CSE/ECE 848 Introduction to Evolutionary Computation

Module 5, Lecture 22, Part 2b
Evolutionary Multi-Objective Optimization for Greenhouse Control

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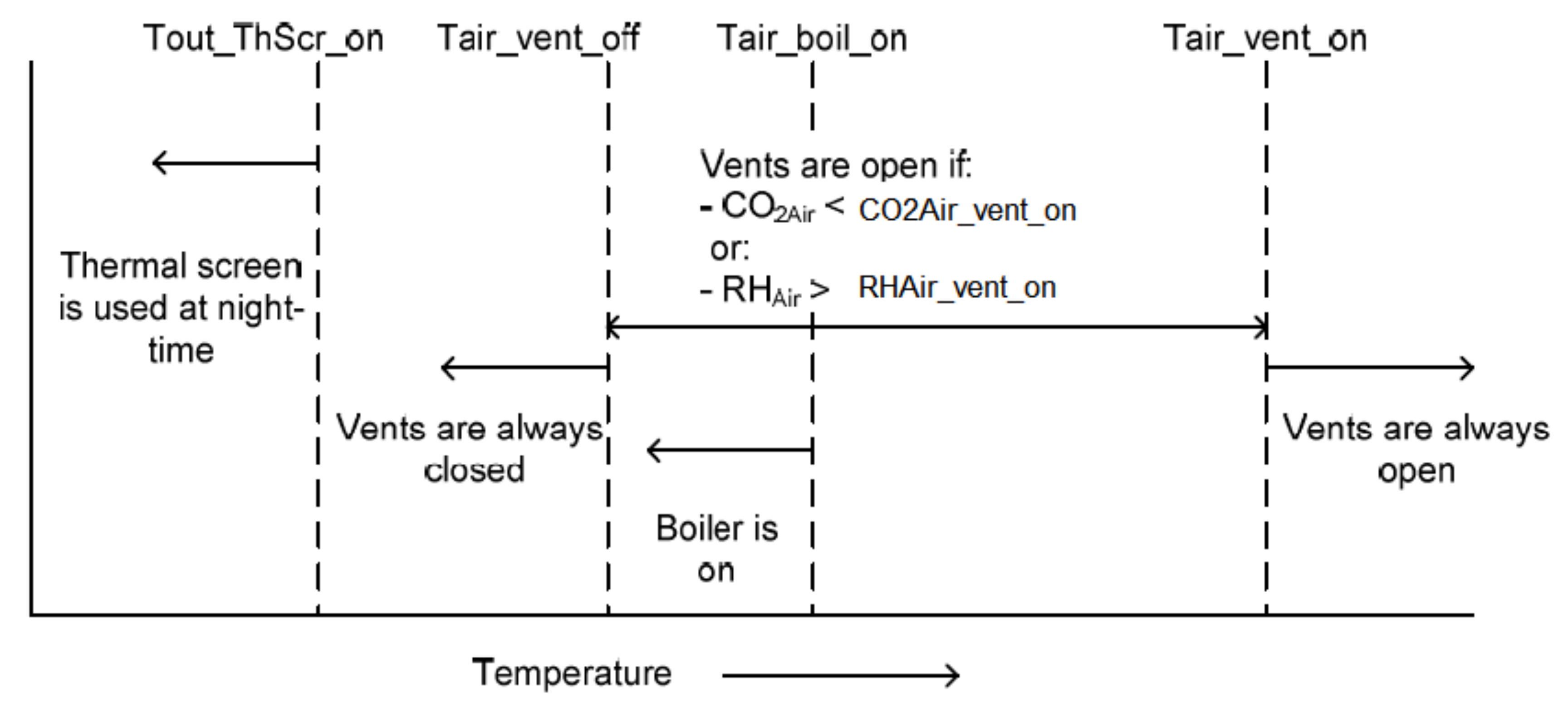
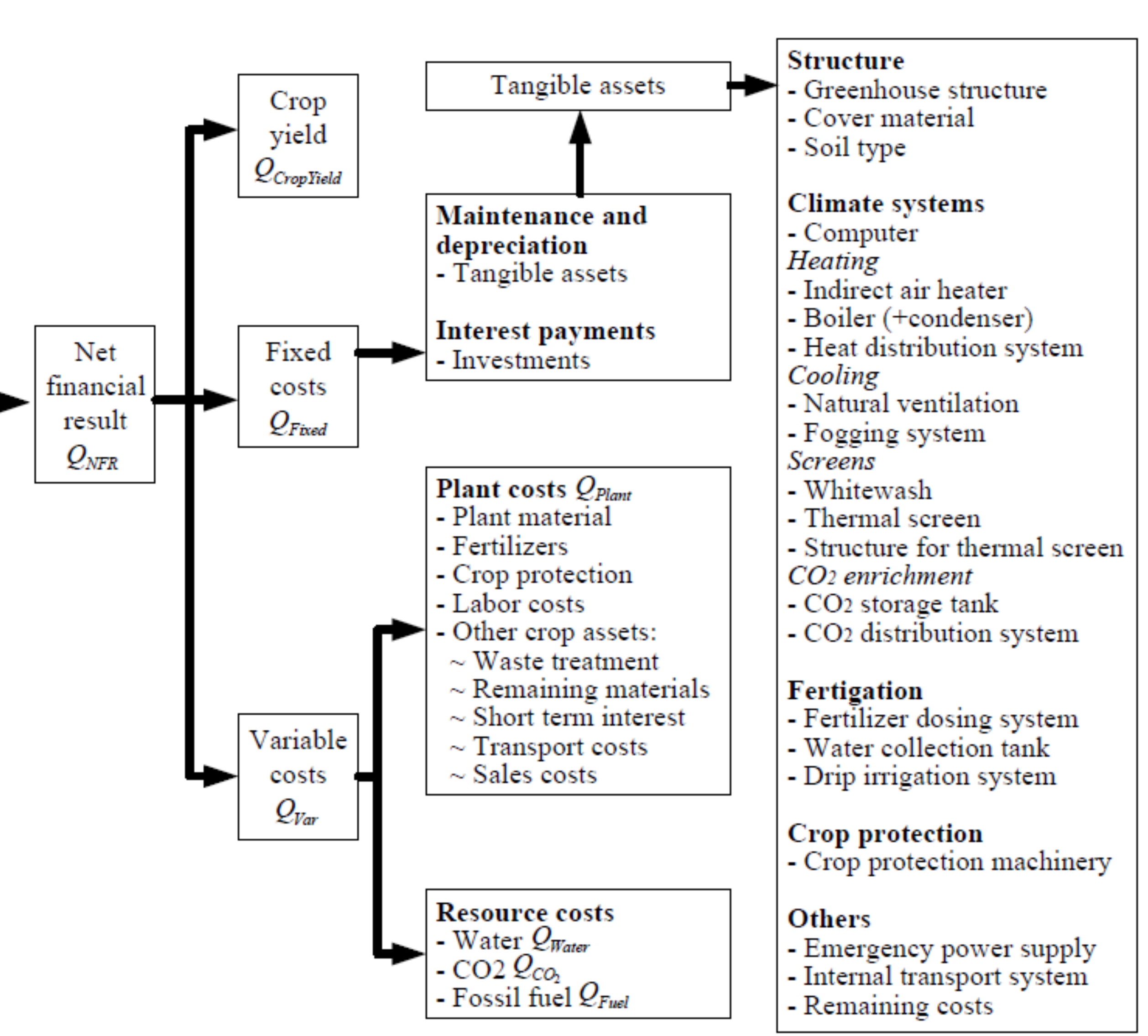
Classical Greenhouse Control Strategy



Source: Vanthoor, 2011

Economic Model



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Economic Model

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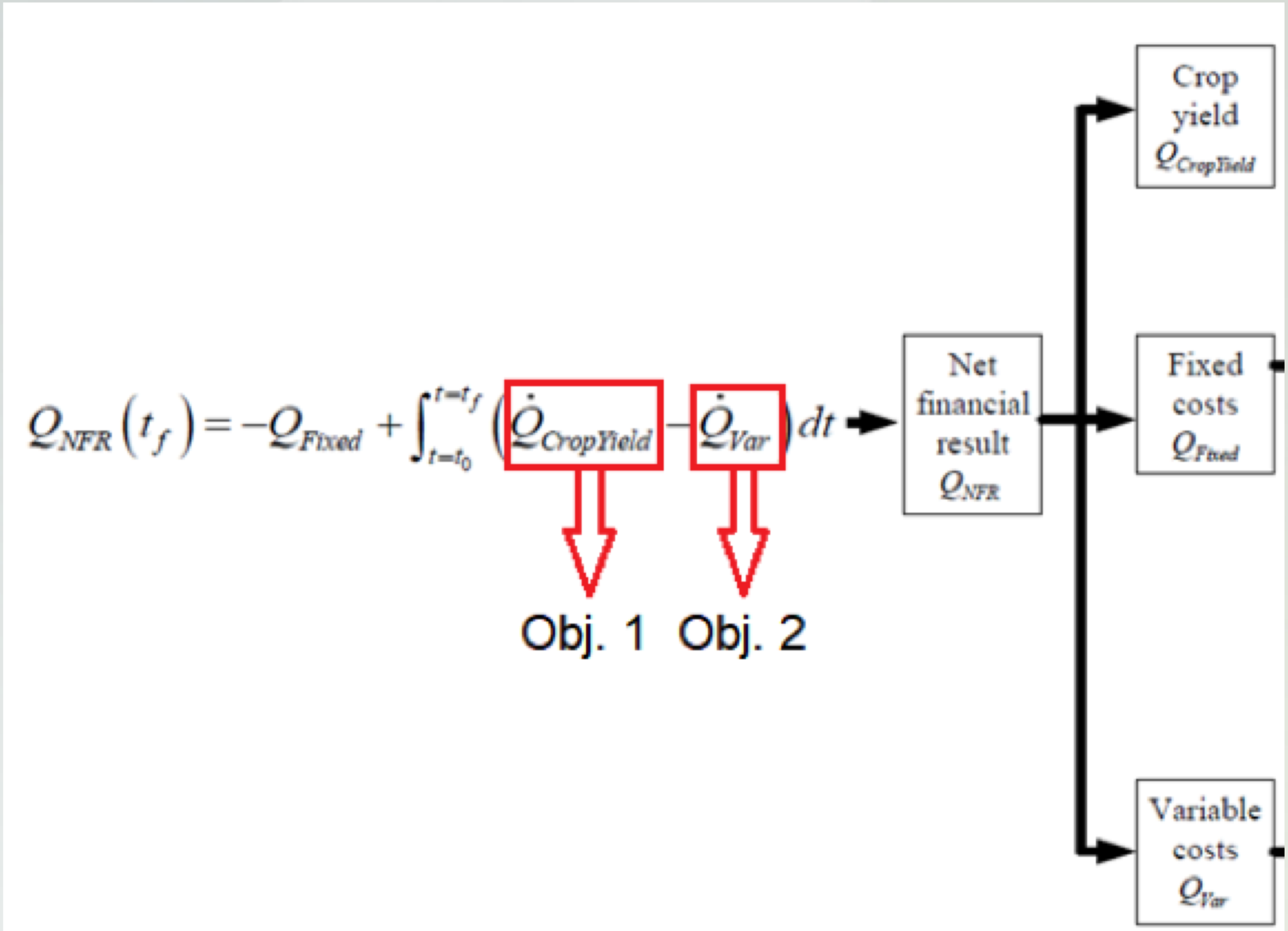


Fitness Evaluation

- Simulate multiple growing seasons for each individual
  - Choose pair of objective values with the worst net financial result (NFR)

Parameter	Value
Growing periods	August 1st, 2006 – July 1st, 2007 August 1st, 2007 – July 1st, 2008 August 1st, 2008 – July 1st, 2009
Simulation Length	334 days
Coordinates	36°48’N, 2°43’W
Height above sea level	151 meters
Greenhouse design	[Whitewash, Boiler Heating, Fogging System, CO2 injection]

Reviewing: NSGA-II Parameters

- Population size and generations based on available resources
- Mutation probability based on size *N* of a chromosome

Parameter	Value
Population size	80
Generations	100
Two-point crossover probability	0.3
Uniform mutation probability	1/N

Reviewing Chromosome Definition

- Chromosome values stored as **integer** vector – WHY INTEGERS?
- Size = 9 integers
- 1.045×10^{26} distinct chromosomes

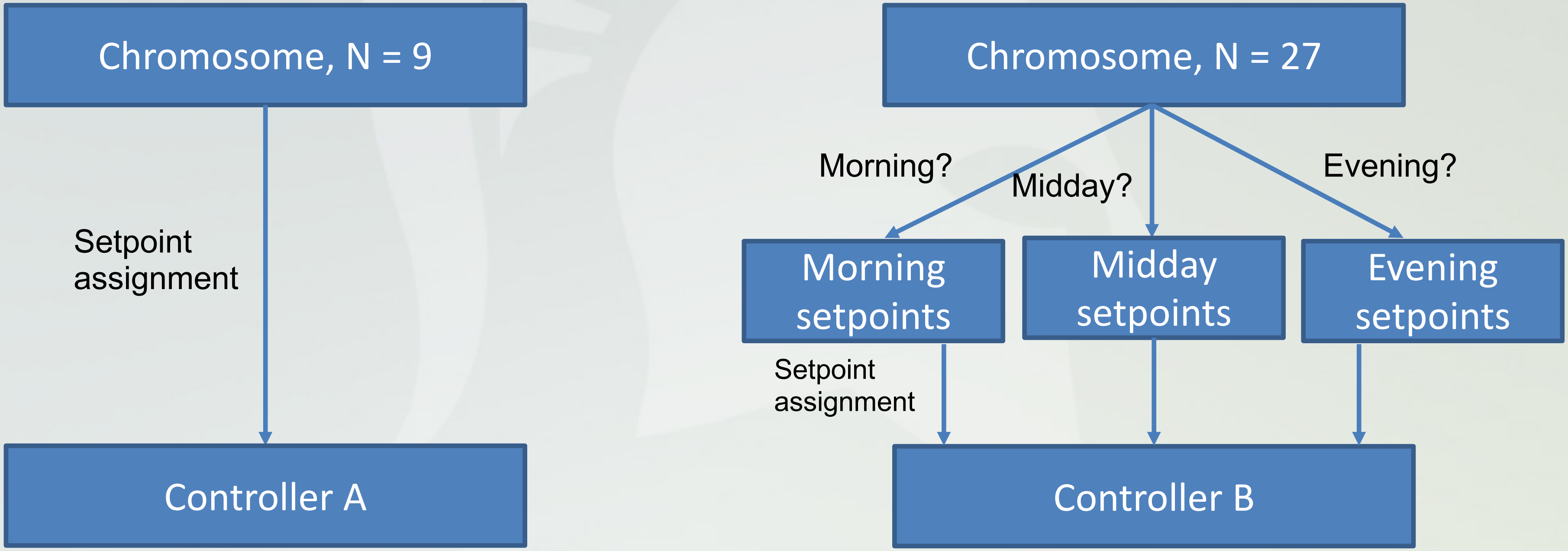
Parameter	Range	Step Size
$T_{AirVentOn}$ (°C)	[10, 30]	0.1
$T_{AirVentOff}$ (°C)	[10, 30]	0.1
$RH_{AirVentOn}$	[1, 10]/10	0.01
$CO_{2AirVentOn}$ (ppm)	[100, 500]	0.1
$T_{AirBoilOn}$ (°C)	[10, 30]	0.1
$T_{OutThScrOn}$ (°C)	[10, 30]	0.1
$CO_{2AirExtMax}$ (ppm)	[500, 1000]	0.1
$CO_{2AirExtMin}$ (ppm)	[100, 500]	0.1
$I_{GlobMax}$ ($W \times m^{-2}$)	[200, 1000]	0.1

Improving Controller Performance by Separating Days into Multiple Time Periods

- We can evolve multiple sets of control rules, to cover different periods of day: morning, day and evening
- (Night is already different)
- To do that, simply replicate chromosome and append a copy for each new time period.
- We’ll compare the unevolved single-point controller with 4 evolved controllers, as shown next

Reviewing Evolved Control Strategies

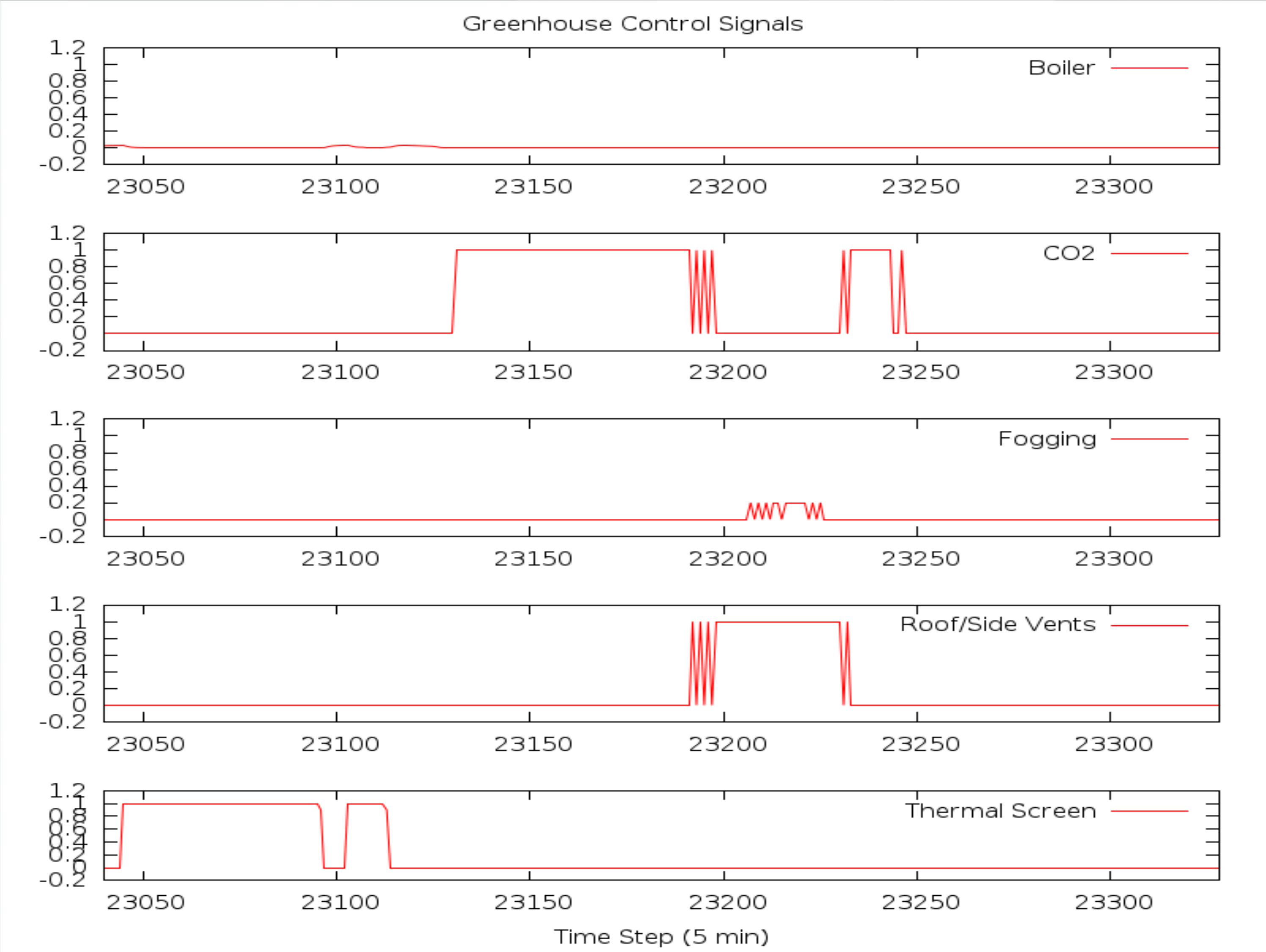
- Controllers are evolved based on a classical strategy for selection of control parameters
  - More complex controllers can reproduce simpler behavior if needed



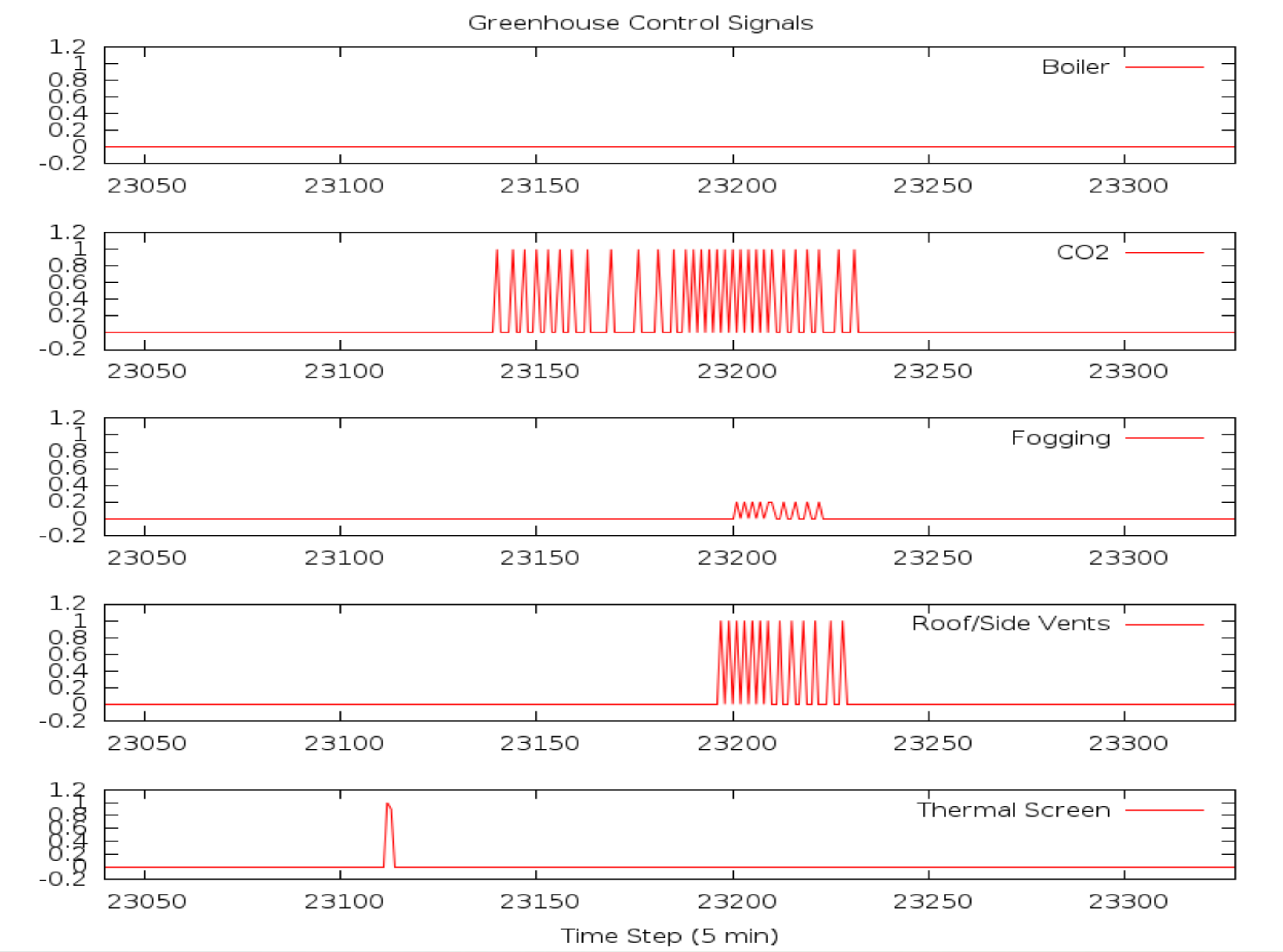
Evolved Control Strategies—What We Learned

- High-yield solutions have aggressive CO_2 enrichment strategy
- Low-energy solutions use less heating and CO_2 enrichment
- Most solutions favor keeping ventilation closed to maximize CO_2 enrichment utilization

High-Yield Control Actions, Typical Day



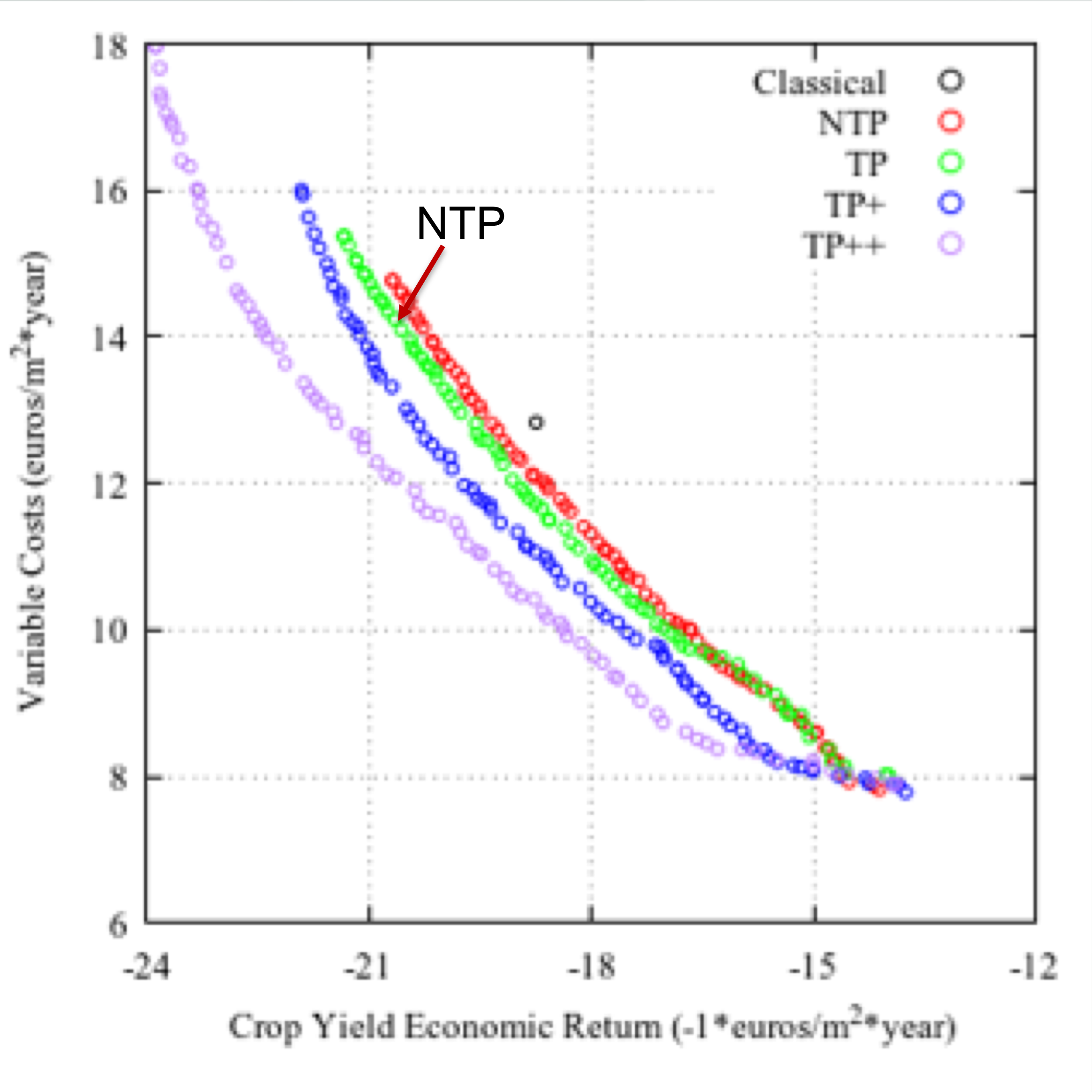
Low-Cost Control Actions, Typical Day



Comparing 5 Types of Controllers

- Single circle: Classical, unevolved controller
- Red points: NTP: Evolved controllers, No Time Partitioning
- Green points: TP: Time Partitioned--Day divided into fixed morning, day and evening. Still 9 variables to evolve for each time period, so 27 total
- Blue points: TP+: Day divided, but transition points now relative to current sunrise, sunset times
- Purple points: TP++: Control also partitioned into before-fruit-set and after-fruit-set; 58 total variables

Evolved Control Strategies



- Based on classical strategy
- Setpoints are evolved, no additional changes