

# Dynamic Simulation of Grain Storage Facilities

Part # 1

Grain Facility Library Development

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**By**

**Dr. Luís César da Silva**



# Luís César da Silva

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- Born in Viçosa – Minas Gerais State
- Brazil





## Education

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- **B.S. Agricultural Engineering** July/1985  
Federal University of Viçosa - Brazil
- **M. S. Agricultural Engineering**, July/1989  
Federal University of Viçosa - Brazil
- **Ph.D, Agricultural Engineering** March/2002  
Federal University of Viçosa – Brazil  
& Kansas State University, Manhattan, KS



# Work Experience

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## **West Paraná State University – UNIOESTE**

- Auxiliary Professor, 1986 -1990
- Assistant Professor, 1990-2002
- Agricultural Engineering Department Head, 1992-1997
- Adjunct Professor, 2002-2004

## **Federal University of Espirito Santo – UFES**

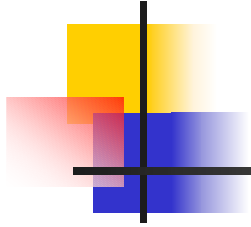
- Adjunct Professor, since 2005



# Ph. D. Thesis - Advisory Committee

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- **Daniel M. Queiroz**, Depart. of Agricultural Engineering, UFV, Ph. D.
- **Rolando A. Flores**, Kansas State University, Ph. D.
- **Evandro C. Melo**, Depart. of Agricultural Engineering, UFV, D. S.
- **Carlos A. B. Silva**, Depart.of Food Technology, UFV, Ph. D.



# Introduction

# What is simulation?



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- Simulation is the operation of a developed model, which main purposes are:
  - (a) to guide the decision process,
  - (b) to carry on analyses and evaluations of systems, and
  - (c) to define solutions for improving a system performance.

(Monsef 1997, Neelamkavil 1987, Maria 1997).



# What is System?

(According to Researches Operations Fundaments)

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- System is *“any sorted group of objects that perform together or inter-work in other to reach one logical goal”*

(Schmidt and Taylor 1970).



# What is Grain Facility System?



Grain Storage Facility is a system designed for the appropriate receiving, cleaning, drying, storing and dispatching of grains and legumes (Flores 1988).

# What is model?

(According to Researches Operations Fundaments)


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Model may be defined as a representation of a system, which aims to describe system elements and their interrelationships.

(Neelamkavil 1987, Maria 1997).

# Computer Simulation Model Classification

(Law and Kelton 1991, Image That, Inc. 1997).



Criteria	Model Classification
Presence or Absence of Variable: <b>Time</b>	Dynamic (Yes) or Static (No)
Presence or Absence of <b>Stochastic</b> Variables	Stochastic (Yes) or Deterministic (No)
How variable <b>Time</b> is incremented	Continuous (Fixed increment value) or Discrete (Aleatory increment value)



# Computer Model - Implementation

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- **Programming Languages**

FORTRAN, COBOL, PASCAL, C, and Visual Basic

- **Simulation Languages or Simulation Packages**

GASP, SLAM, ARENA, ADA, EXTEND and @RISK

(Loza-Garay 2000, Roberts and Dessouky 1998 ).

# Extend - Characteristics



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- Commercialized by Imagine That, Inc.
- General-purpose language
- Libraries hold blocks,
- Blocks (model processes, make calculus, and plot graphics)
- *Main Libraries: Generic and Discrete Event*



# Model Implementations and Use

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## **Implementation Phases:**

- **Verification, Validation, and Testing**

## **Model Experimentation (Use)**

- (a) Sensitivity analysis
- (b) Scenarios analysis
- (c) Optimization
- (d) Monte Carlo Simulation



# Objective

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Develop mathematical models to simulate  
the dynamics of grain storage facilities.

Note: Developed model are classified as ***dynamic, stochastic and discrete.***

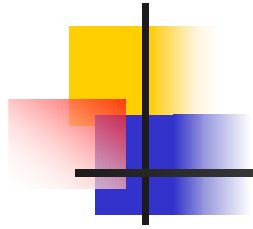


# Specific Objectives

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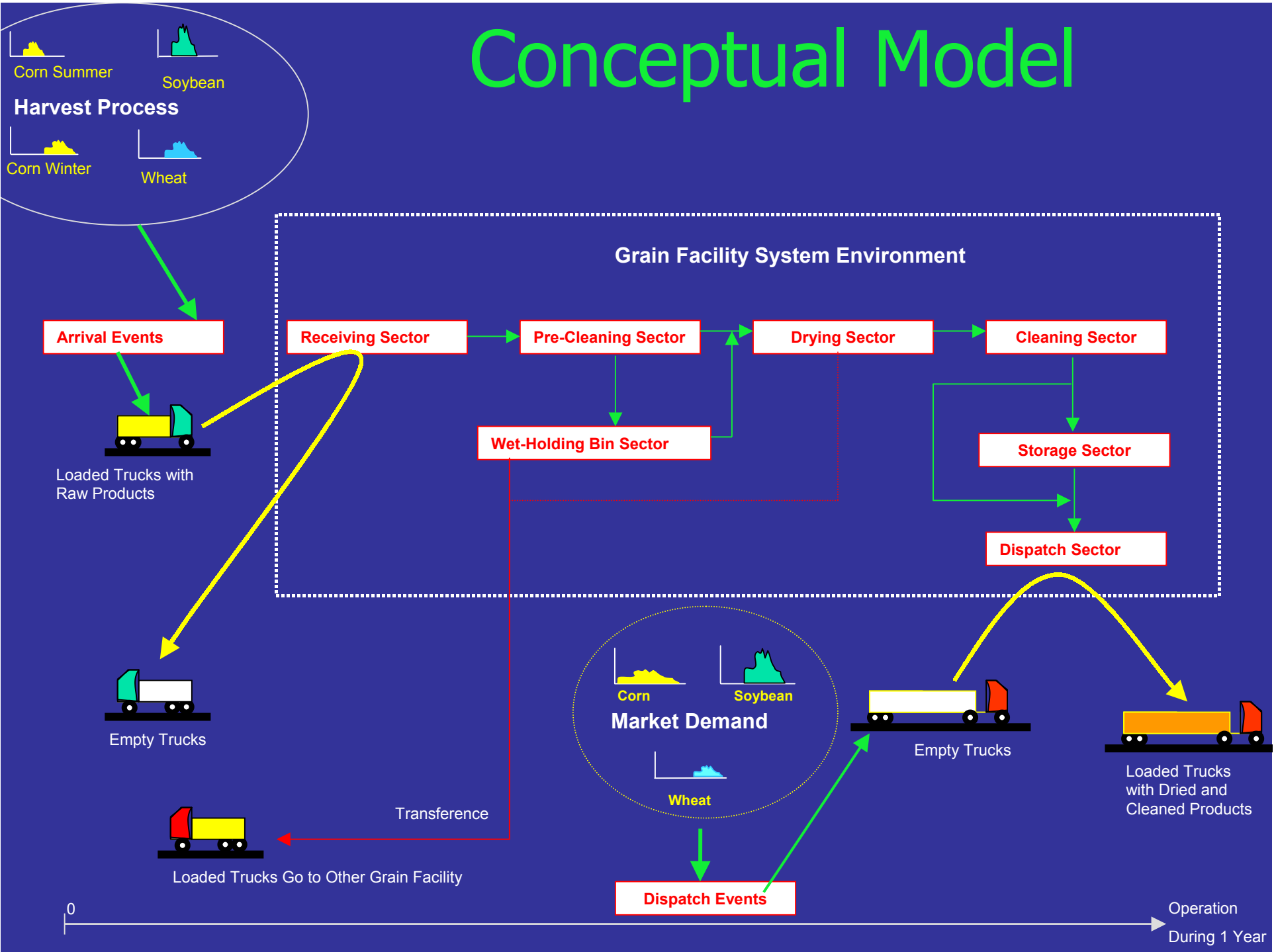
- Develop an Extend library to simulate processes and unitary operations related to grain storage facilities.
- Validate the model using real data.



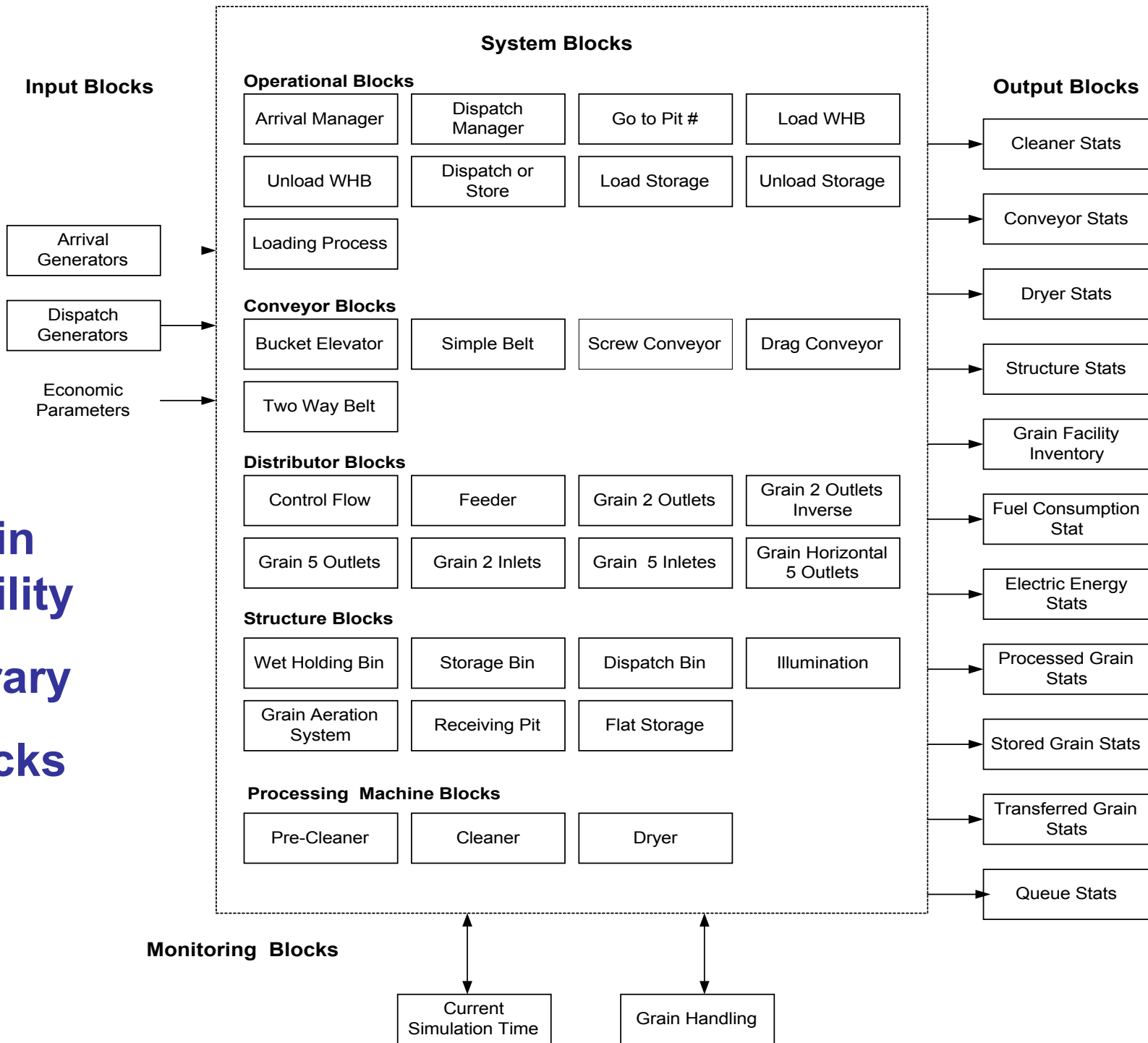


# Model Philosophy

# Conceptual Model

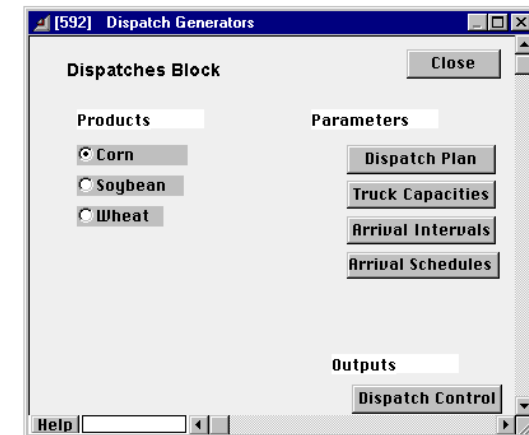
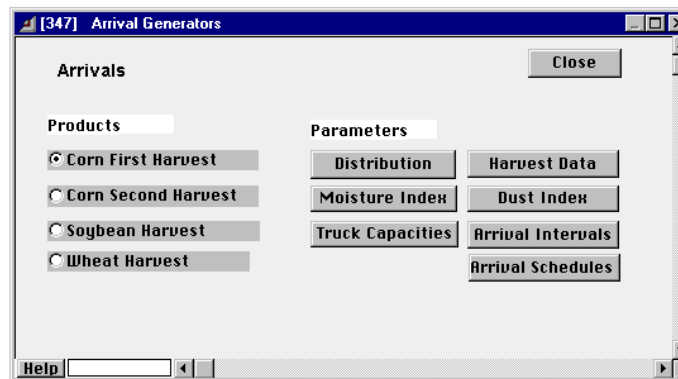
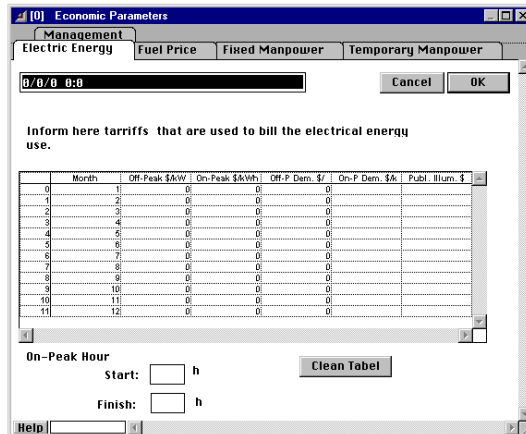
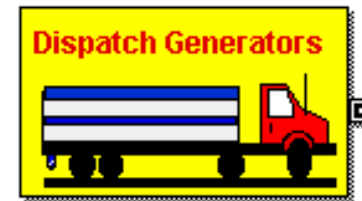


# Grain Facility Library Blocks



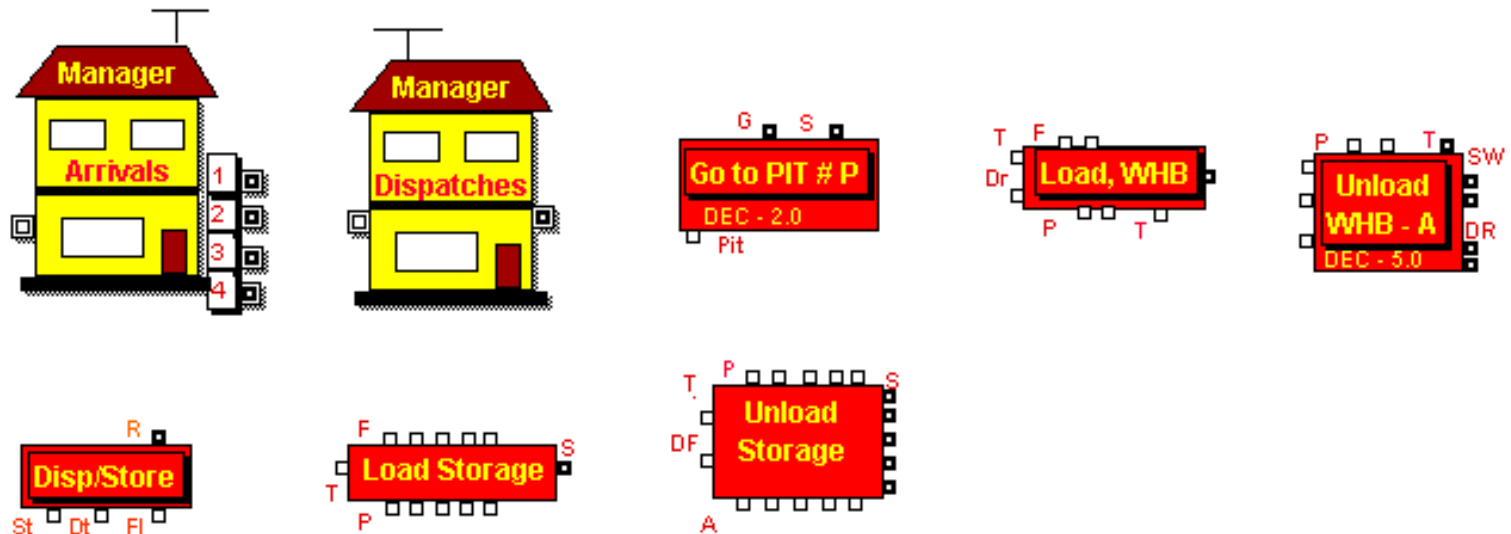
# Input Blocks

(These blocks define global system operation conditions)



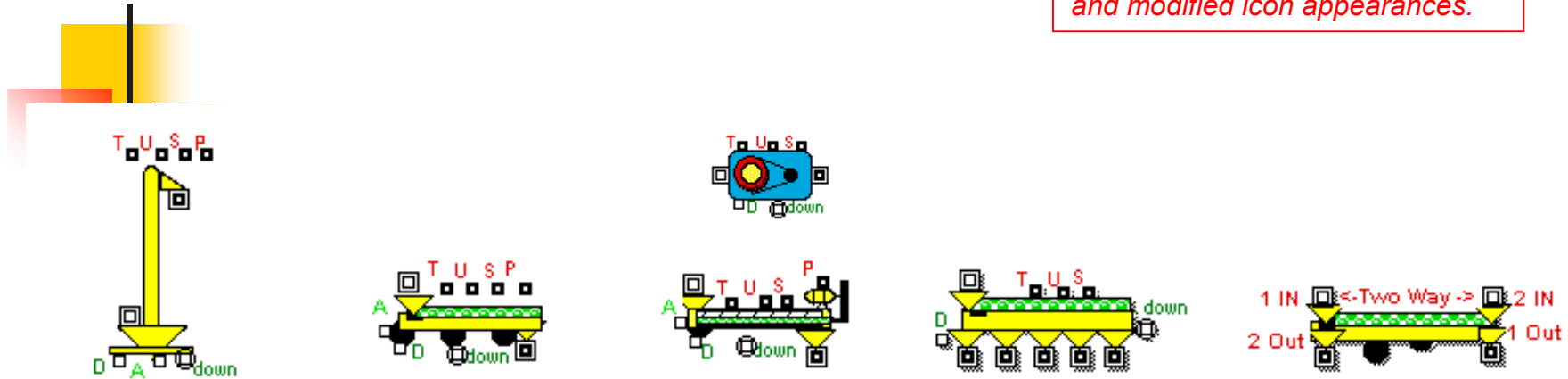
# Operational Blocks

These blocks were developed to simulate management decision-making in grain storage facilities and to specify the constraints that establish the system logic.



# Conveyor Blocks

*They were developed using the Extend™ block called Machine . It was implemented new line codes and modified icon appearances.*



**Input Window**

**Output Window**

[1142] Bucket Elevator

Characteristic | Grain Results | Shutdown | Animate | Item Stats

150 [Cancel] [OK]

Nominal Capacity (mth):

Electric Motor Power (hp):  Efficiency (%):

New Equipment Price R\$:

Maintenance & Repairs %:

Shut Down Time - min:   Consider

Utilize blocking

Boolean T connector (Energy Use is not calculated.)

Utilize down time

Help | EL-04

[1142] Bucket Elevator

Characteristic | Grain Results | Shutdown | Animate | Item Stats

150 [Cancel] [OK]

	Items	Corn	Soybean	Wheat	Total
Arrivals:	500	463.19	0.00	0.00	463.19
Dispatches:	500	463.19	0.00	0.00	463.19

Note: Values express in metric tons.

Utilization:  Total Cost:  MTH:

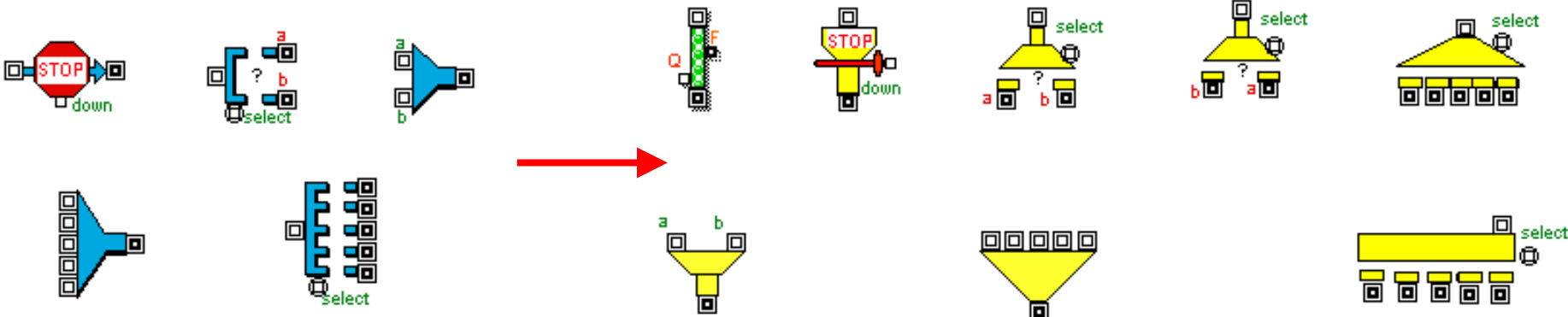
Efficiency - %:

Electric Energy	Off Peak	On Peak
Use - kWh:	<input type="text" value="125.32"/>	<input type="text" value="0.00"/>
Demand - kW:		
- Monthly Pinnacle Value :	<input type="text" value="14.17"/>	<input type="text" value="0.00"/>

Help | EL-04

# Distributor Blocks

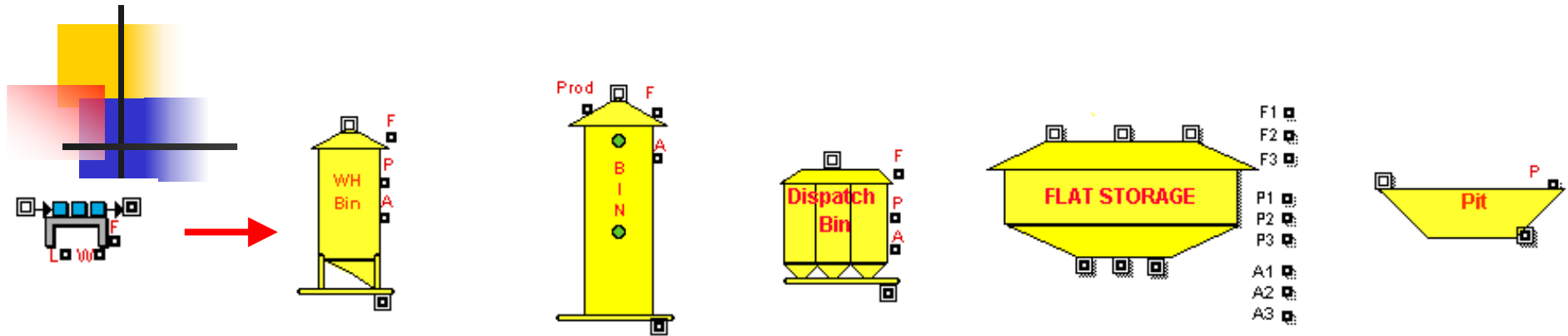
(Function: define and control grain flow direction)



The six Extend™ blocks (left) had their icon appearances modified, as shown in right side, to ease their identification in the grain storage facility models

# Structure Blocks

(They were developed using the Extend™ block called *Buffers*. It was implement new line codes and icon appearance. )



**Input Window**

[1111] Grain Bin

Characteristics | Item Stats | Animate | Grain Results

Cancel OK

Static Capacity ton :

New Structure Price R\$:

Maintenance & Repairs % :

Store:

Nominal capacity can be ultrapassed.

Unloading Equipment

Motor Power - cv

Turn On at :  % of capacity

Help | Sto Bin-01

**Output Window**

[1111] Grain Bin

Characteristics | Item Stats | Animate | Grain Results

Cancel OK

Utilization

	Corn	Soybean	Wheat	Total
Arrivals:	<input type="text" value="460.87"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="460.87"/>
Dispatches:	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>
Current Stock:	<input type="text" value="460.87"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="460.87"/>

Note: Values express in metric tons.

Stored Product:

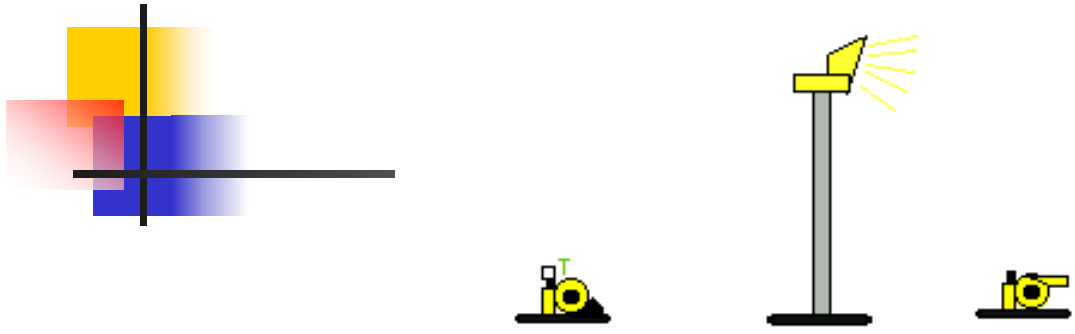
Electric Energy

	Off Peak	On Peak
Use - kWh:	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>
Demand - kW:		
- Monthly Pinnacle Value:	<input type="text" value="0"/>	<input type="text" value="0.00"/>
- Current Value:	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>

Help | Sto Bin-01



# Structure Blocks: Motor, Illumination and Grain Aeration



They were developed to simulate the electrical energy use in activities such as illumination and aeration.

Input Window

[1499][342] Illumination

Results Outside Illumination Office General Uses

Cancel OK

User needs to define other electric loads, which for example it is employed on outside illumination system and office consumption.

Outside Illumination

	Month	Power - kW	On Hour	Off Hour
0	1	0.3	7	5
1	2	0.3	7	5
2	3	0.3	7	5
3	4	0.3	7	5
4	5	0.3	7	5
5	6	0.3	7	5
6	7	0.3	7	5
7	8	0.3	7	5
8	9	0.3	7	5
9	10	0.3	7	5
10	11	0.3	7	5
11	12	0.3	7	5

Enter Table # 1

Clear Table # 1

Help ILL-01

Output Window

[1499][342] Illumination

Results Outside Illumination Office General Uses

12/1/1/1/2 0:0

Cancel OK

Electric Energy

Use - kWh: Off Peak 0.30 On Peak 0.00

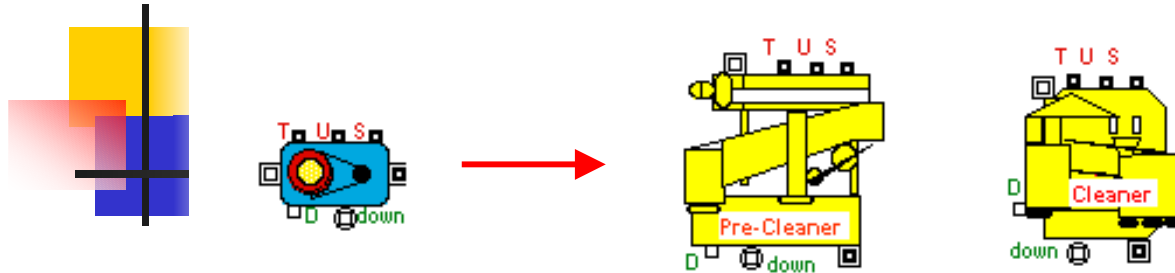
Demand - kW:

- Monthly Pinnacle Value: 0.30 0.00

- Current Value: 0.30 0.00

Help ILL-01

# Processing Machines: Pre-Cleaner and Cleaner



They were developed using the Extend™ block called Machine . It was implemented new line codes and modified icon appearances.

Input Window

[9] Pre-Cleaner

Characteristic Results Shutdown Animate Performance

Pre Cleaning Machine Cancel OK

Nominal Capacity (mth):

Electric Motor Power  Efficiency (%):

New Equipment Price R\$:

Maintenance & Repairs %:

Comments

Help PL-01

Output Window

[9] Pre-Cleaner

Characteristic Results Shutdown Animate Performance

dustDelta Cancel OK

	Items	Corn	Soybean	Wheat	Total
Arrivals:	<input type="text" value="500"/>	<input type="text" value="500.00"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="500.00"/>
Dispatches:	<input type="text" value="500"/>	<input type="text" value="497.50"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="497.50"/>
Dust Removed:		<input type="text" value="2.50"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="2.50"/>

Note: Values express in metric tons.

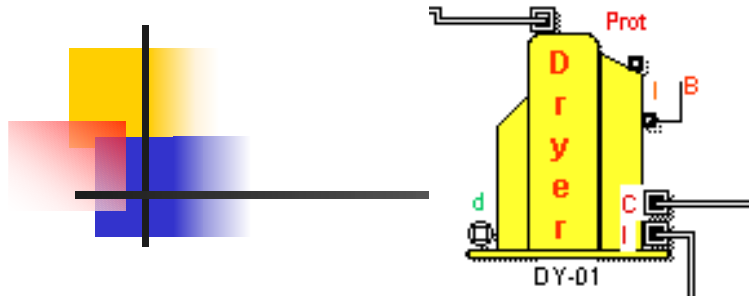
Utilization:  Total Cost:  MPH:

Foreign Material Content %: In:  Out:  Efficiency %:

Electric Energy	Off-Peak Hours	On-Peak Hours
Use - kWh:	<input type="text" value="77.43"/>	<input type="text" value="0.00"/>
Demand - kW:		
- Monthly Pinnacle Value :	<input type="text" value="5.67"/>	<input type="text" value="0.00"/>
- Current Value :	<input type="text" value="2.67"/>	<input type="text" value="0.00"/>

Help PL-01

# Processing Machines: Dryer



*The Dryer block, classified as hierarchical, was designed to simulate the drying process in mixed flow dryers. The conceptual model fundamentals is Queue Theory.*

[962] Dryer SuperNew

### Dryer

**1 - Inputs**

Dryer #:   
 Final Moisture Content % w.b.:   
 Unload System Electric Power hp:

**2 - Outputs**

Protocol:

Help | DY-01

[875][360] Dryer MonitorNew

Show Grain Stats

Dryer Performance Data -

	Corn	Soybeans	Wheat	Total
Wet Grain In - ton:	<input type="text" value="289.95"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="289.95"/>
Removed water - ton:	<input type="text" value="18.09"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="18.09"/>
Dryed Grain Out - ton:	<input type="text" value="136.18"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="136.18"/>
Fuel Use :	<input type="text" value="7.80"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="7.80"/>
Fuel Bill \$:	<input type="text" value="0.00"/>			

Real Quantity of Product Upon Drying - mt=

Dryer Utilization: 
 Items - Arrivals:

Working Hours: 
 - Departures:

- Held:

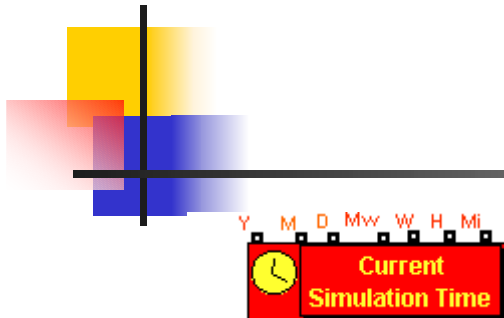
Drying:

Dryer Performance mt/h:

Help | DY-01

# Monitoring Blocks

(They were developed for collecting, processing and passing information among model blocks during simulation )



[1975][273] Current Simulation Time

Time Show Results

Year : 1

Month : 1

Week : 4

Day : 26

Week Day: Thu 5

Hour : 16 40

Cancel OK

Help

[1976][274] Grain Handling Stats

Parameters

Grain Stats Identification Item Stats Queue & Pit Report

MM/DD/YY - Hour: Jan/26/1 15:27

Update Now Cancel OK

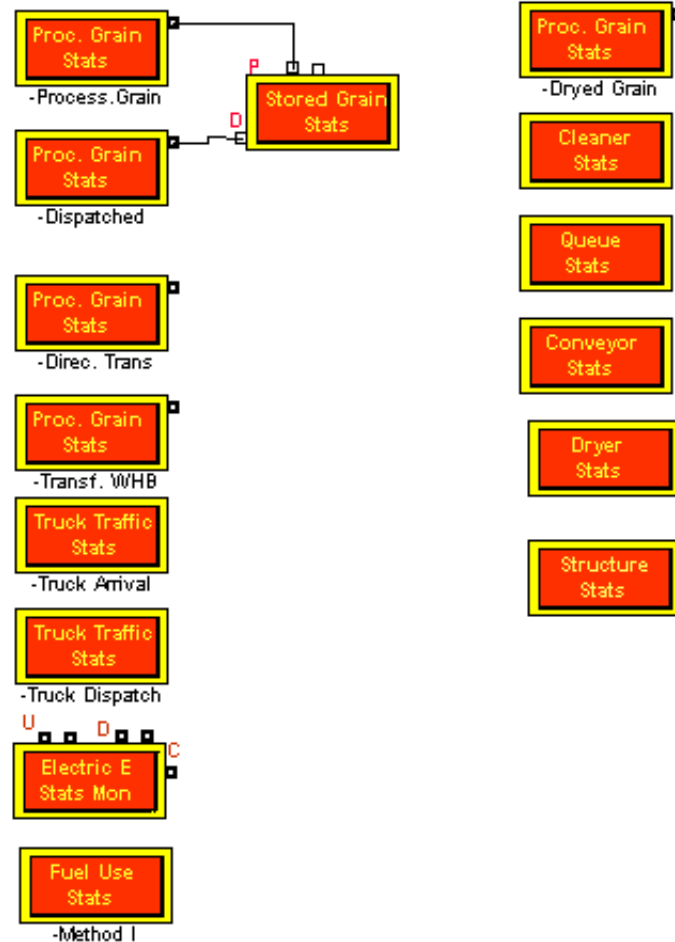
	Block	Name	Type	Metric Ton	Full	Cap. mt
0	1123	Pit-04	Com	30	0	300
1	340	Pit-03	Com	30	0	300
2	123	Pit-02	Com	180	0	300
3	1287	Pit-01	Com	19	0	300
4	3176	DY-01	Com	91	1	88
5	1846	WHB-02		0	0	300
6	1831	WHB-01		0	0	300
7	2175	FLA-01 Cell-03		0	0	5000
8	2172	FLA-01 Cell-02		0	0	8000
9	2164	FLA-01 Cell-01	Com	68.200916	0	5000
10	2711	Dis-01		0	0	80

See protocols instead Capacity

Help ULM

# Output Blocks

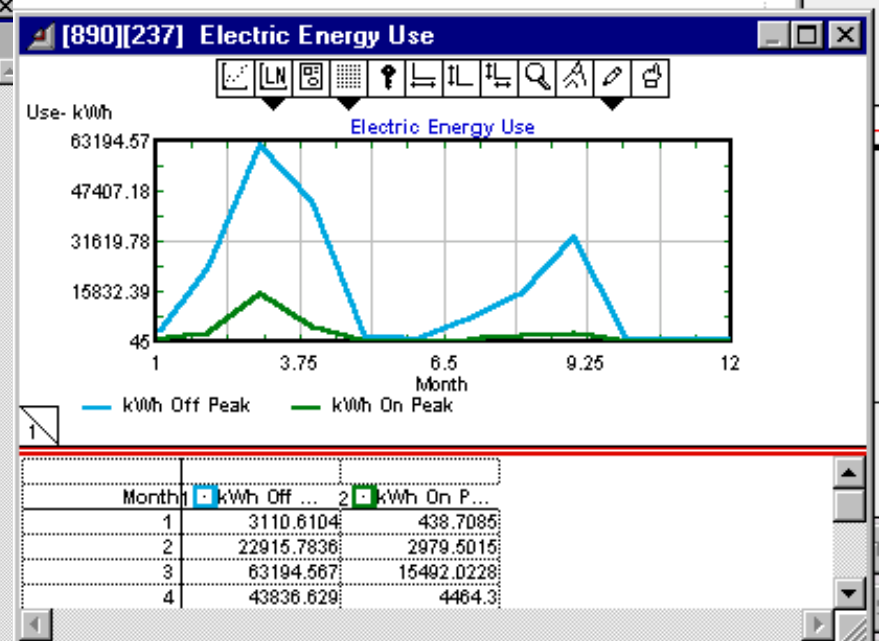
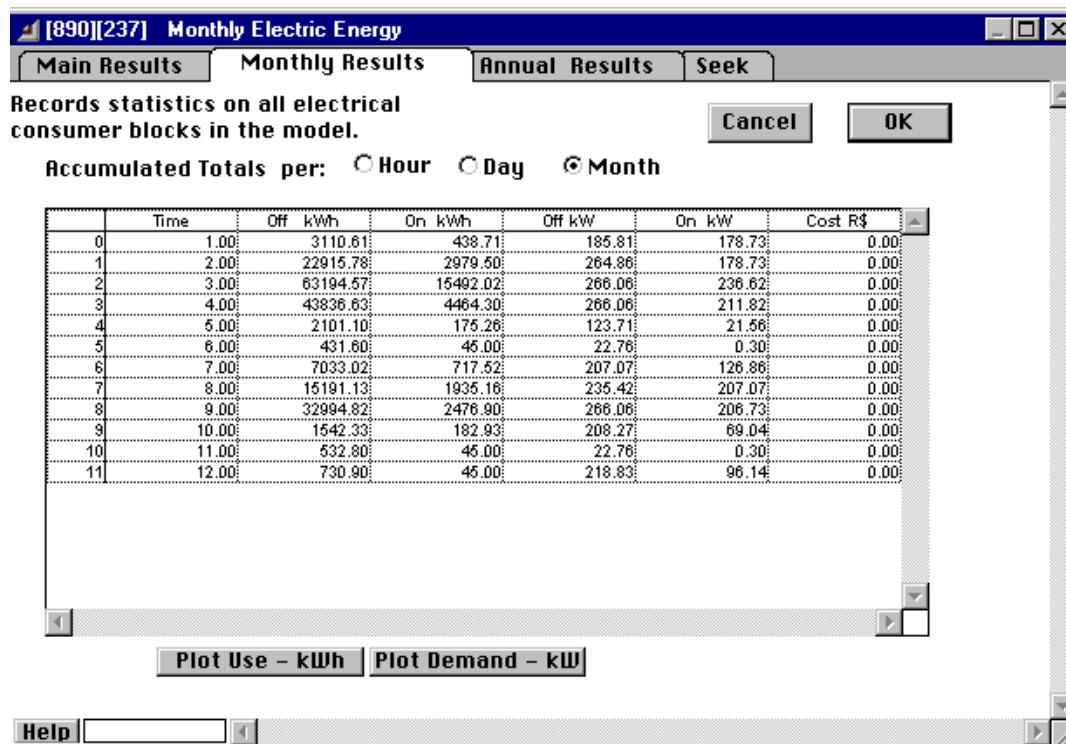
(Generates 20 Types of Reports)



*Blocks of this category were developed using "Activity Stats", an Extend™ block, and are intended to: (i) get information from specific blocks according to a frequency defined by the user, (ii) process this information, and (iii) elaborate reports in table or graphic format.*

# Output Blocks

Example: *Electric Energy Stats* simulates electrical energy metering equipment. It collects output data from blocks that simulate electrical energy use and elaborate reports .



# End – Part # 1

## Grain Facility Library Development



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**Please feel free to contact me:**

Dr. Luis Cesar da Silva

Federal University of Espírito Santo - UFES  
Agrarian Science Center - CCA

CP: #16

29.500-000 - Alegre - ES - Brazil

Voice: +55 28 3552-8918

Fax : +55 28 3552-2622

E-mail: [silvalc@agais.com](mailto:silvalc@agais.com) or [silvaluisc@yahoo.com](mailto:silvaluisc@yahoo.com)

Website: [www.agais.com](http://www.agais.com)