# Tecnología de los SRFV
# Tipos y configuraciones de SRFV

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 952879*

# Problema y Oportunidad

## El coste eléctrico para agricultores y Comunidades de Regantes

- FENACORE : incremento de costes 627% - 1255%
- 40% - 50% del total de costes de producción
- 2º consumidor eléctrico en España

## Mercado Potencial

- Sur de Europa: 14 millones Ha -16GW – 24.000M€
- Norte de África (Red + diesel): 1,5GW – 2.250 M€

# ¿Por qué sabemos de bombeo FV y calidad?

## Bombeo FV

**PRS (UE, 1993):**

- 600 bombas; UPM: control de calidad

**Desde 1995:**

- Marruecos, Argelia, Túnez: 53 bombas
- Egipto: 5 bombas

**Riego (MICCIN, 2012):**

- Prototipo en Villena

**MASLOWATEN (2015)**

## Calidad técnica en el marco de Project Finance – Due diligence

**Proyectos**:

- 80 plantas FV multiMW – 12 países - 1 GW

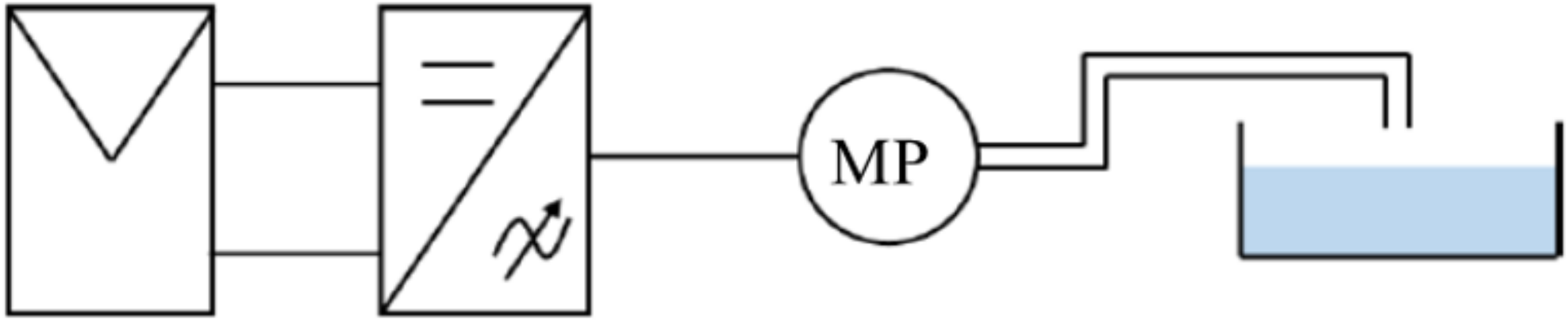
**Empresas**:

- Acciona, Guascor, Conergy, Unión Fenosa, Fotosolar, Atersa, Nobesol, Proener, Epuron, Ateia, Element Power, Gehrlicher, Solon, Gadir, Cadmos, Dresser-Rand, Bosch, Gestamp, IM2, Scorpio, Sky Solar, Alten, Lugec, WOK, Abalados, Garrigues

**Bancos**:

- Santander, BBVA, BARCLAYS, BANESTO, Pastor, Caja Navarra, Banco de Vasconia, Sabadell Atlántico, Caja Madrid, Guipuzcuano, Caja Rural de Navarra, Bancaja, Caja Murcia, KUTXA, Espírito Santo, Zaragozano, Valencia, Caja Laboral Popular, La Caixa, Caja de Galicia
- West LB, Caixa Geral, HSH Nordbank AG, KfW, Leasink, Intesa Sanpaolo, BayernLB,

# Tecnología de los SRFV




**¡Parece simple!**

**¡Limitado a 40 kW hasta 2015!**

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# Lo que **NO** es un SRFV

## Lo que NO es:

- MPPT en el variador
- Solución preparada desde fábrica
- Adaptar la red de riego al sistema FV
- Presión constante = Aumentar el tamaño del sistema FV a balsa

## El pobre estado del arte actual:

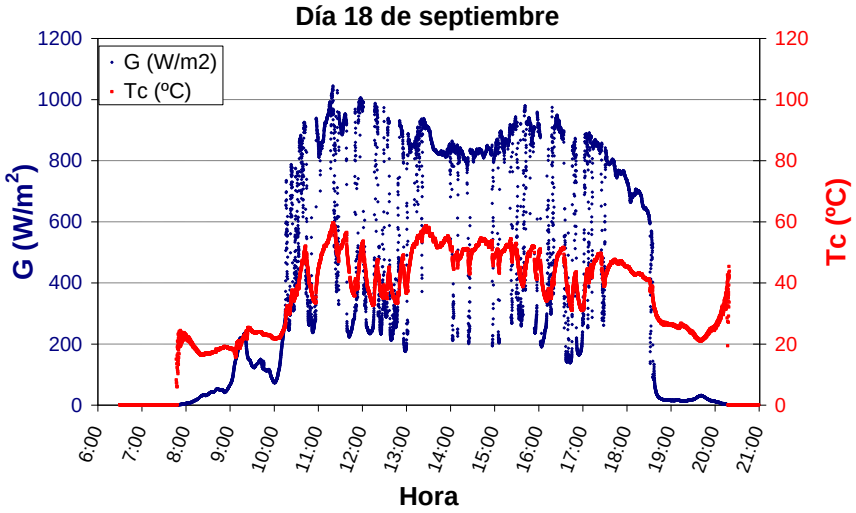
- 4 ofertas a una comunidad de regantes:
  - Tamaño: de 90 kWp a 250 kWp
  - Precio: de 1€/Wp a 2,7€/Wp

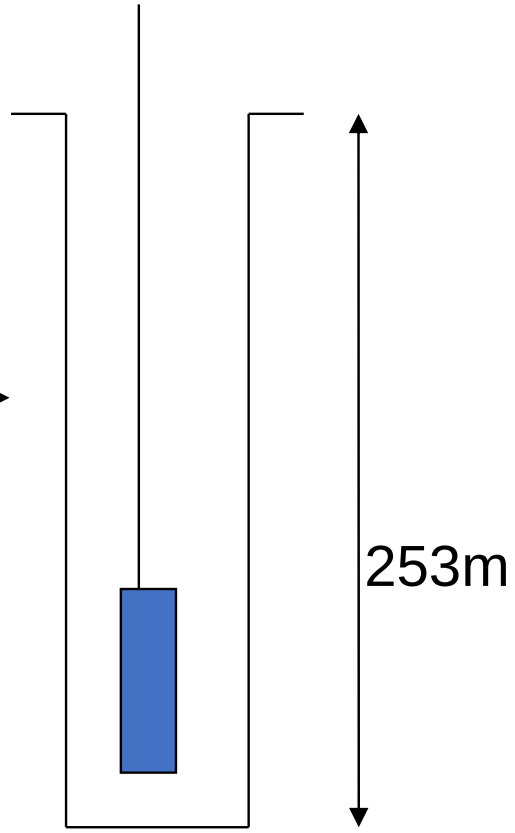
- No es que engañen; es que es nuevo conocimiento

# Lo que **SÍ** es un SRFV

- Ser **robusto frente a las fluctuaciones de potencia FV** debidas al paso de nubes
- **Ajustar la producción FV a las necesidades de riego**
- Estar **integrado en el sistema de riego pre-existente**
- Asegurar la **fiabilidad durante 25 años**

# Robusto frente al paso de nubes

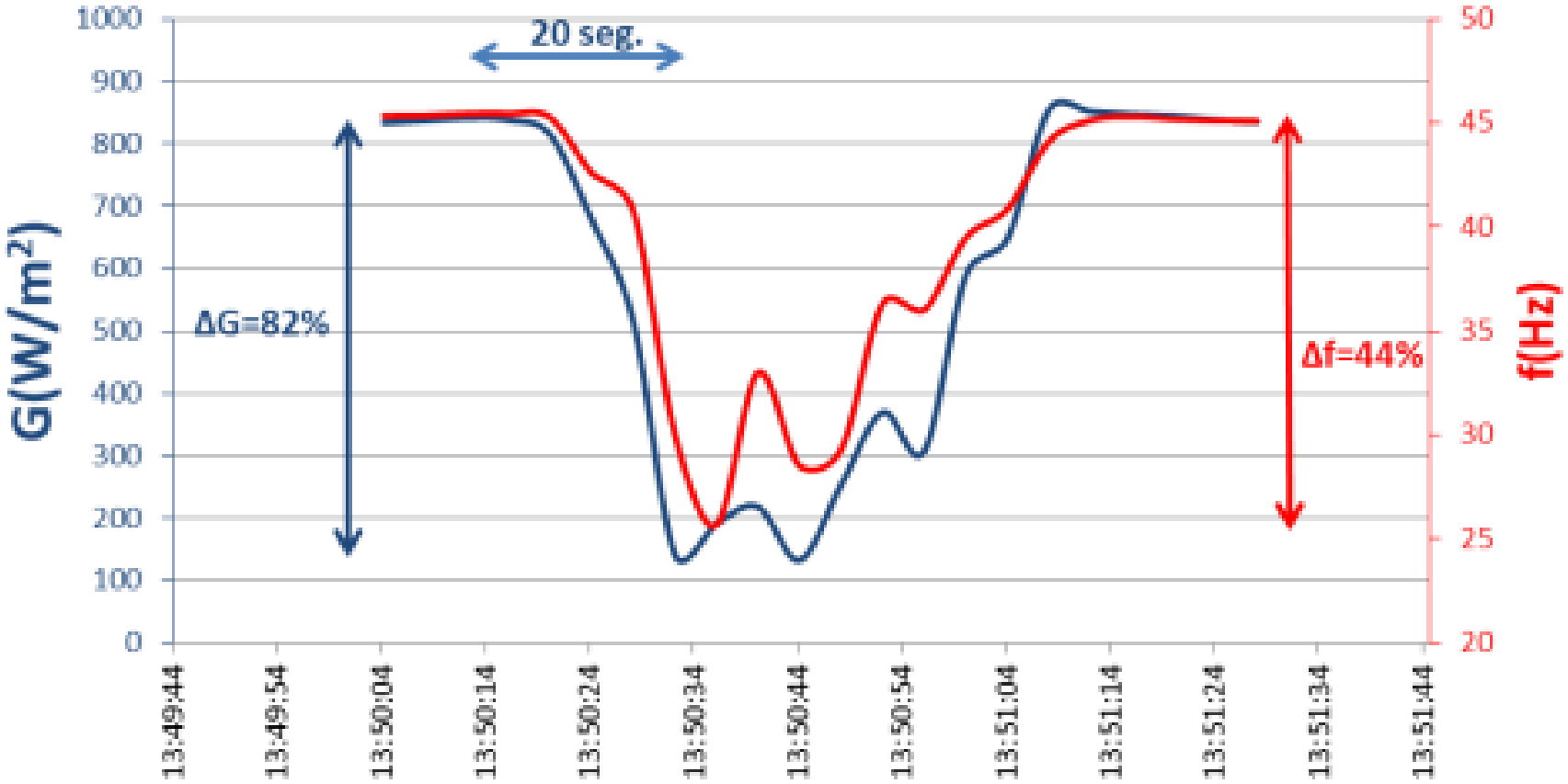



## Desestabilización y parada brusca del variador:

- Golpe de ariete: reduce el tiempo de vida de la parte hidráulica
- Sobretensiones: reduce el tiempo de vida del variador y motobomba

# Robusto frente al paso de nubes

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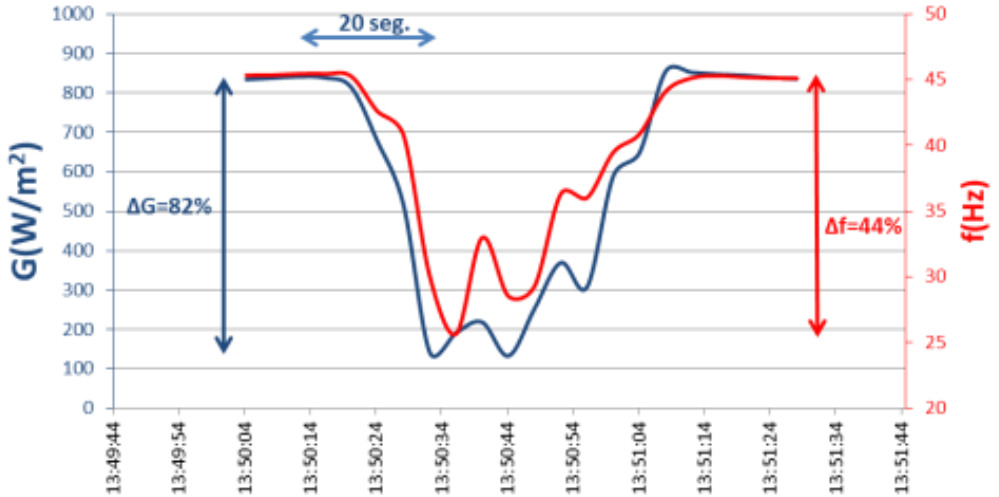
# Robusto frente al paso de nubes

- Principal característica de los SRFV
- **Permite trabajar sin la red cuando se desee.**
- Lo distingue de los autoconsumos:
  - Patente
  - Evita términos de potencia caros

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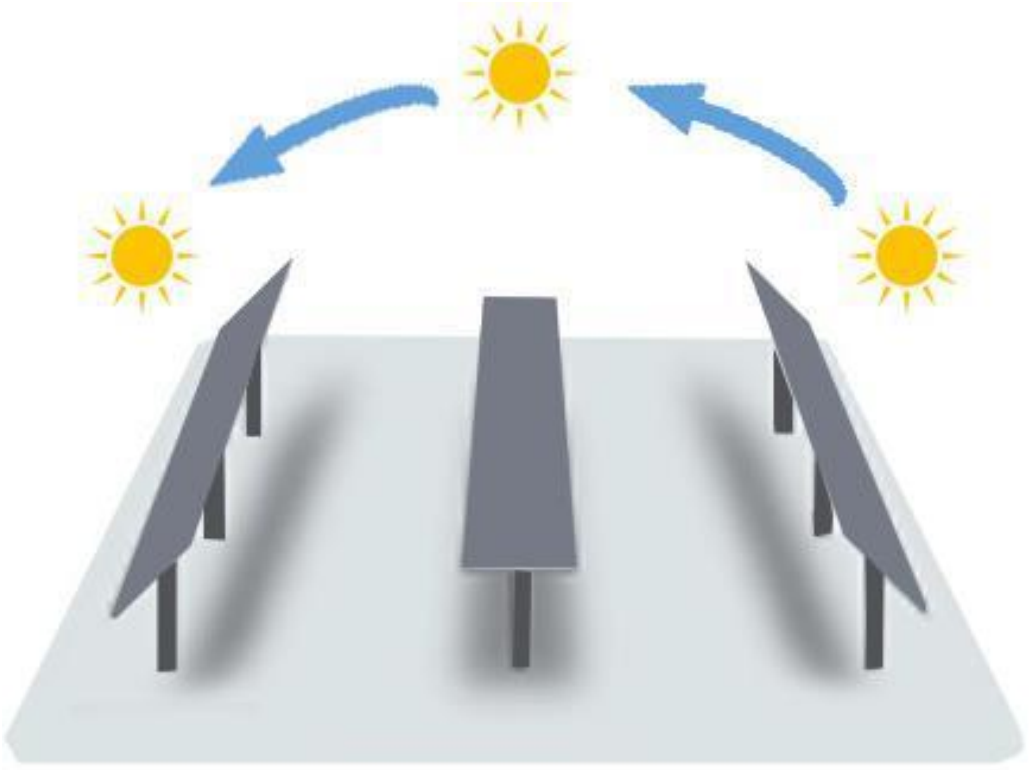
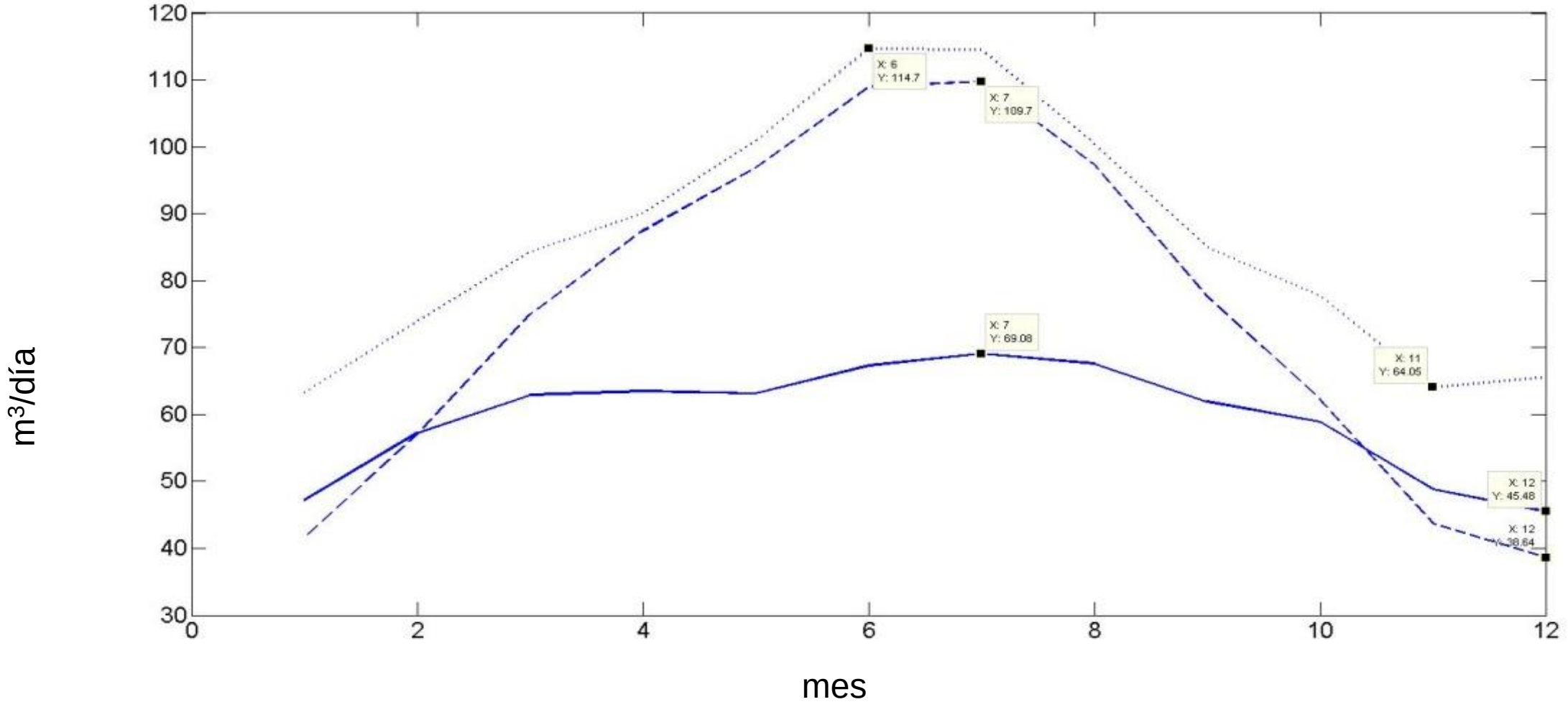
# Ajustar la producción FV a las necesidades de riego

Seguidor N-S:



# Ajustar la producción FV a las necesidades de riego

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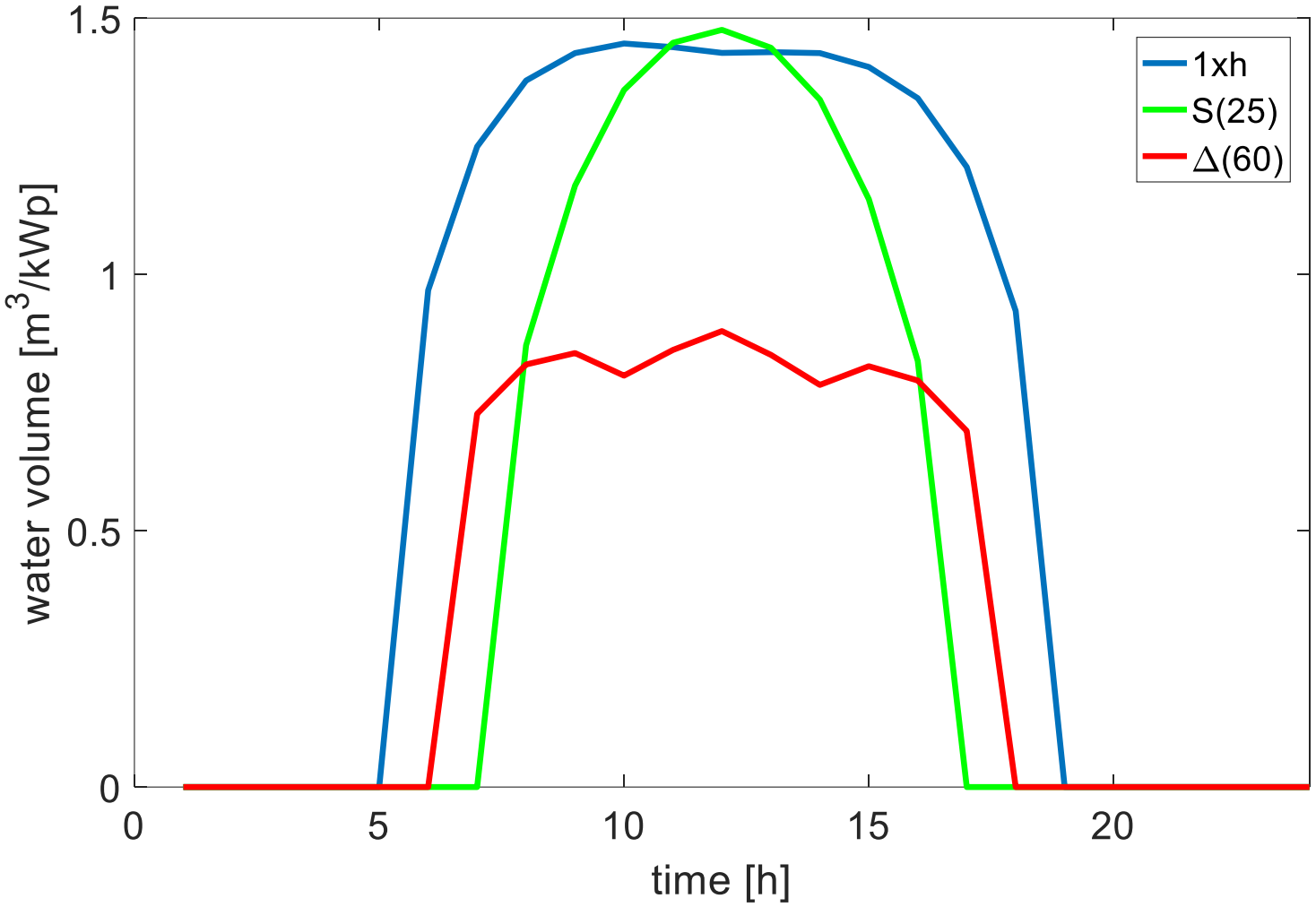
# Ajustar la producción FV a las necesidades de riego

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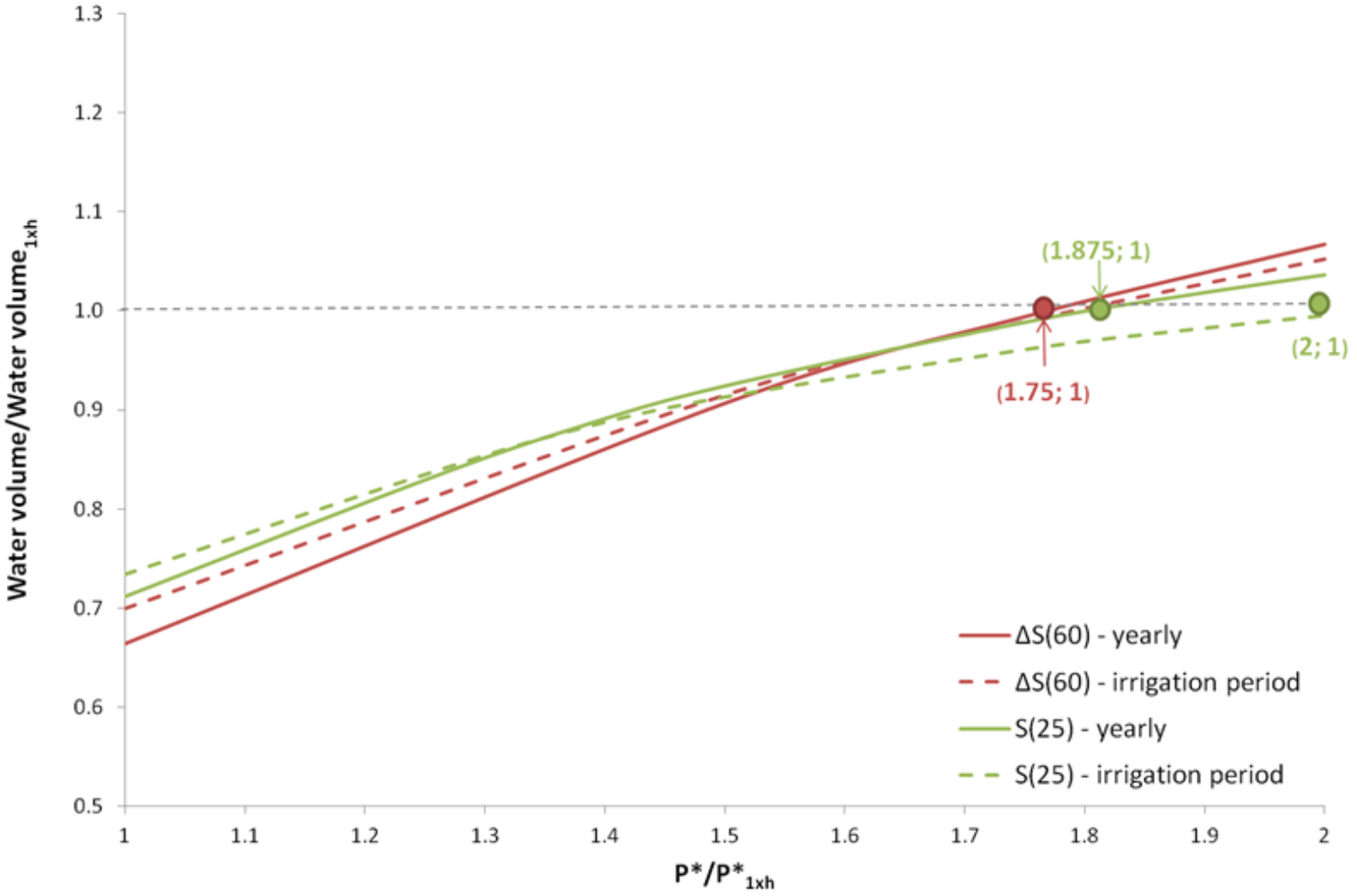
# Ajustar la producción FV a las necesidades de riego

- Perfil constante:
  - Seguidor horizontal
    - Más horas
    - Ocupa 15 $m^2$/kWp

    (estático sur: 8 $m^2$/kWp)
  - Estructura delta
    - Ocupa 12 $m^2$/kWp

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# Integrado en el sistema de riego preexistente


Reducir el grado de novedad:

Mismo sistema de gestión

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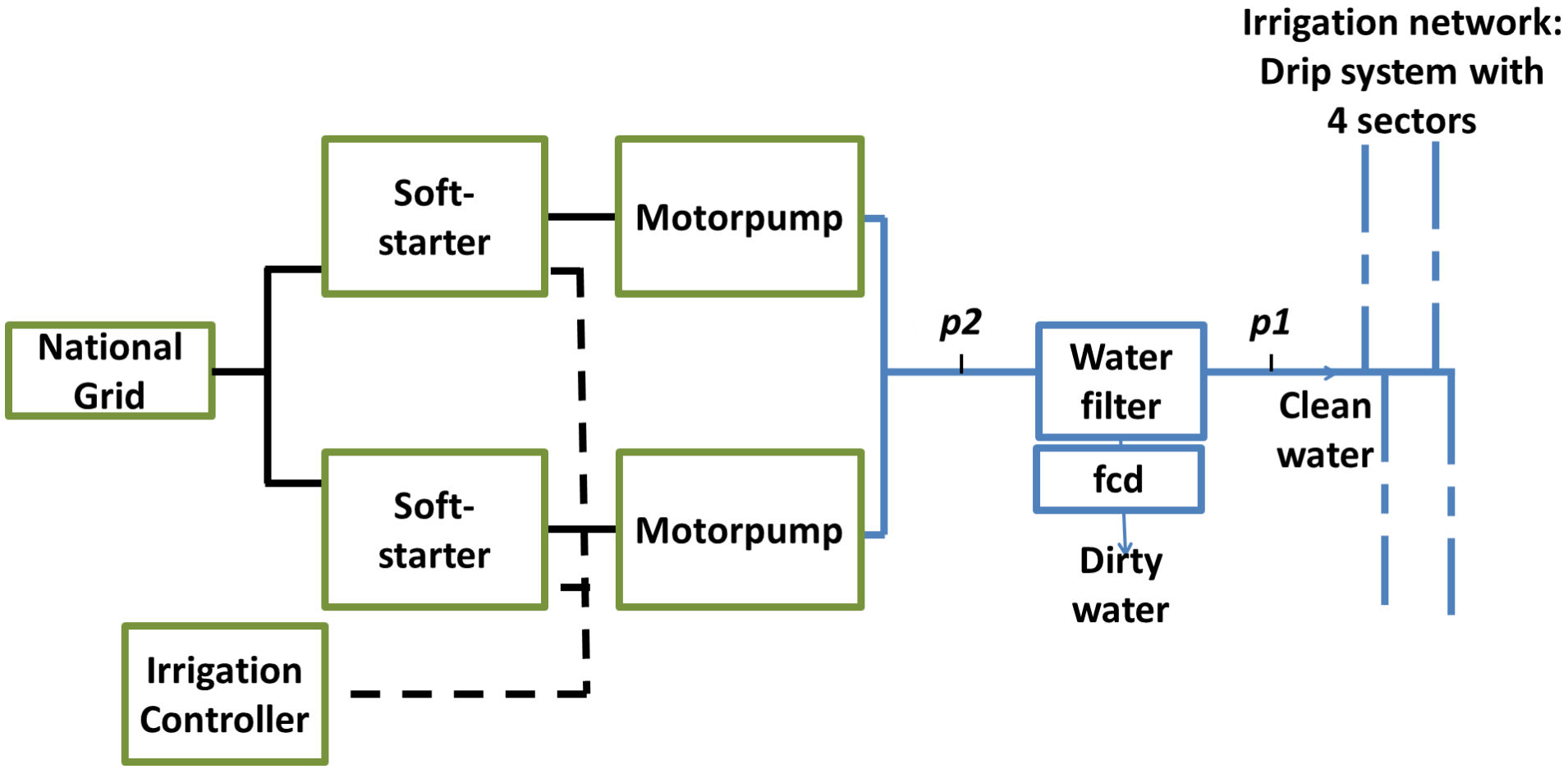
# Integrado en el sistema de riego preexistente

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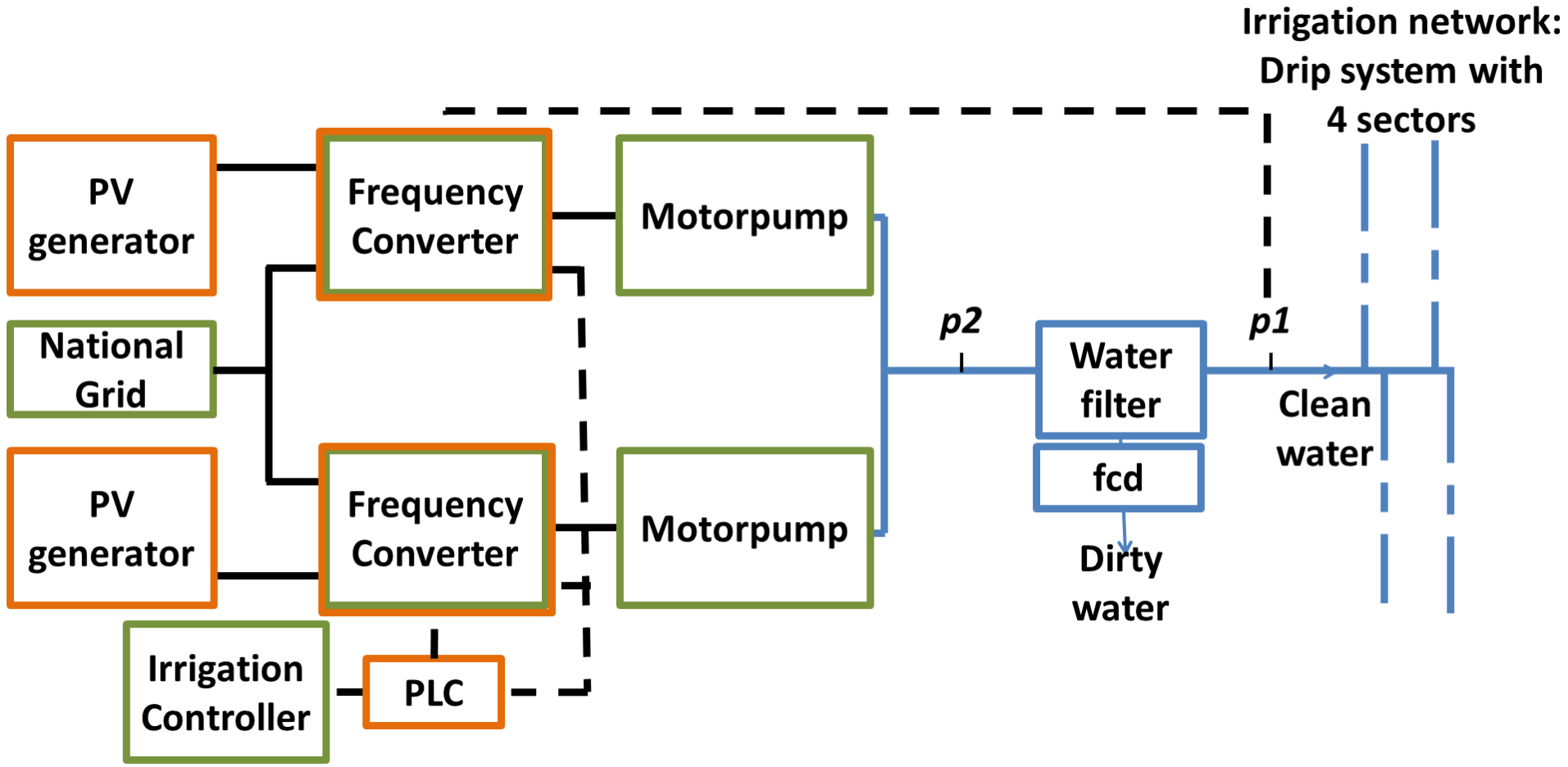
# Integrado en el sistema de riego preexistente

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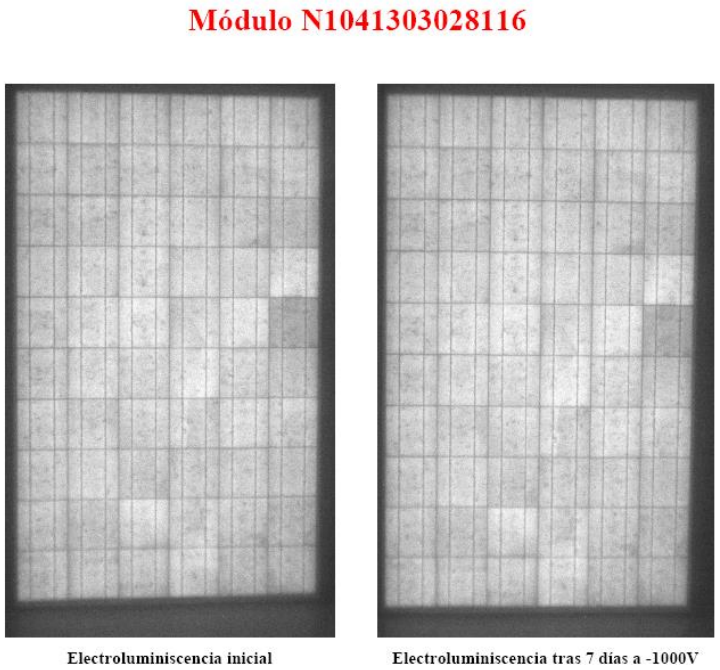
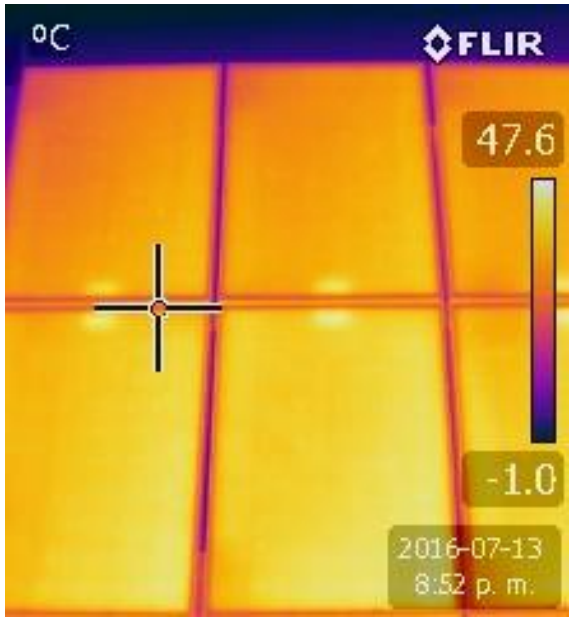
# Asegurar la fiabilidad durante 25 años

- Especificaciones técnicas
- Control de calidad

} En contrato

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# Tipos de SRFV

- Aislados (en períodos seleccionables)
- Híbridos hidráulicos
- Híbridos eléctricos

- Elevación a balsa (caudal variable)
- Bombeo directo (presión constante)

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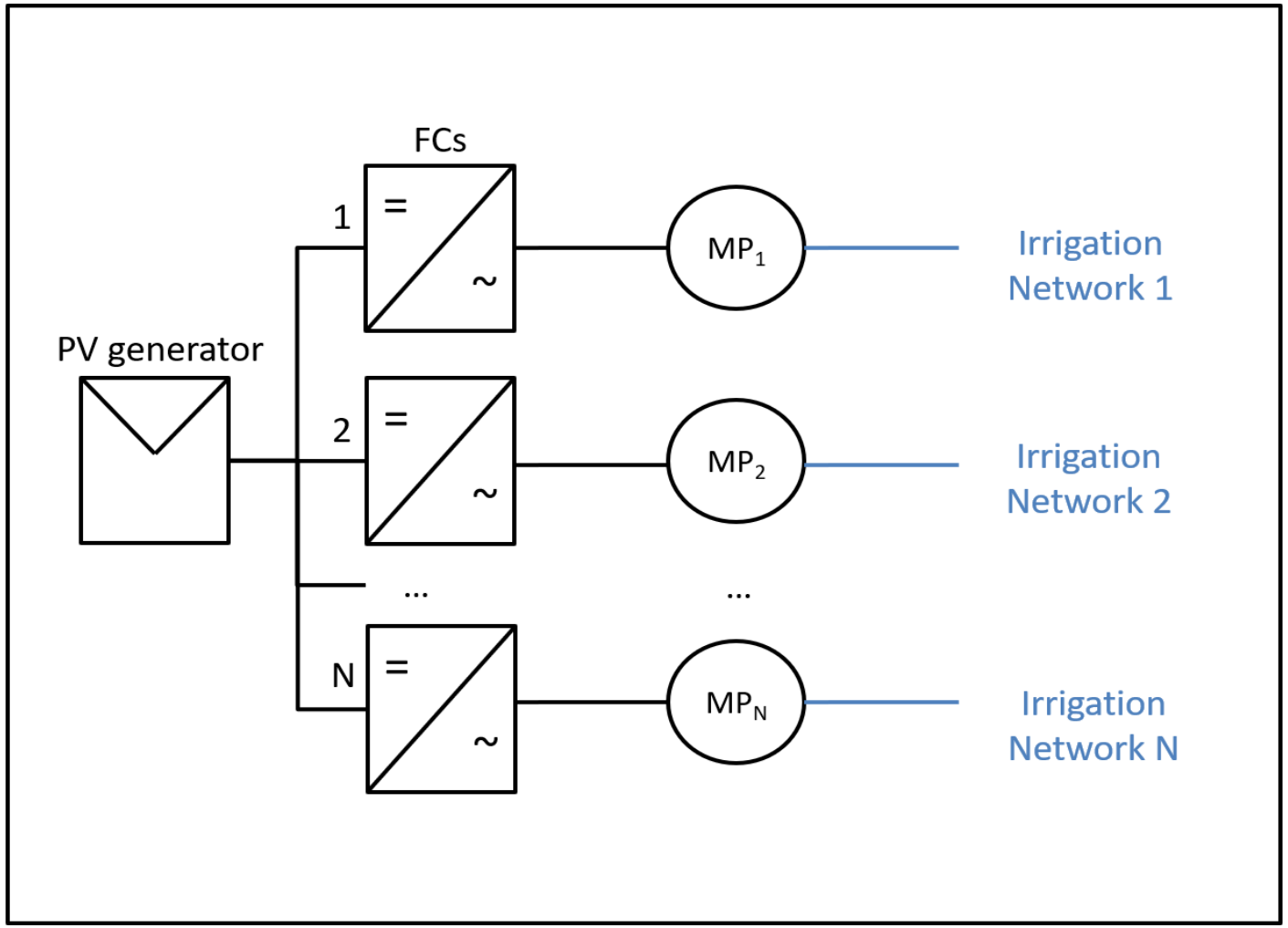
# SRFV aislado (en períodos seleccionables)

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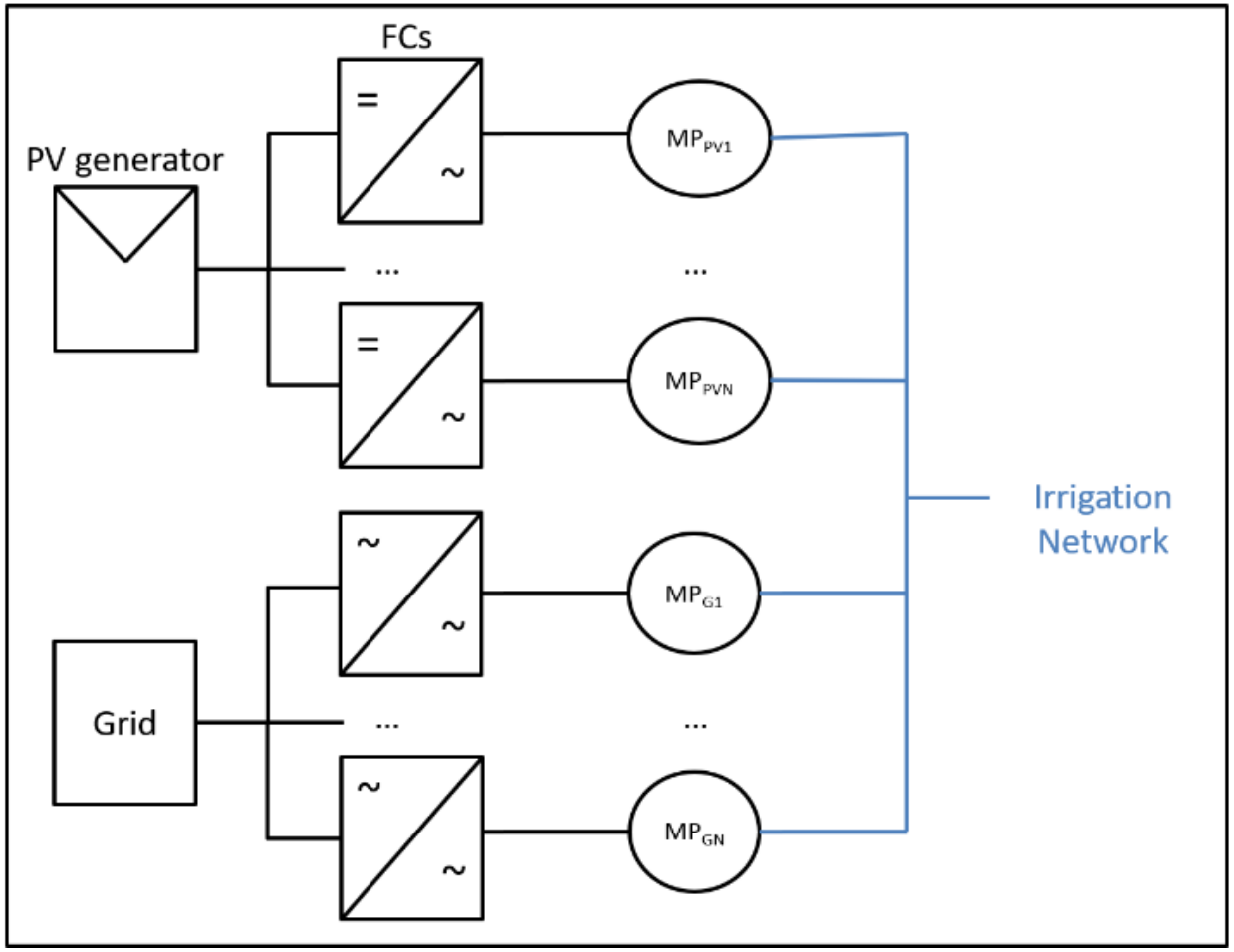
# SRFV híbrido hidráulico

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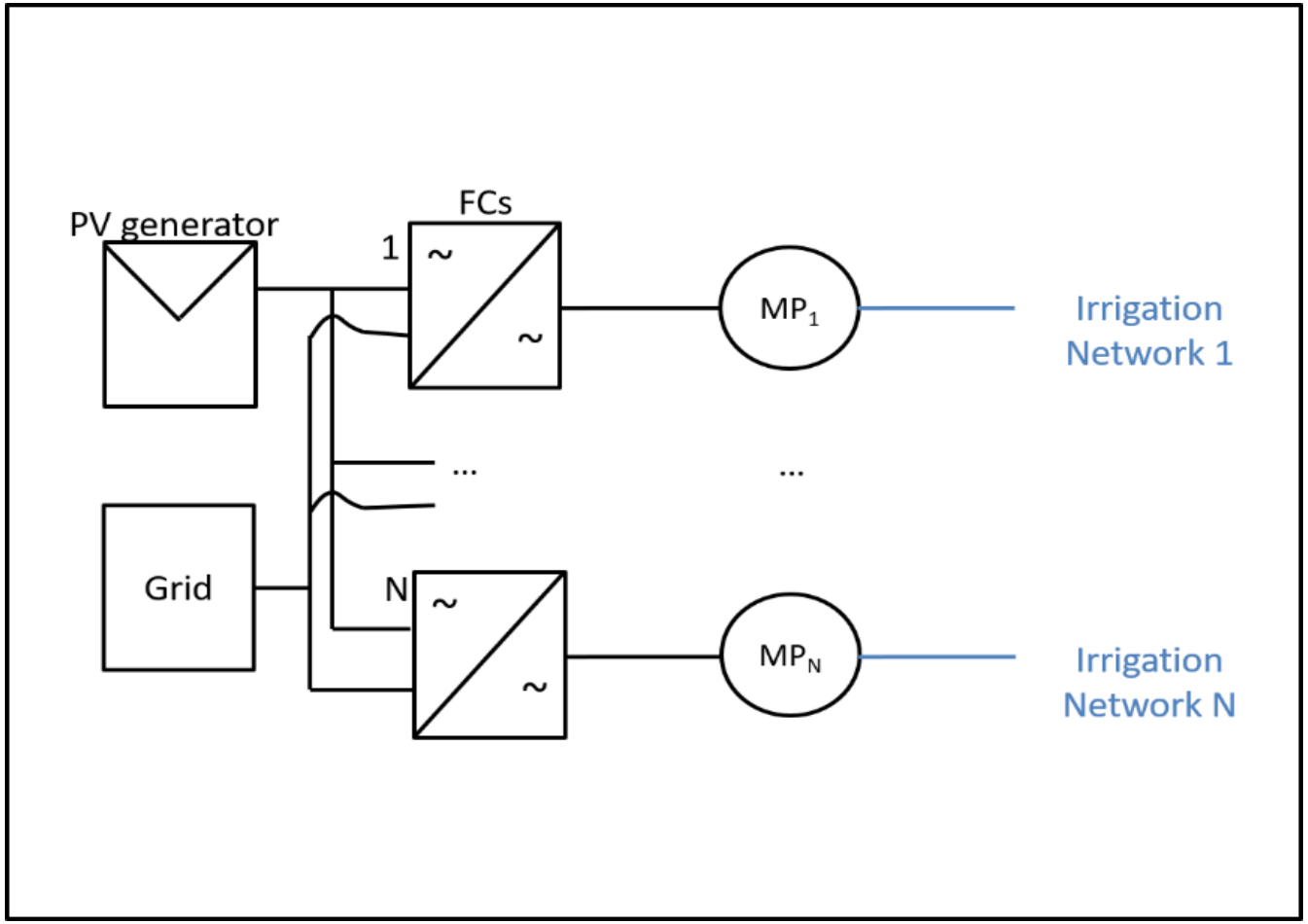
# SRFV híbrido eléctrico

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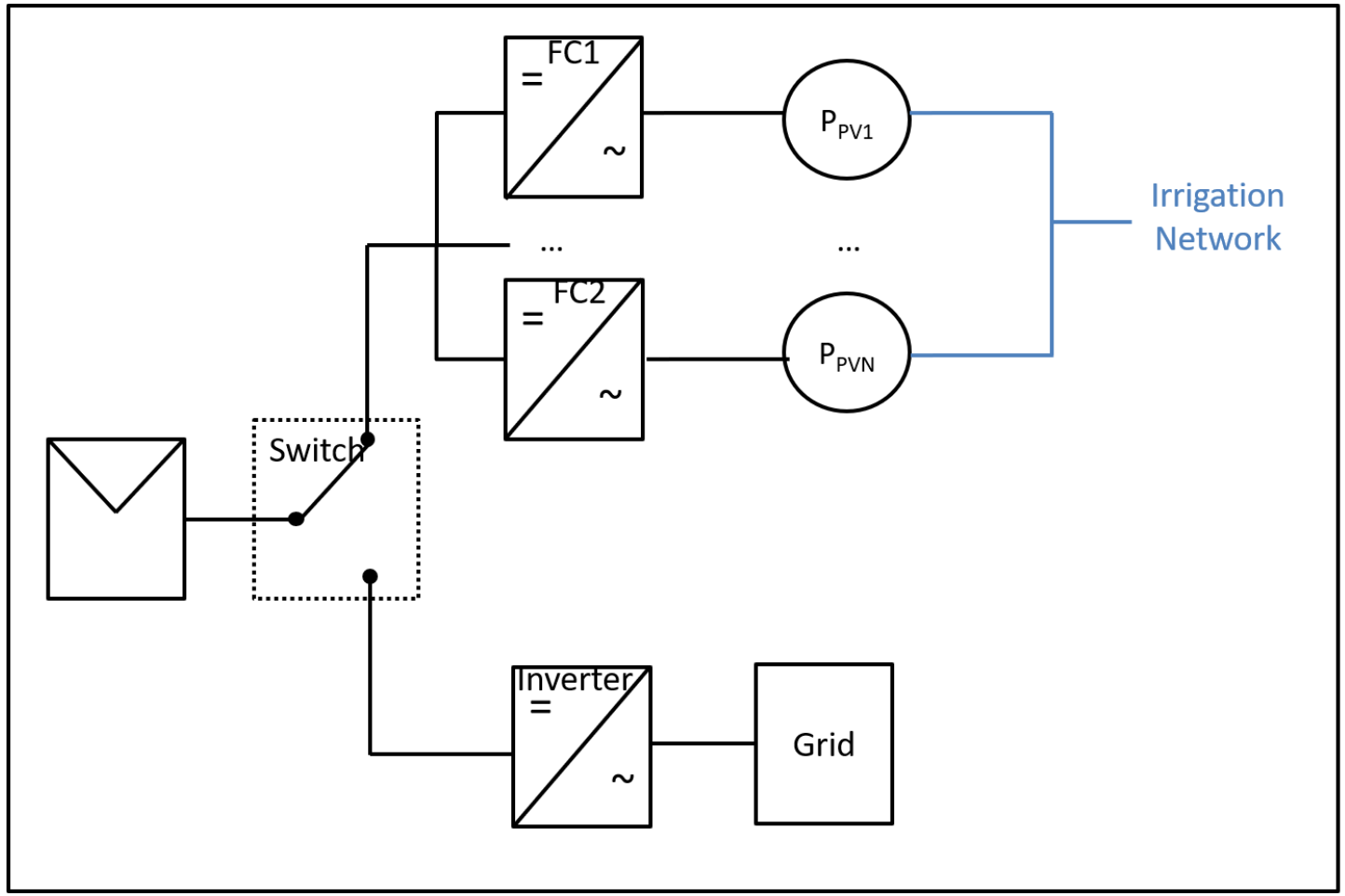
# Con exportación a red

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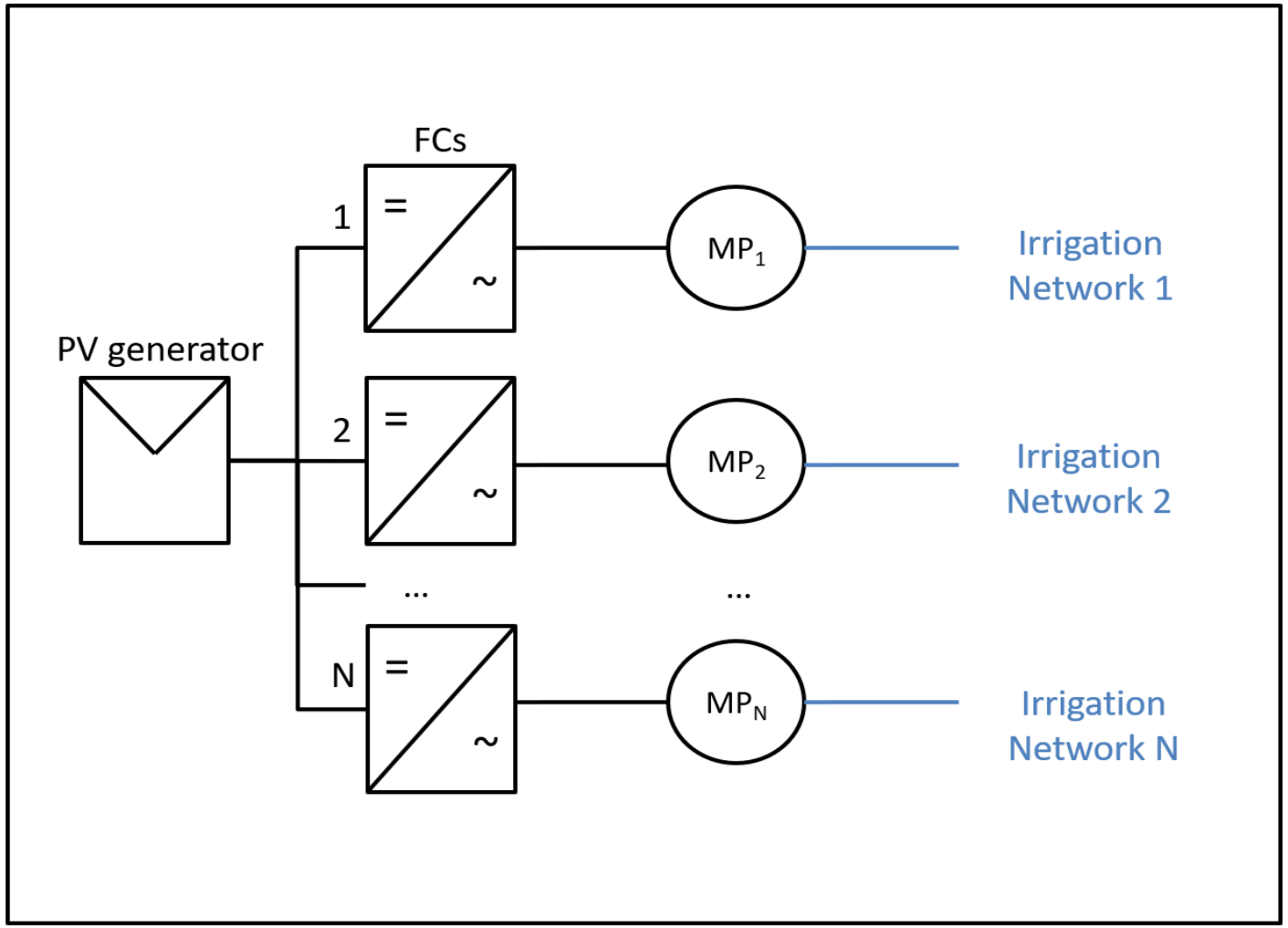


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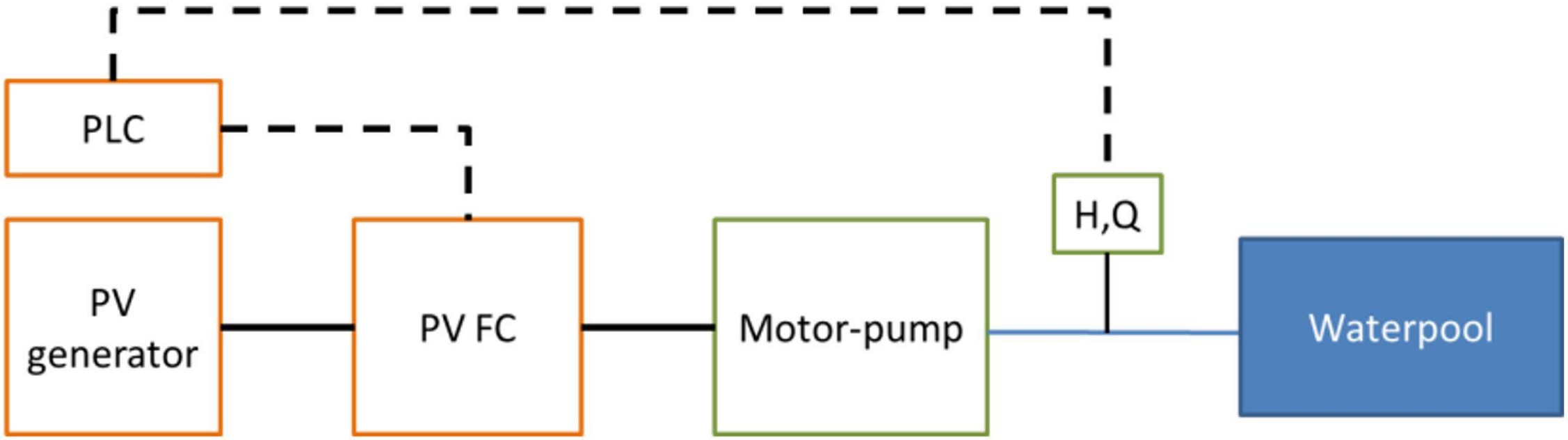
# Ejemplo: Villena

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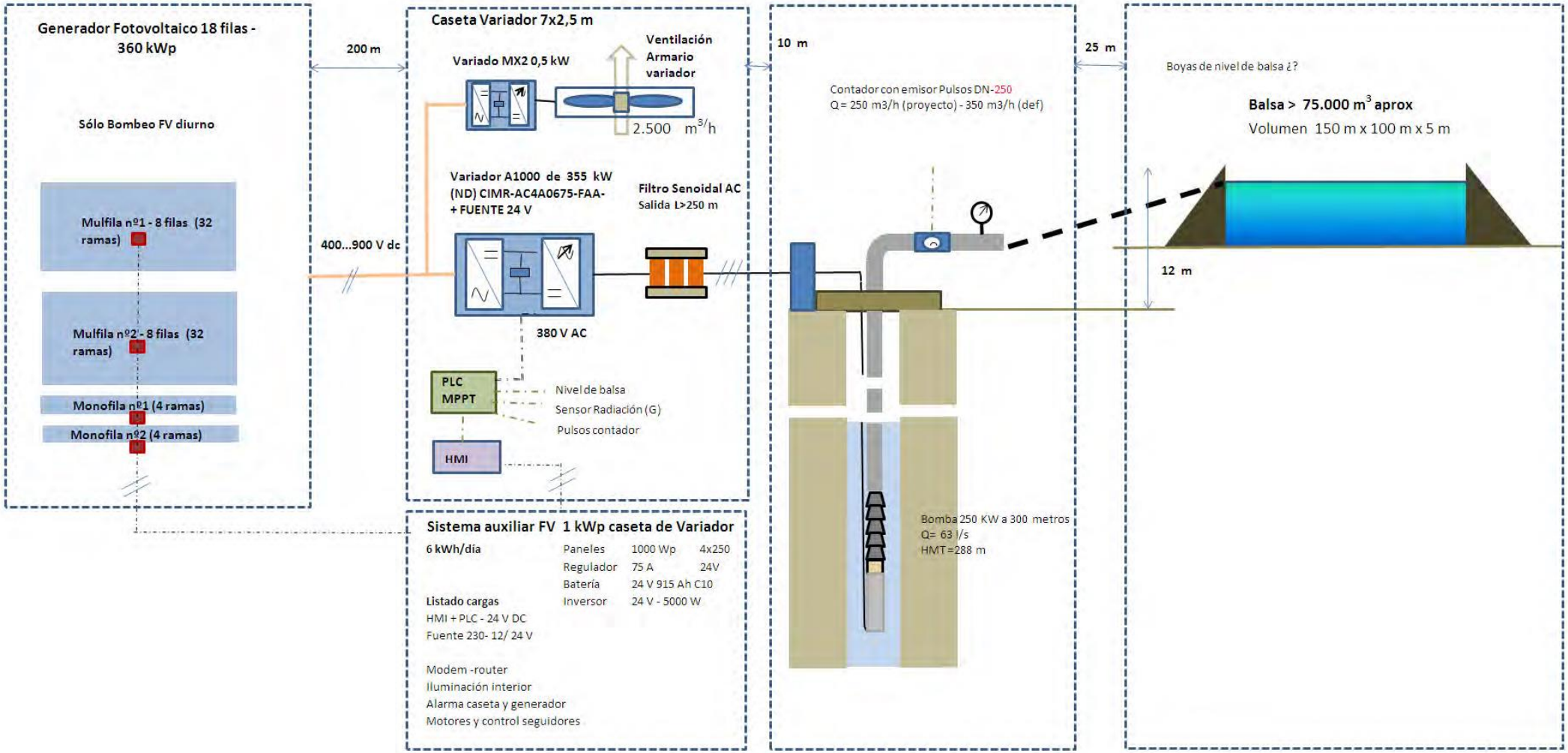


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# Ejemplo: Villena

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# Ejemplo: Villena



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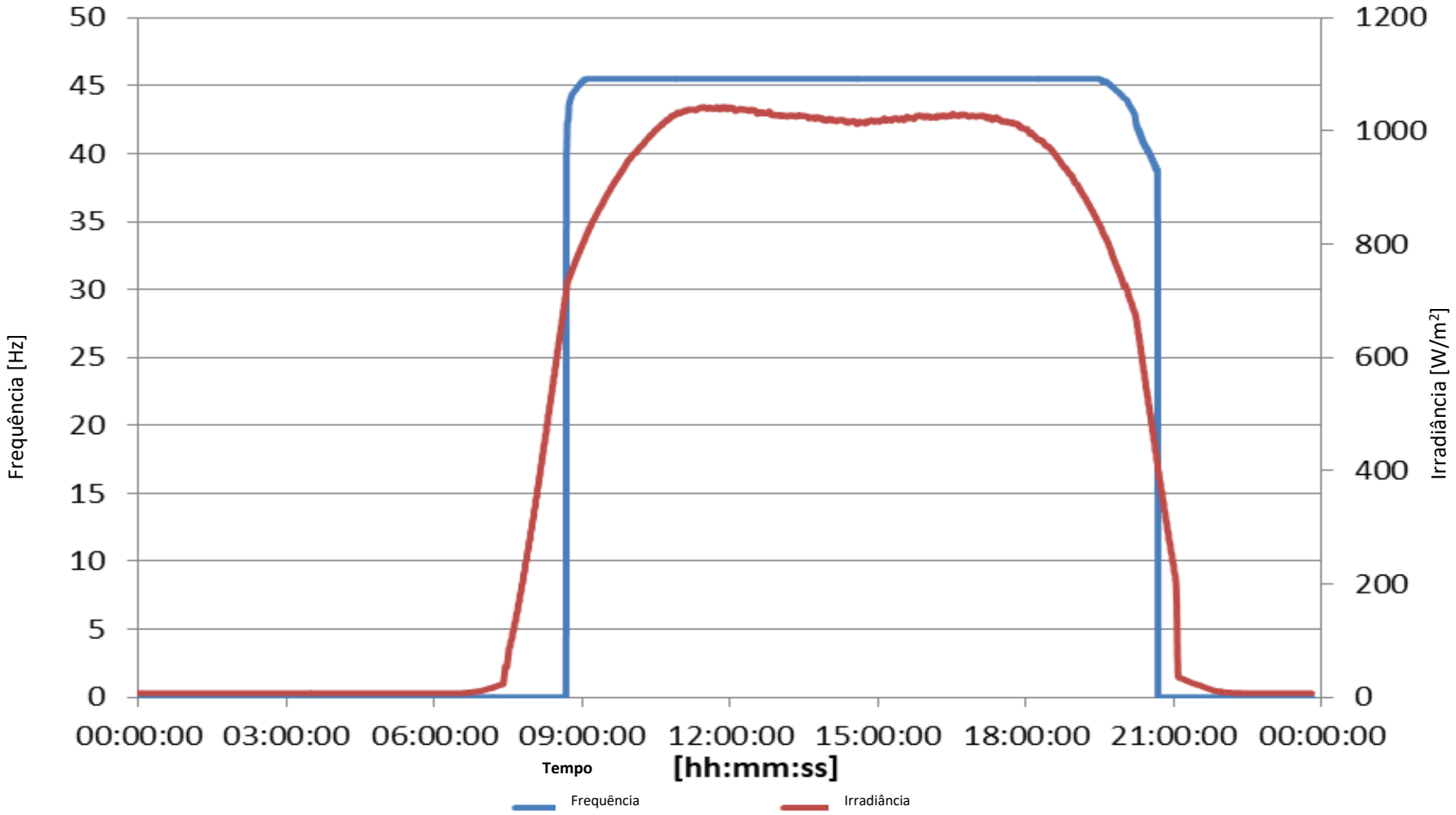
# 3 de julio de 2017

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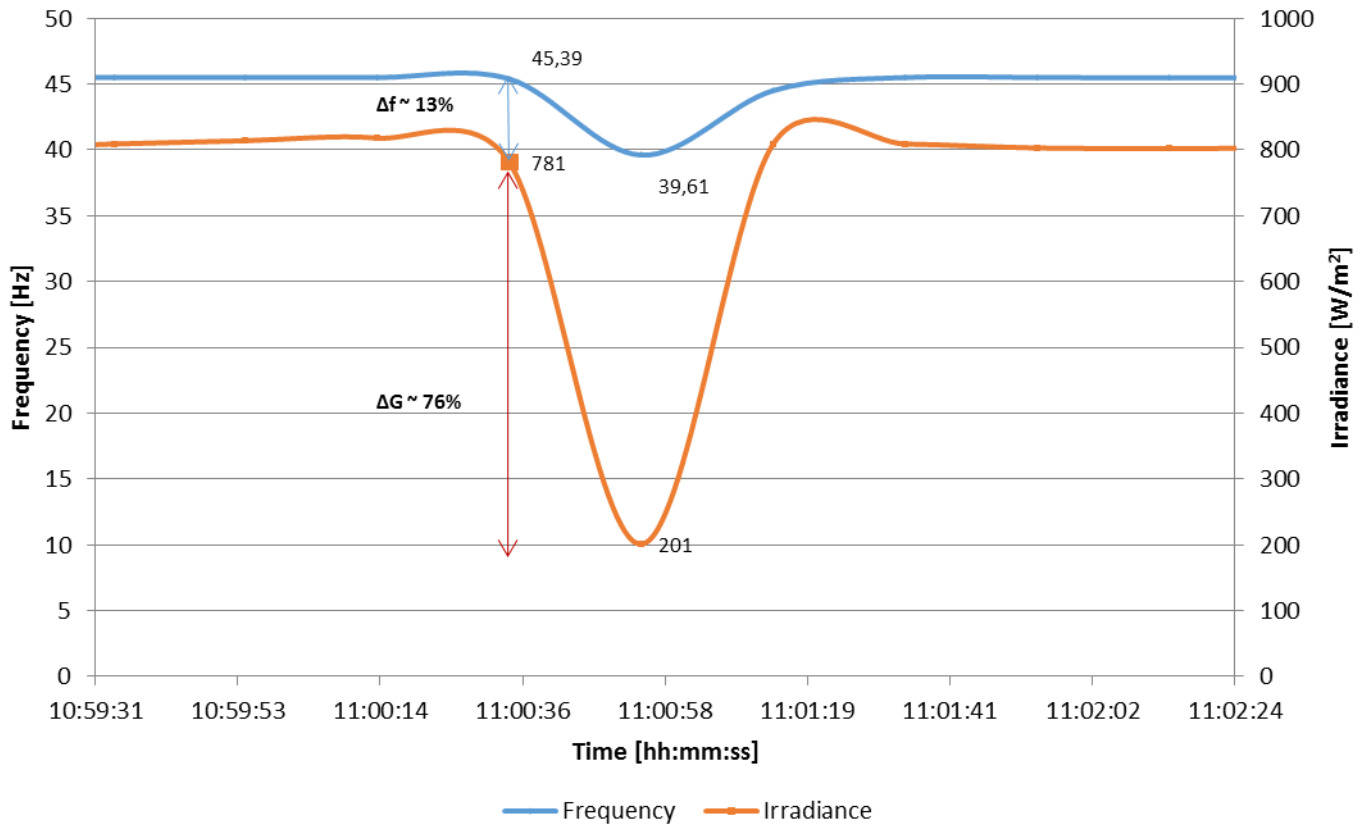
# 19 de octubre de 2017

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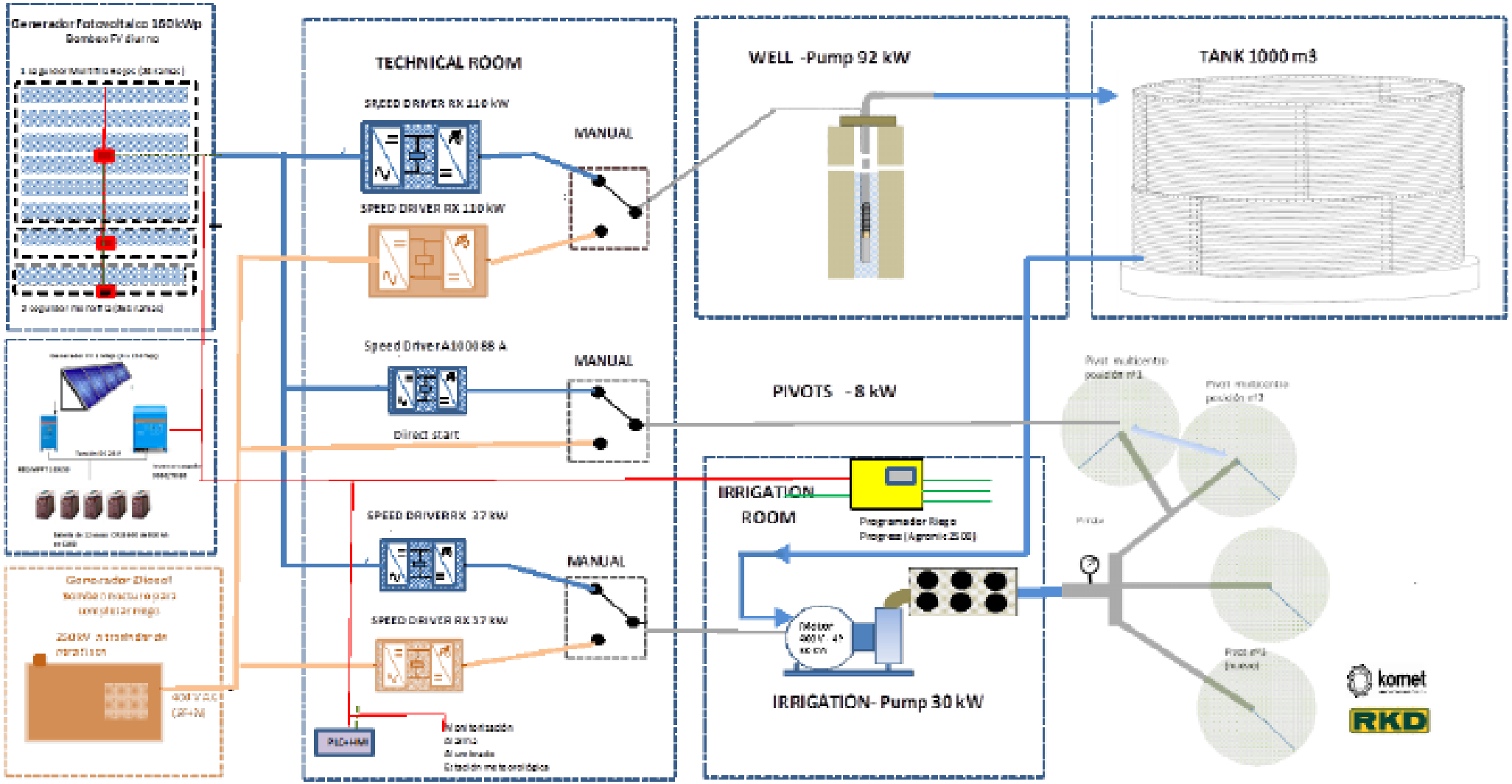
# Ejemplo: Alaejos

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# Ejemplo: Alaejos





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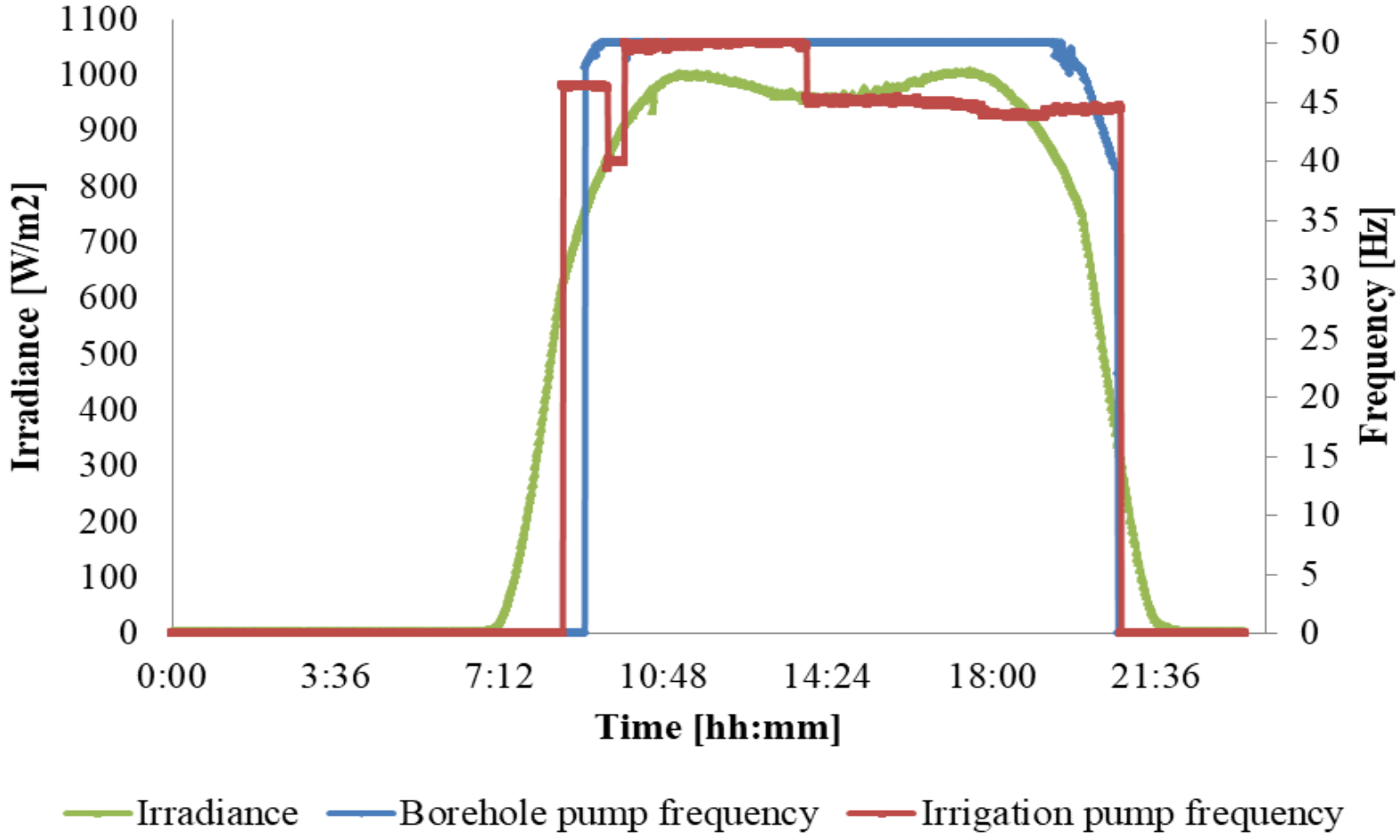
# 11 de julio de 2017

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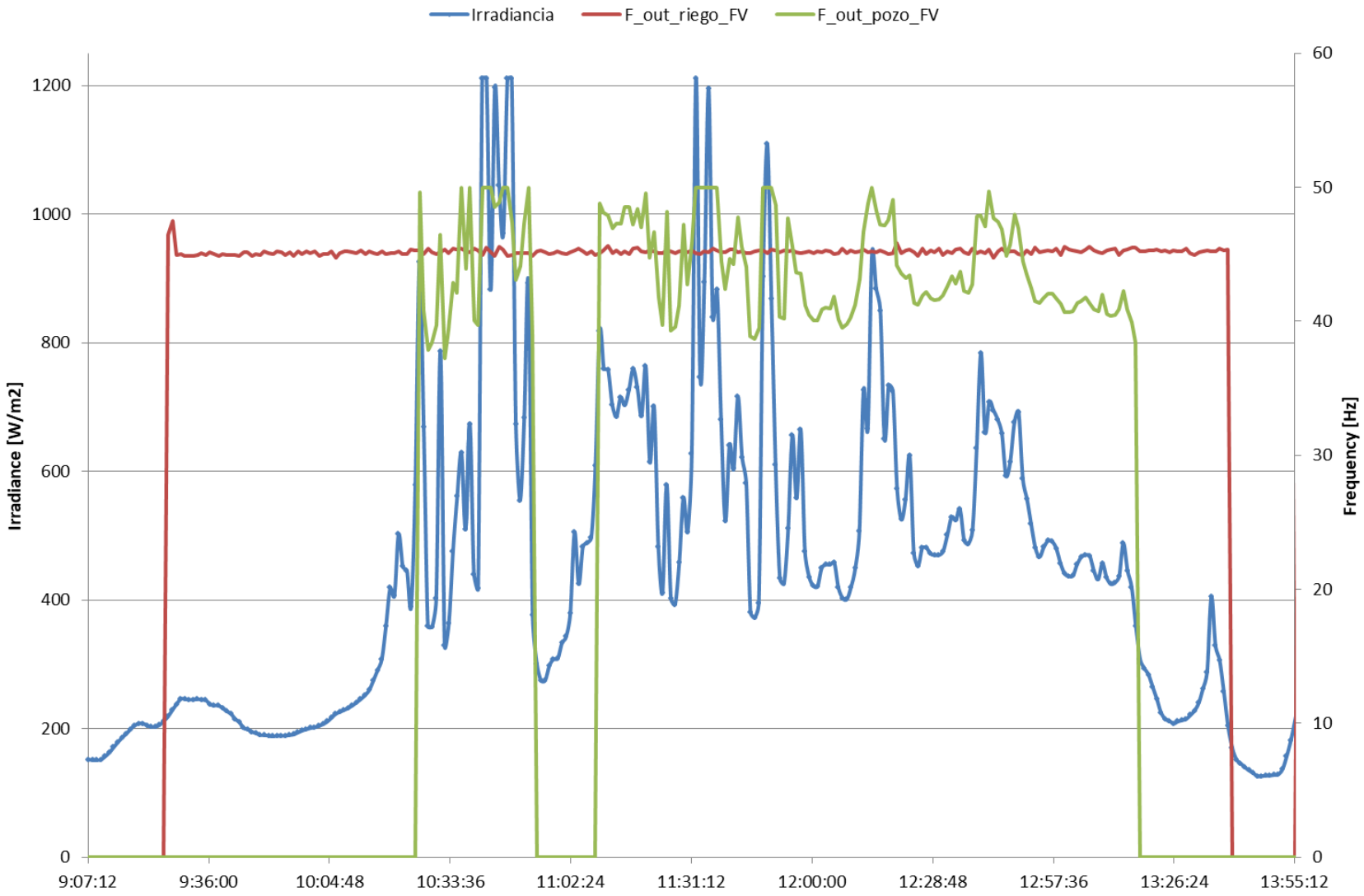
# 9 de junio de 2018

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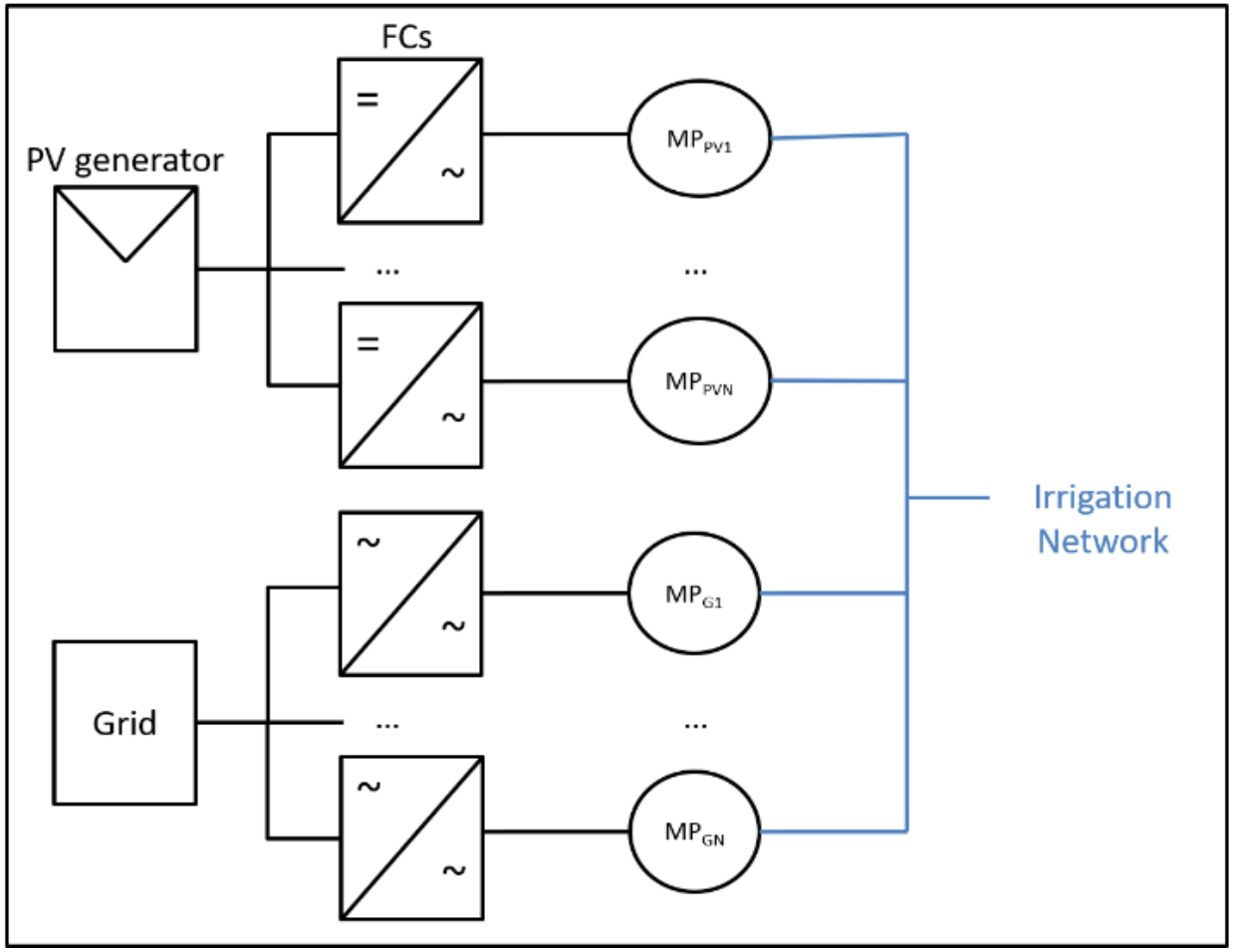
# SRFV híbrido hidráulico

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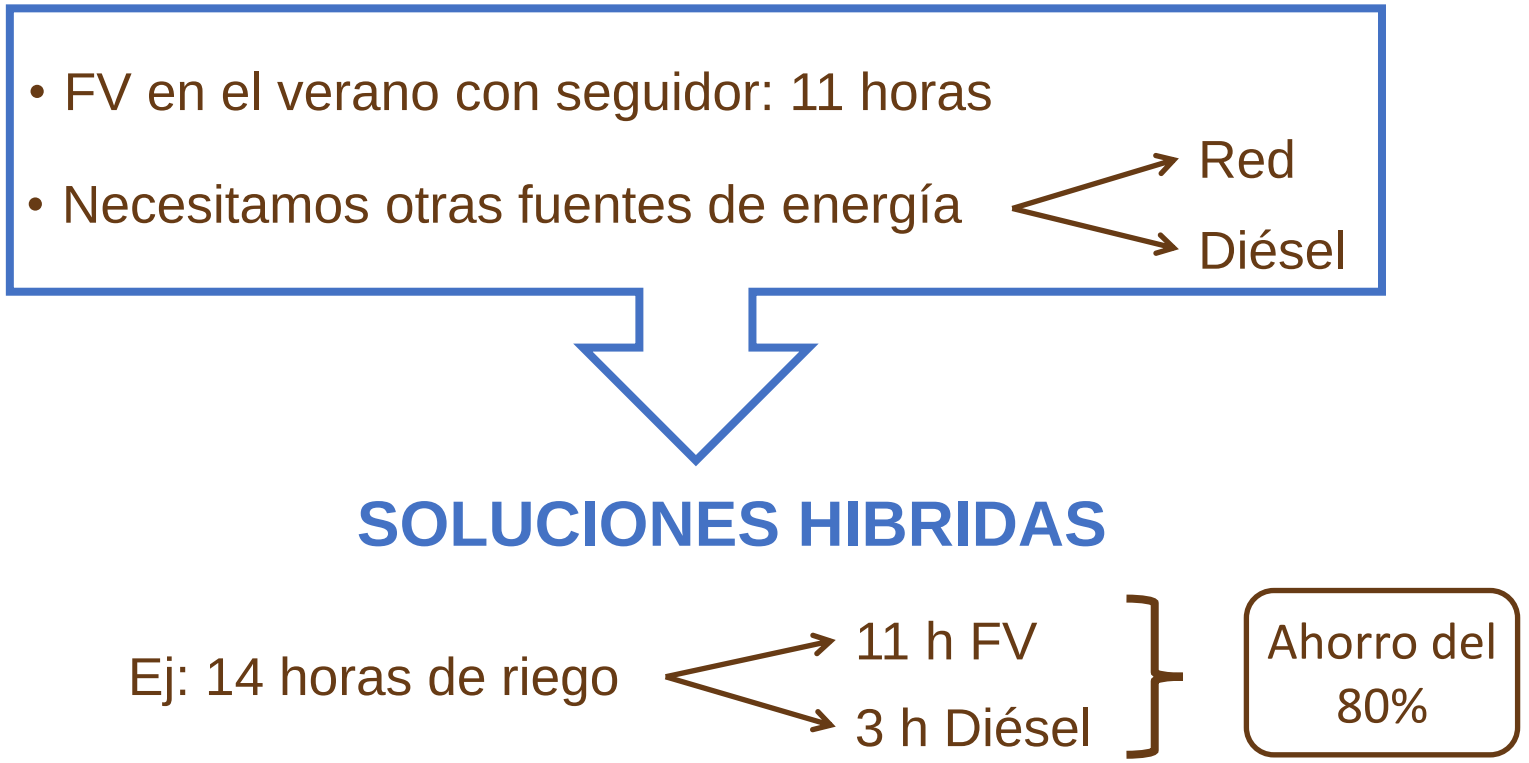
# ¿Por qué un sistema hibrido?

- ¿Qué soluciones para riegos con más de 11 horas al dia?

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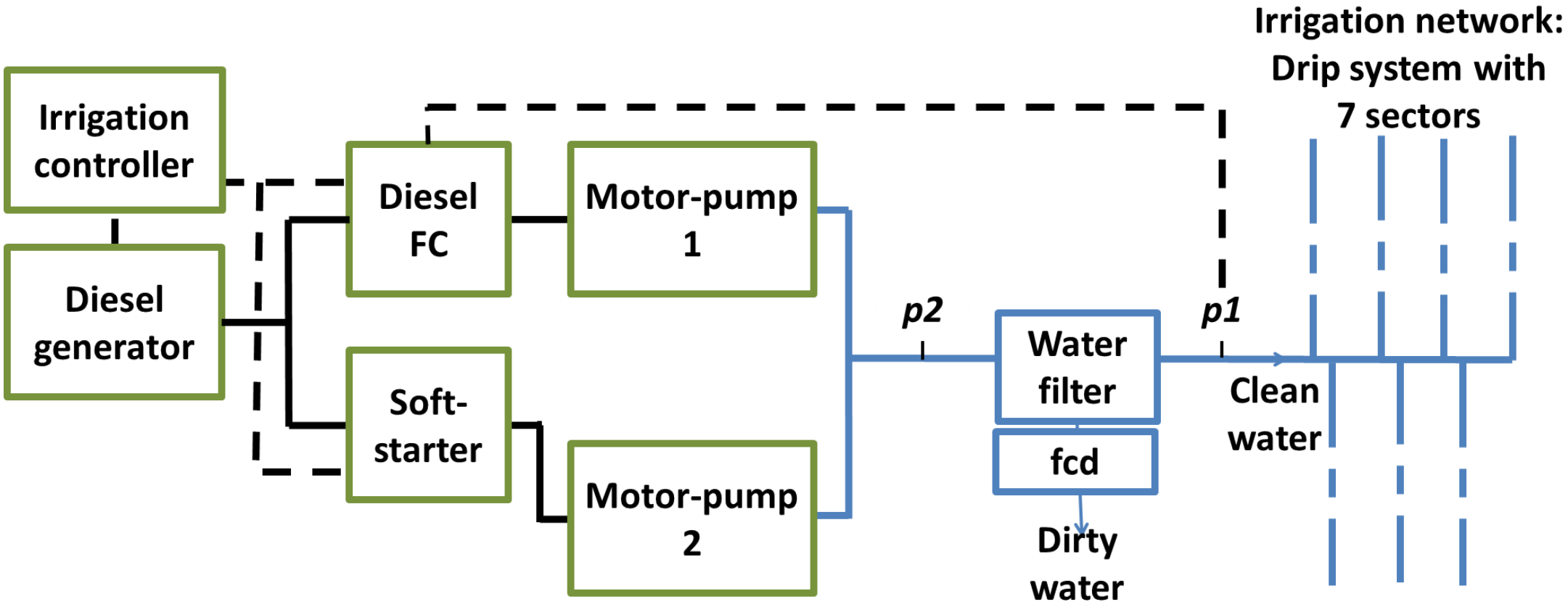
# Ejemplo: Alter do Chão

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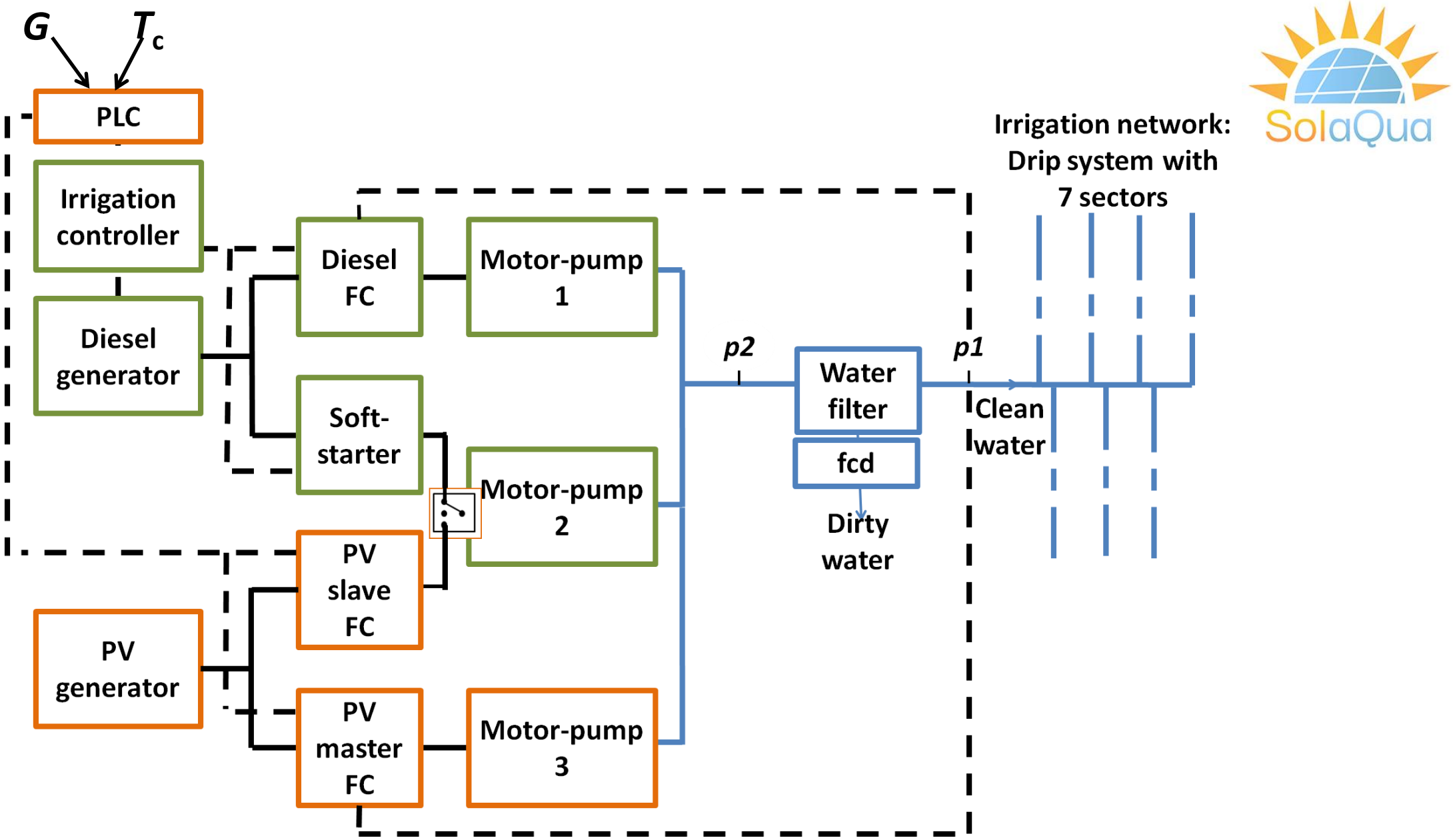


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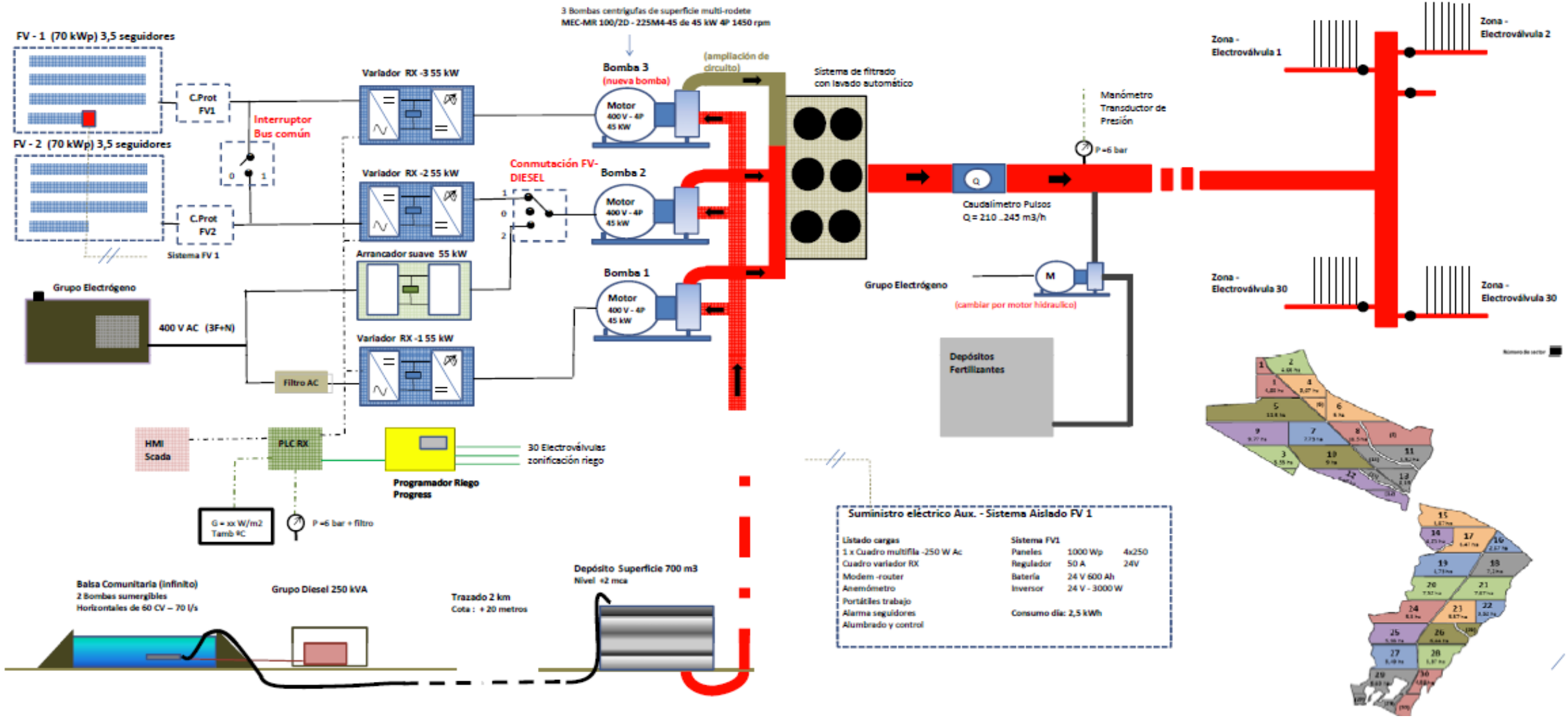


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# Ejemplo: Alter do Chão

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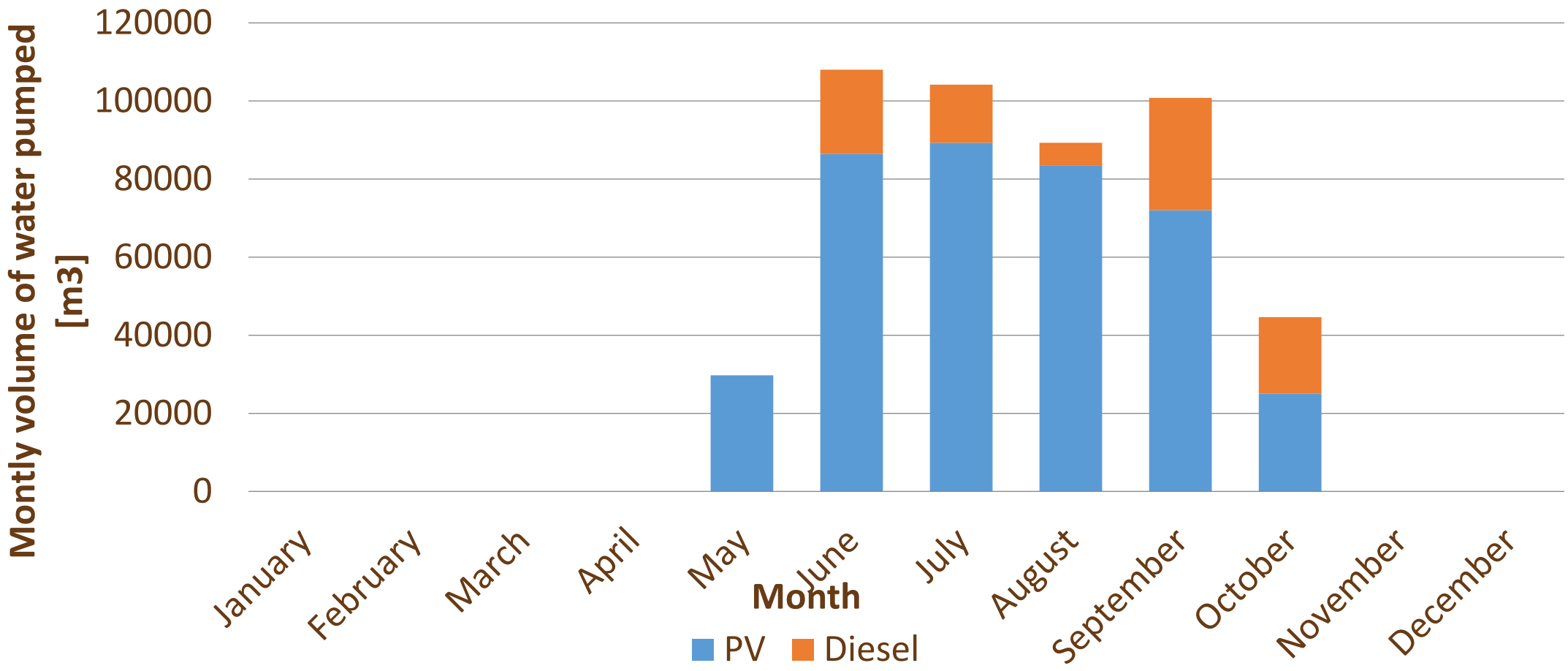
# FV vs. diésel

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# Indicadores de calidad

- Paso de nube
- Índice de rendimiento para SRFV

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# Paso de nube

$$\sigma_{cloud} = \frac{\#\text{nubes resistidas}}{\#\text{nubes}}$$

$$\sigma_{cloud} \geq 95\%$$

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# Paso de nube

| Año | $\sigma_{nube}$ (4 s) (%) | $\sigma_{nube}$ (3 s) (%) | $\sigma_{nube}$ (3 s cum.) (%) |
|---|---|---|---|
| **Antes** | 61.0 | **46.9** | 65.0 |
| **Después** | 96.9 | **95.1** | 97.9 |

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# Índice de rendimiento para SRFV

Índice de rendimiento FV en conexión a red:

$$PR = \frac{E_{\mathrm{PV}}}{P^*/G^*} \times \frac{1}{\int G dt}$$

Siempre que hay irradiancia, se inyecta

Problemática en riego FV:

- Factores externos que impiden aprovechar la energía FV

No siempre que hay irradiancia, se inyecta

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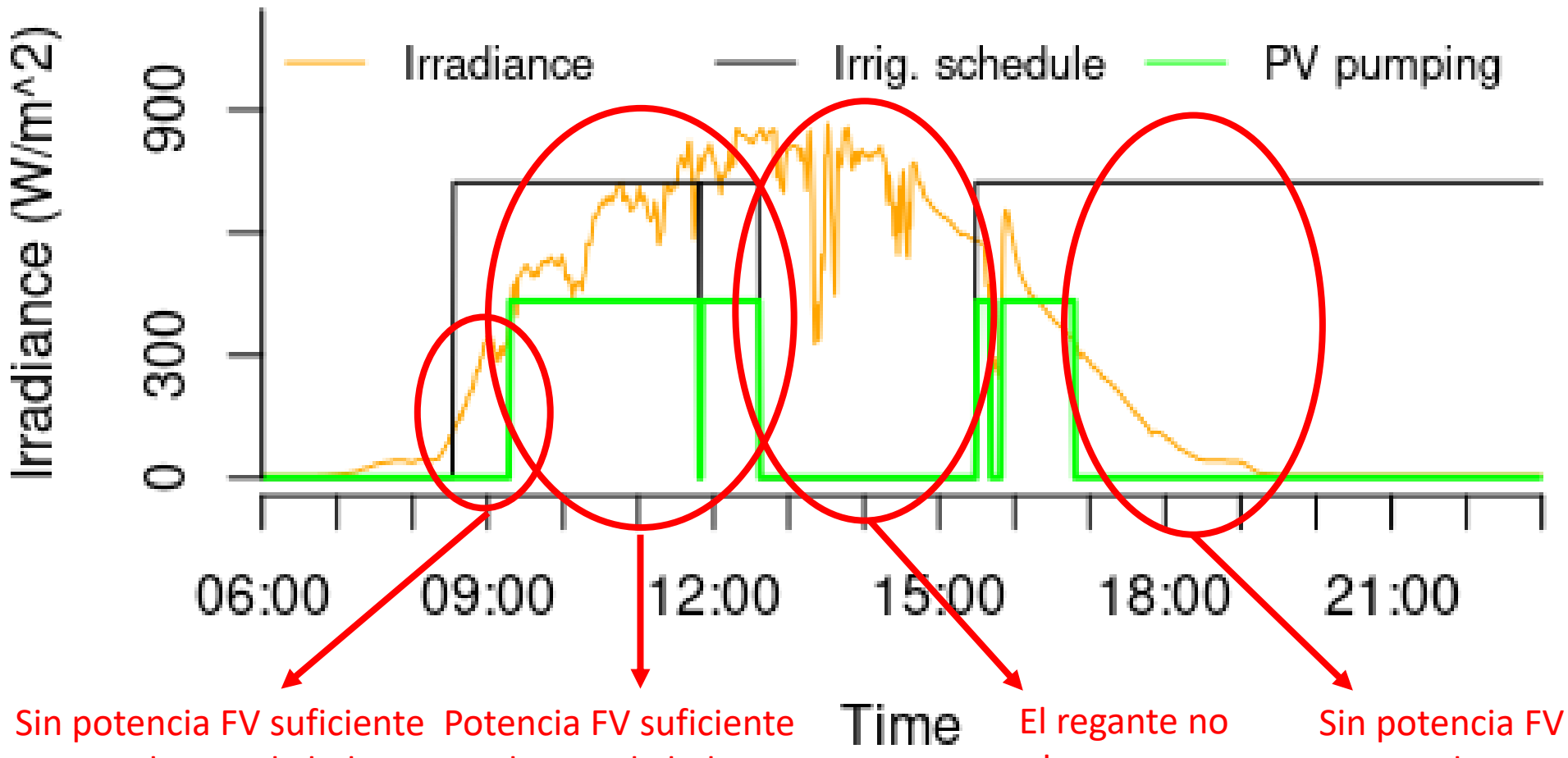
# Situaciones de desaprovechamiento FV




Sin potencia FV suficiente para alcanzar la balsa

Potencia FV suficiente para alcanzar la balsa. Hay potencia FV sobrante

El regante no desea regar

Sin potencia FV suficiente para alcanzar la balsa

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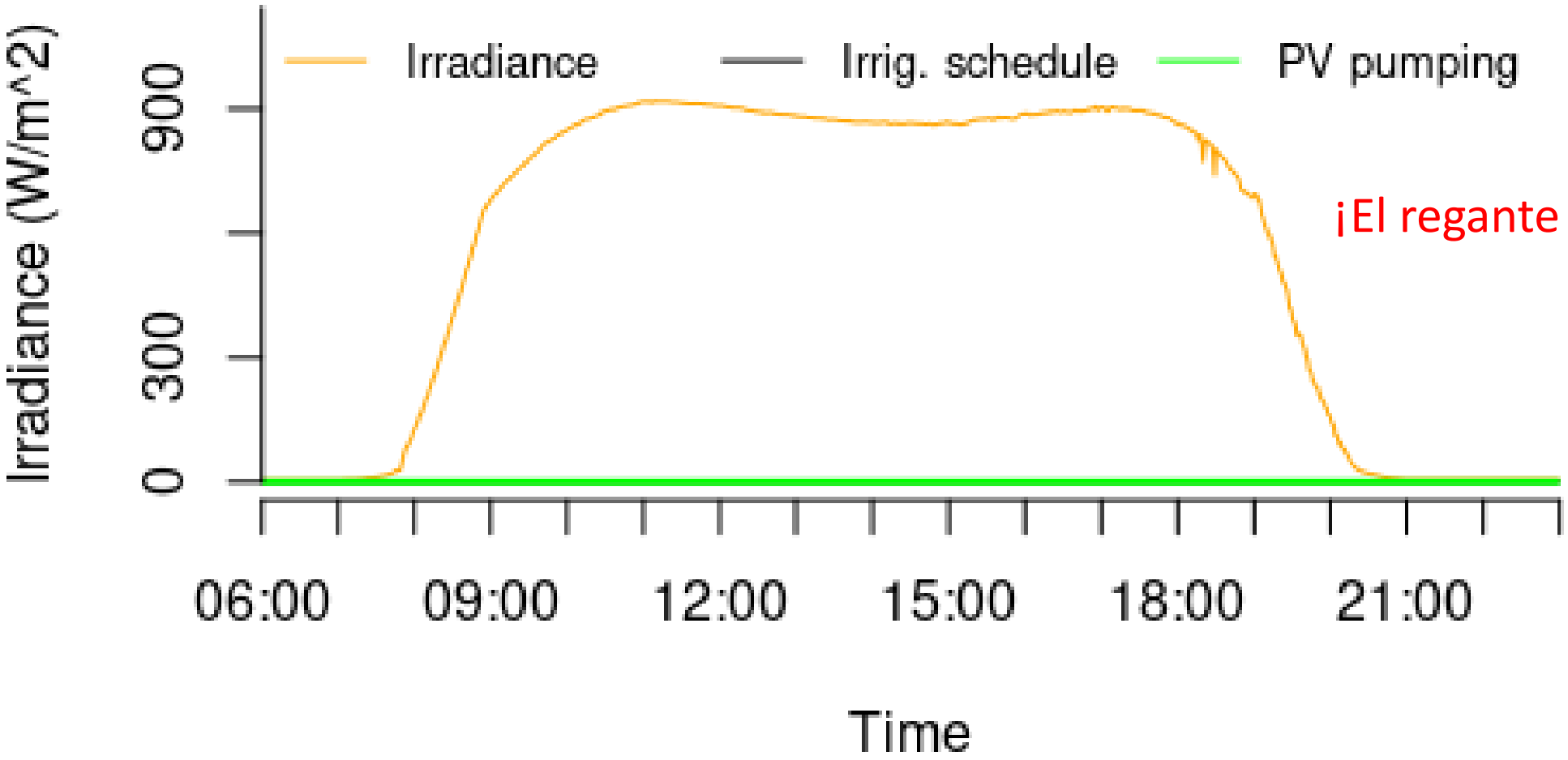
# Situaciones de desaprovechamiento FV




¡El regante no desea regar!

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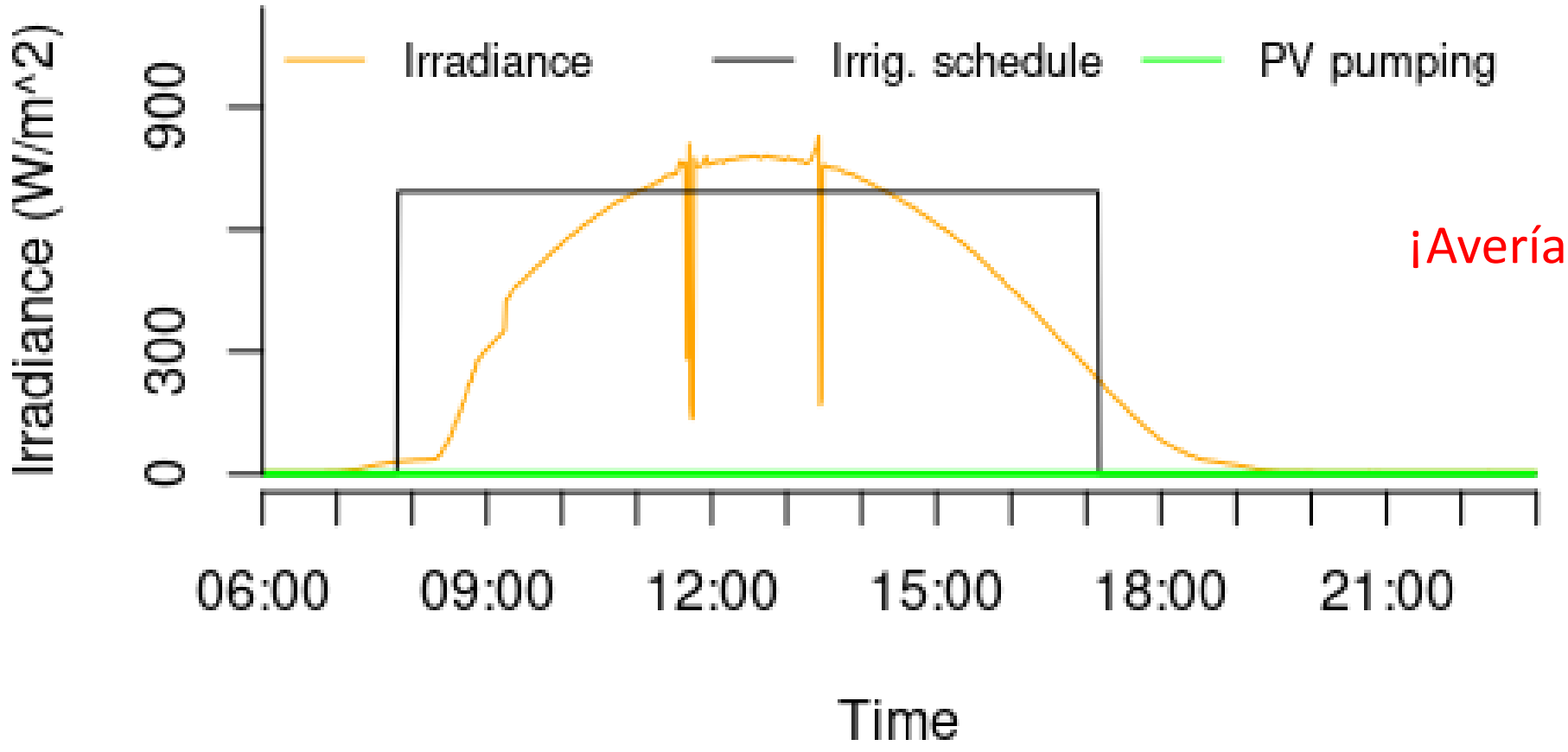
# Situaciones de desaprovechamiento FV




¡Avería en el SRFV!

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# Índice de rendimiento para SRFV

**Factorización del PR:**

$$PR = \frac{E_{\mathrm{PV}}}{P^*/G^*} \times \frac{1}{\int G dt}$$

$$PR = PR_{\mathrm{PV}} \times UR_{\mathrm{IP}} \times UR_{\mathrm{PVIS}} \times UR_{\mathrm{EF}}$$

$$PR_{\mathrm{PV}} = \frac{E_{\mathrm{PV}}}{P^*/G^*} \times \frac{1}{\int G_{\mathrm{used}} dt}; \quad UR_{\mathrm{IP}} = \frac{\int_{\mathrm{IP}} G dt}{\int G dt}; \quad UR_{\mathrm{PVIS}} = \frac{\int G_{\mathrm{useful}} dt}{\int_{\mathrm{IP}} G dt}; \quad UR_{\mathrm{EF}} = \frac{\int G_{\mathrm{used}} dt}{\int G_{\mathrm{useful}} dt}$$

Índice de rendimiento del riego FV

Ratio de Uso asociado al Periodo de Riego

Ratio de Uso asociada al sistema hidráulico

Ratio de Uso Efectivo del regante

# Índice de rendimiento para SRFV

**Factorización del PR:** $PR = PR_{\mathrm{PV}} \times UR_{\mathrm{IP}} \times UR_{\mathrm{PVIS}} \times UR_{\mathrm{EF}}$

## Valores esperables:

- PR > 65%
- $PR_{PV}$ ≈ conexión a red
- $UR_{IP}$ depende de cultivo y tamaño de balsa
- $UR_{PVIS}$ se necesita más sistemas
- $UR_{EF}$ > 98%

# Visita Virtual 360º

## Aldeanueva de Ebro: 213 kWp

https://www.youtube.com/watch?v=qMn-HJdvizY

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¡Muchas gracias por su atención!

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