

Teaching Several Software and Tools for Bachelor Students of Chemical Engineering: Simulation and Optimization

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INTRODUCTION

Over the last decade, the industry sector has increasingly relied on modelling, simulation, and optimization methods to address challenges and enhance efficiency in manufacturing [1-3]. These methods aid in reducing production costs, optimizing time management, and improving customer service [4]. Simulation and optimization teaching must be updated and re-designed for future engineers, training students on mathematical modeling and optimization tools, as well as simulation techniques applicable to chemical and production systems, combining different methods and tools compatible with new engineering trends.

INTRODUCTION

PURPOSE

The purpose of this course was the re-design of the current program in the Simulation and Optimization subject of the Chemical Engineering Degree at the Universidade de Santiago de Compostela (USC). The objective was to train students with the mathematical modeling, optimization and simulation skills, in an effective way accordingly with the new developments in the engineering context.

METHODOLOGY

METHODOLOGY

The course included a combination of theoretical instruction and hands-on projects to facilitate learning. Students were introduced to a range of simulation and optimization methods and software tools relevant to manufacturing processes. Seven group projects provided opportunities for students to apply their knowledge to real-world scenarios, fostering practical problem-solving skills and facilitating a deeper understanding of mathematical modeling, simulation techniques and optimization methods.

CONCLUSION

MODELS

PRINCIPLES OF MODELING



PROCESS OPTIMIZATION

INTRODUCTION TO PROCESS OPTIMIZATION



OPTIMIZATION WITHOUT RESTRICTIONS



OPTIMIZATION WITH RESTRICTIONS



NETWORK ANALYSIS



ANALYSIS AND SIMULATION OF PROCESSES

SYSTEMS STRUCTURE

SEQUENTIAL MODULAR STRATEGY FOR THE SIMULATION OF PROCESSES IN STATIONARY REGIME

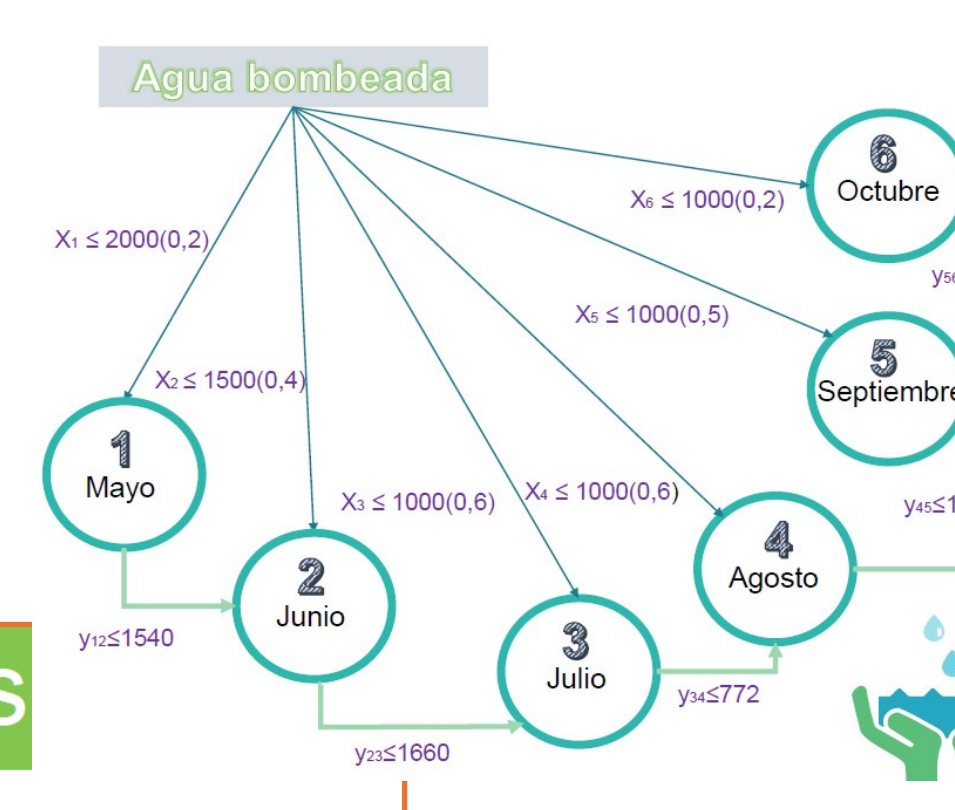
EQUATION-ORIENTED STRATEGY FOR THE SIMULATION OF PROCESSES IN A STATIONARY REGIME

SKILLS	
GENERAL	CG.3 Knowledge in basic and technological subjects enables them to learn new methods and theories and gives them the versatility to adapt to new situations
	CG.4 Ability to solve problems with initiative, decision-making, creativity, and critical reasoning to communicate and transmit knowledge, skills, and abilities in the field of industrial engineering
SPECIFIC	CQ.2.1 Ability to analyze and design processes and products
	CQ.2.2 Ability to simulate and optimize processes and products
	CQ.4.1 Ability to design, manage and operate chemical process simulation procedures
	CQ.4.2 Control and instrumentation of chemical processes
TRANSVERSE	CT.1 Capacity for analysis and synthesis
	CT.4 Skills for the use and development of computer applications
	CT.6 Problem-solving
	CT.8 Teamwork
	CT.13 Ability to apply knowledge in practice



- Método de Búsqueda
- Planteamiento del Problema
- Modelo Matemático
- Simulación en Vensim PLE
- Resolución Gráfica
- Método de Kuhn-Tucker
- Método de la Gran M
- Método Simplex
- Análisis de Sensibilidad
- Resolución por Redes
- Simulación en Aspen Hysys

Optimización de costes de un sistema de energías renovables para el riego de una plantación de tomates



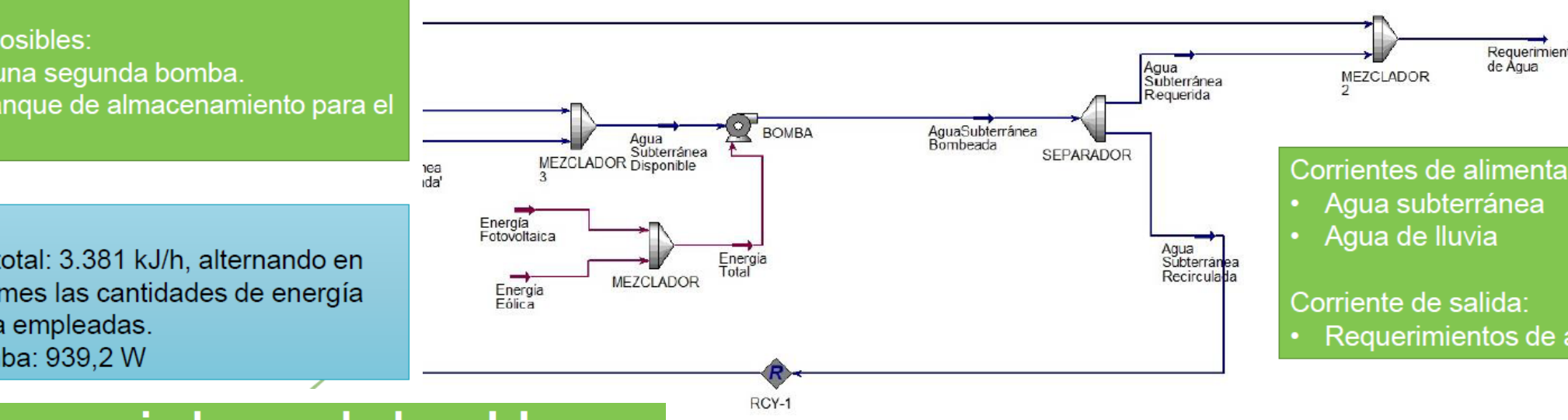
Solución óptima: coste de 2.180,36 €

Resolución por redes

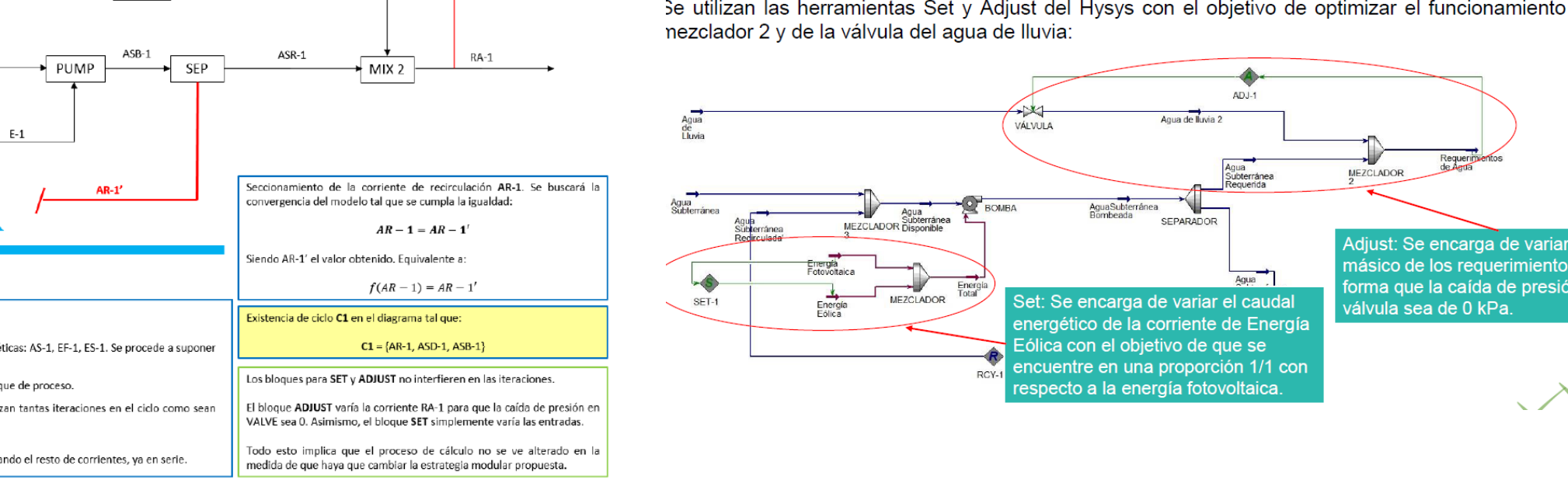
Se desea estudiar la alternativa de almacenaje de agua no utilizada en cada mes, pues los costes de bombeo varían según la época del año. La capacidad máxima de bombeo varía según los meses. El coste de almacenaje será de 10 céntimos de euro por metro cúbico de agua y por mes. Al variar la cantidad de lluvia a lo largo del año los requerimientos de agua serán diferentes todos los meses. A continuación, se muestran los datos apropiados. Resuelva el problema minimizando los costes de bombeo mediante un problema de redes.

Mes	Requerimientos de agua (m³)	Bombeo máximo (m³)	Coste de bombeo por m³ (€)
Mayo	460	2000	0,2
Junio	1380	1500	0,4
Julio	1888	1000	0,6
Agosto	1500	1000	0,6
Septiembre	1000	1000	0,6
Octubre	1000	1000	0,6

Simulación en Aspen Hysys



Se utilizan las herramientas Set y Adjust del Hysys con el objetivo de optimizar el funcionamiento del mezclador 2 y de la válvula del agua de lluvia:



Modelo matemático

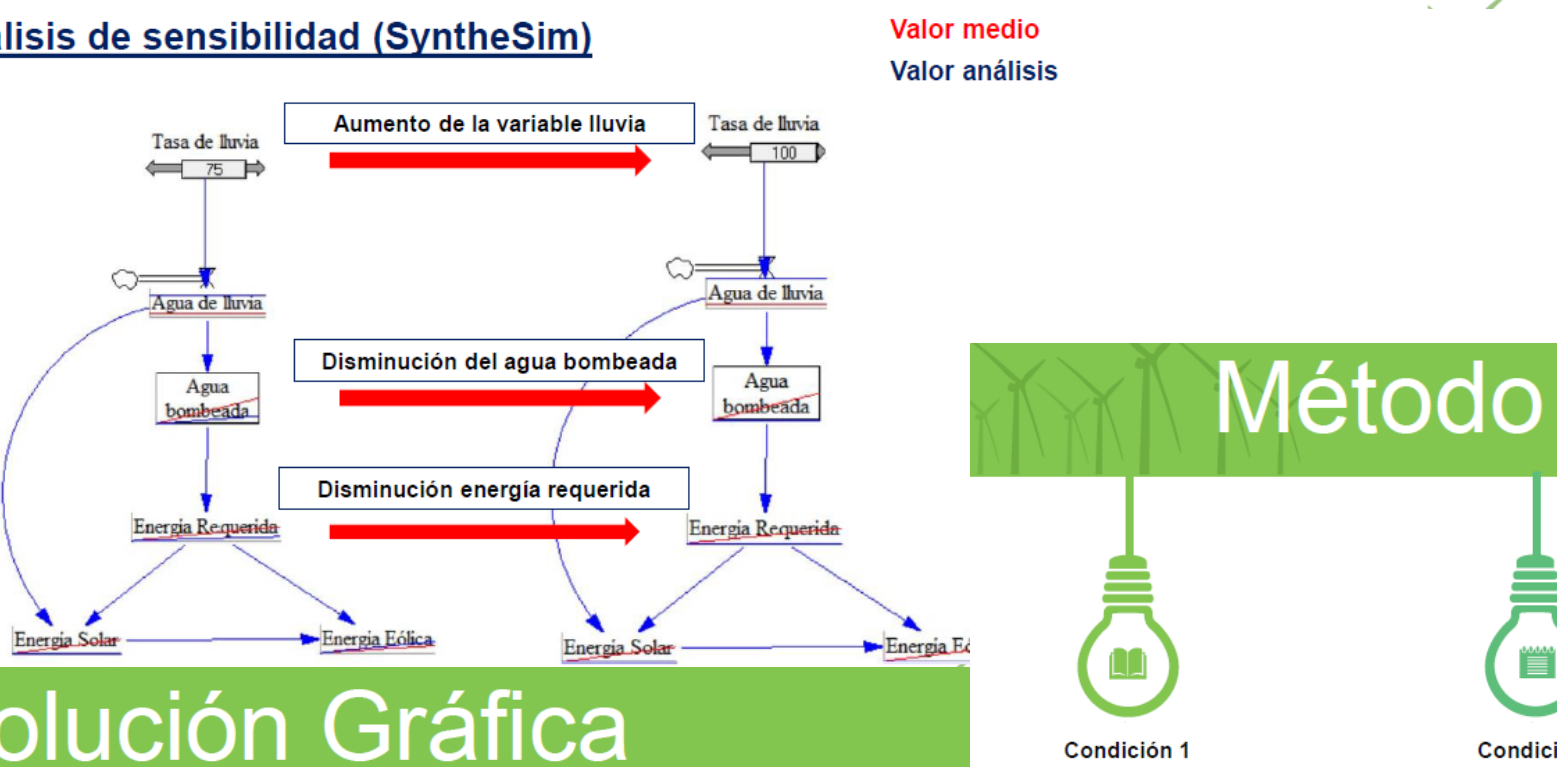
Definición de variables
 N_{pv} : Número de paneles fotovoltaicos
 N_w : Número de turbinas eólicas
Función objetivo (Minimizar el coste del ciclo de vida del sistema)
 $min z = C_{pv}N_{pv} + C_wN_w \rightarrow z = 591,56N_{pv} + 978,97N_w$
Restricciones
 Demanda de consumo: $E_{pv}N_{pv} + E_wN_w \geq D \rightarrow 235N_{pv} + 73N_w \geq 23820,25$

Planteamiento del problema

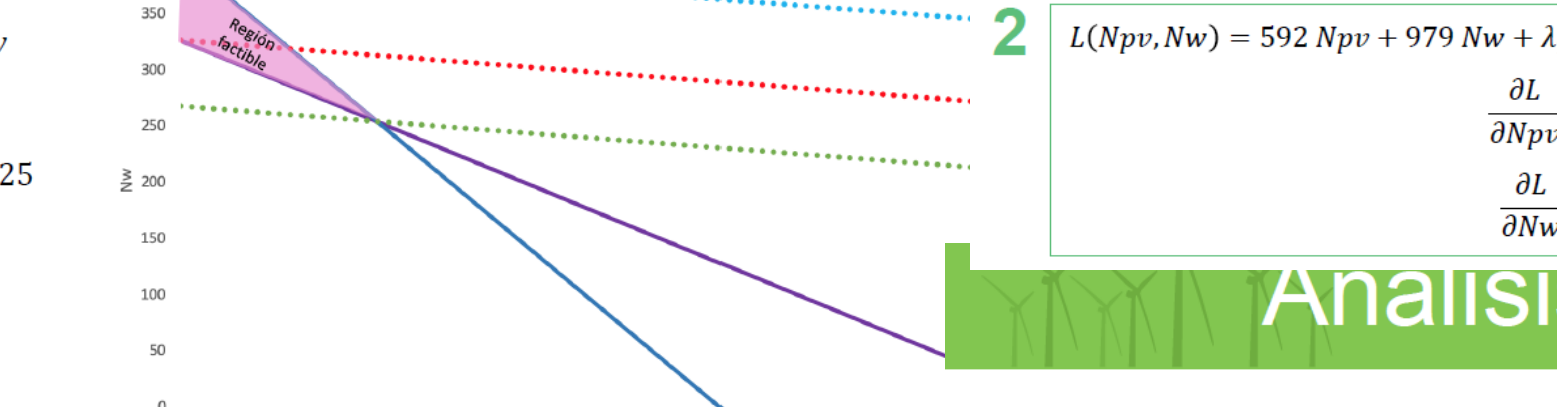
Se estudia el uso de sistemas de energía 100% renovable para el riego de un campo de tomates. El sistema consiste en una formación de paneles fotovoltaicos (PV) y generadores eólicos (W) que suministran la energía empleada en el riego por una unidad central para un área de 4 hectáreas. Se desea conocer el número de paneles solares y generadores eólicos necesarios para minimizar el coste total del ciclo de vida del sistema. El periodo de riego es de 144 días que van de mayo a octubre. La superficie disponible para la instalación de los sistemas de energía renovable no debe exceder el 10% del área de cultivo.

	Panels fotovoltaicos	Generadores eólicos
Requerimientos de agua de riego (m³/día)	342	743
Coste de capital (€)	300	300
Coste de remplazo (€)	300	300
Coste de operación y mantenimiento (€)	10	30
Energía producida (kWh)	235	73
Superficie ocupada (m²)	65	10

Simulación en Vensim PLE



Resolución Gráfica



Análisis de sensibilidad

Variable	Valor medio	Valor análisis
Tasa de Bata	0,30	0,30
Tasa de Bata (máx)	0,30	0,30
Tasa de Bata (mín)	0,30	0,30

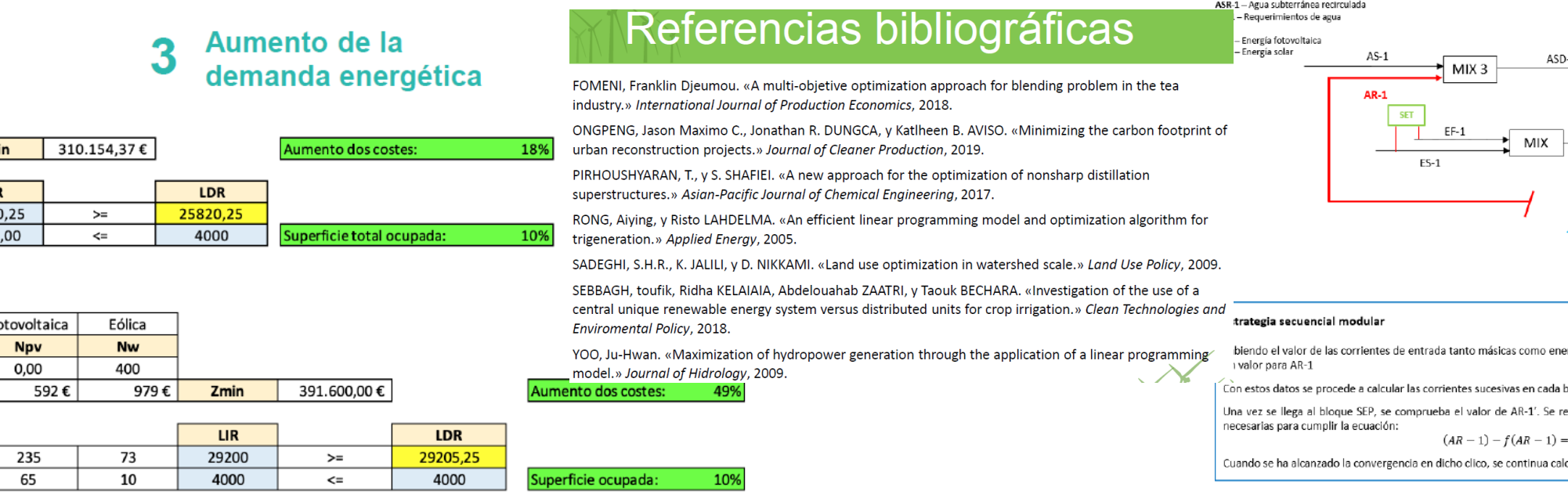
Método de Kuhn-Tucker

Se calcularon los requerimientos energéticos de la bomba, necesarios para llevar a cabo la operación del proceso:

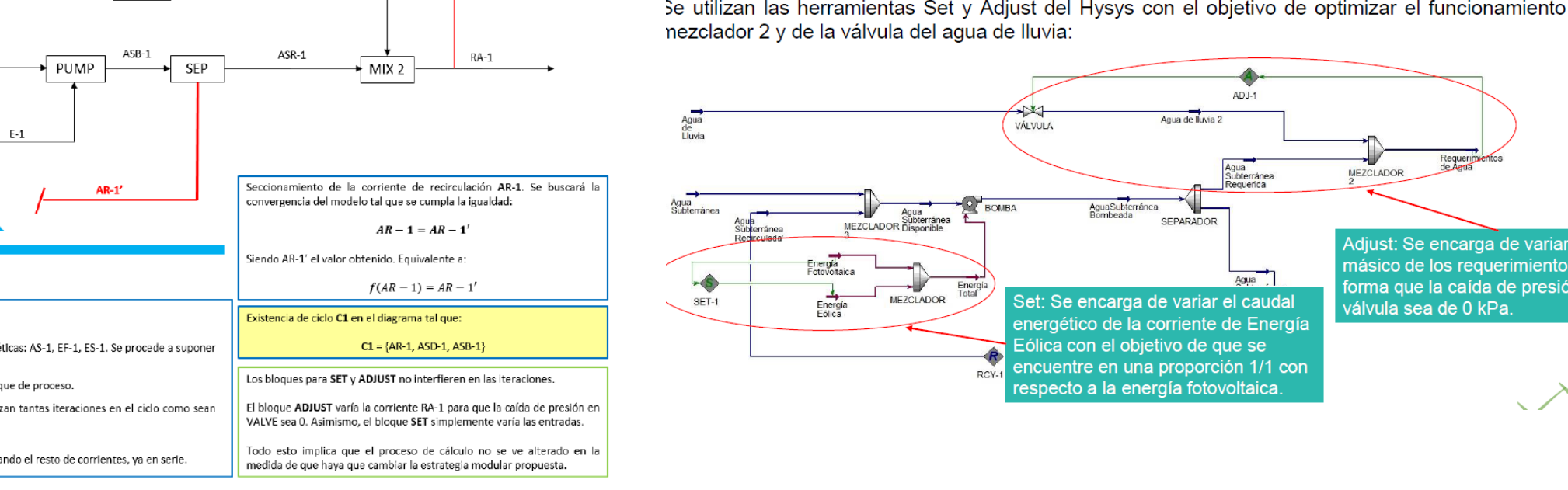
Mejoras energéticas posibles:
 • Estudiar el uso de una segunda bomba.
 • Instalación de un tanque de almacenamiento para el agua recirculada.

Cálculos energéticos:
 • Aporte de energía total: 3.381 kJ/h, alternando en función del tipo de mes las cantidades de energía eólica y fotovoltaica empleadas.
 • Potencia de la bomba: 939,2 W

Estrategia secuencial modular Hysys



Uso de las herramientas Set/Adjust



CONCLUSION

This work underscores the significance of integrating simulation and optimization education to align with technological advancements, particularly in the industrial realm, while also preparing students for evolving job market demands and enhancing company performance. Specifically tailored for chemical engineers, the newly introduced course at the Universidade de Santiago de Compostela, emphasizes essential tools and software relevant to industrial applications. Faculty members, experienced in the field, emphasize the course's learning objectives, aimed at equipping students with skills to seamlessly transition into the workforce.

REFERENCES: Tripathi et al. Processes, vol. 10, no. 8, p. 1587, 2022; Rodič, Organizacija, vol. 50, no. 3, pp. 193–207, 2017; Winston and S. C. Albright, Practical management science, 5th ed. Boston: Cengage Learning, 2015; Garcia and F. You, "Supply Chain Design and Optimization: Challenges and opportunities," Computers & Chemical Engineering, vol. 81, pp. 153–170, 2015.