Feasibility study
- Formulation of commercial strategy

Presentation 27/09/99

- *Task 6 - main participants*
- *Task 6 - key issues, objectives and deliverables and approach*
- Some facts and figures

'2005'

'Knowing where you are heading means knowing where you have come from'

P&O Nedlloyd annual report 1998

Some facts and figures

- Commodities
- Trade lanes
- Competition
- External observations

Market trends

- Freezers, MA and CA units
- Reefer container is taking over
- FOB conditions
- product diversification
- door to door is required

CEET2005
Task 6 - Reefer Project Group

Project Leader

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28-10-99 13

Task 7

ATO

Development of the Supervisory Optimising Control algorithms Task 7 CEET 2005

Augustus 1999

Contents

- Introduction
- Total SOC-system
  - global structure
  - detailed structure main module
  - objectives control algorithms
- Planning
- Input from other tasks

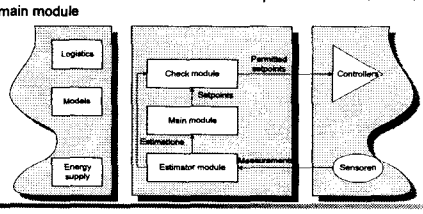
Introduction

- Project goals
  - optimal quality maintenance
  - substantial energy savings
  - sustainable energy supply
- Task 7 objective

  Development of a Model-based Control Algorithm for refrigerated container transport of agro-products

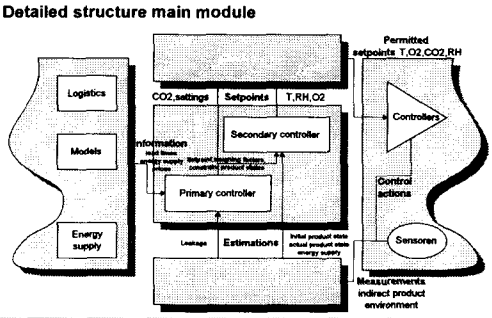
Total structure SOC-system

- Global structure
  - Main module: Economical optimisation of the transport process with respect to product quality and energy usage
  - Check module: Check calculated setpoints and assumptions for main module
  - Estimator module: Measure and calculate parameters and states for main module



Total structure SOC-system

- Detailed structure main module



Total structure SOC-system

- Objective primary control algorithm
  - optimal economical efficiency of the overall transport process (long-term)

$$J = P(Q)\,M - \int_{t0}^{tf} L(c,x,u,v,t)\,dt$$

  - inputs: lead times, energy supply, nominal weather, product prices
  - outputs: quality setpoints, additional settings local controllers
- Objective secondary control algorithm
  - minimise short-term energy usage with acceptable inhomogenity and follow quality setpoint

$$J = \int_{t}^{t+\Delta t} (W_r\,(actual\ value - quality\ setpoint) - L(c,x,u,v,t) - W_i\,\Delta c)\,dt$$

$$\dot{F} \le \dot{F}_{max}$$

$$\dot{R}_{min} \le \dot{R} \le \dot{R}_{max}$$

  - inputs: quality setpoints, weighing factors, measurements (quality and energy)
  - outputs: setpoints local controllers

Planning SOC-system

- **Part 1: Preparation and global SOC-system structure development** **end 31-5-99**
  - Preparation
  - Development of global structure of the SOC-system
  - Simulation with the SOC-system structure
- **Part 2: Conditioning of climate and testing the secondary controller algorithms** **end 31-5-00**
  - Preparation of the available models
  - Development of final structure of the SOC-system
  - Development and testing of secondary control algorithms
- **Part 3: CA-control and implementation in a container** **end 30-9-01**
  - Preparation of available models
  - Development of SOC-system
  - Implementation and testing of the SOC-system

Input from other tasks

- **Task 1 (product):**
  product quality model for the three products types
- **Task 2 (models/controller hardware):**
  models of container climate, refrigerating unit and CA-unit
- **Task 3 (energy system):**
  Model of energy supply system
- **Task 4 (green chemicals):**
  ?
- **Task 5 (sensors):**
  cheap, reliable, free-of-maintenance sensors (O_2, CO_2, calorimeter)
- **Task 6 (marketing/logistics):**
  knowledge of trip path and duration