UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

INSTITUTO DE PESQUISAS HIDRÁULICAS

Internal Report

Detailing some effects of the combined use of storage devices on the performance of hydro PV hybrid systems based on complementary energy resources

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Porto Alegre, January 28, 2014.

CONTENTS

PRESENTATION

This report presents the results of computational simulation of hybrid systems based on PV and hydroelectric energy, as part of the doctoral thesis of the first author. The results were also used to build some graphics used in papers submitted to the journal Renewable Energy, Elsevier.

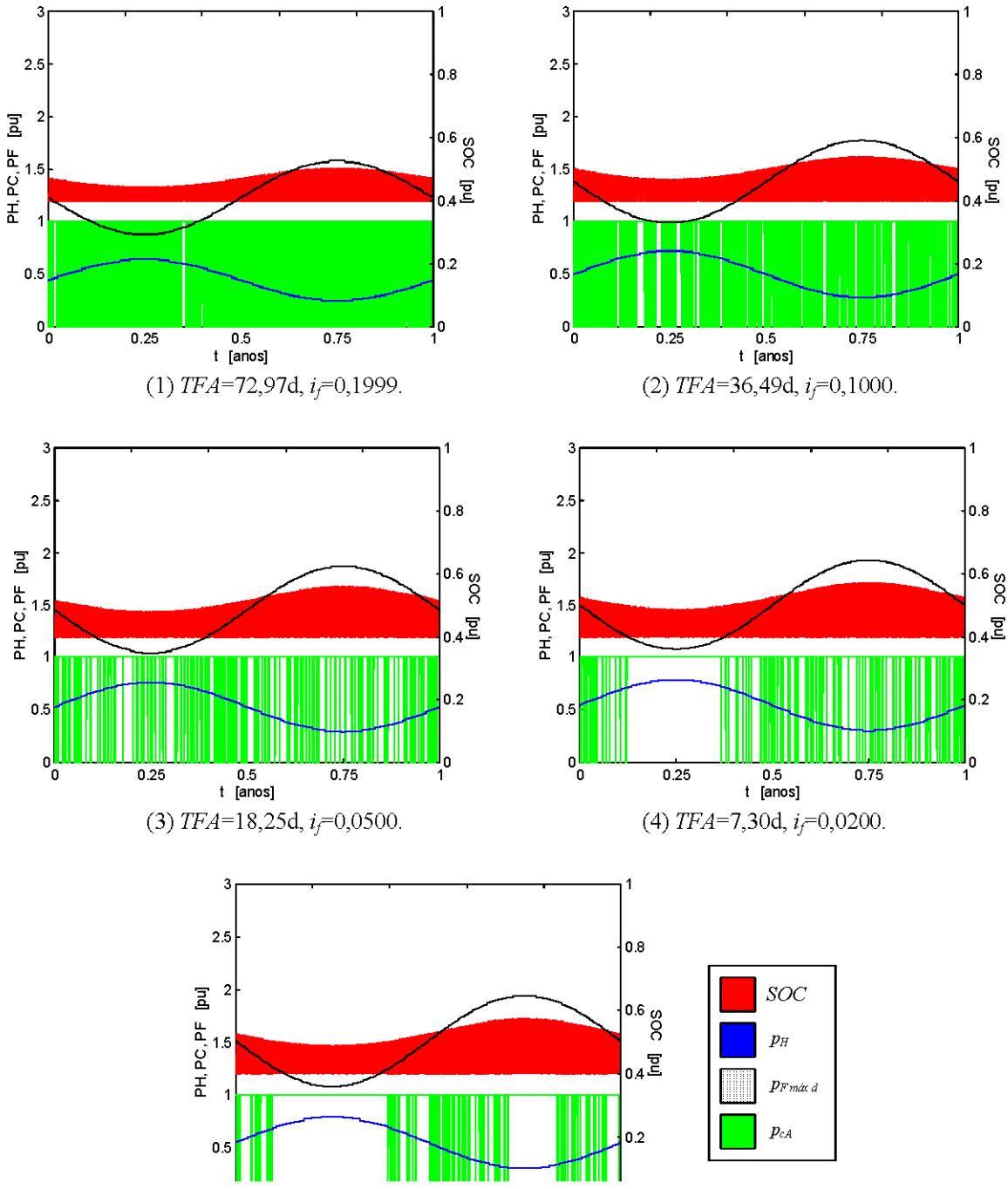

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FIGURE 1. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.

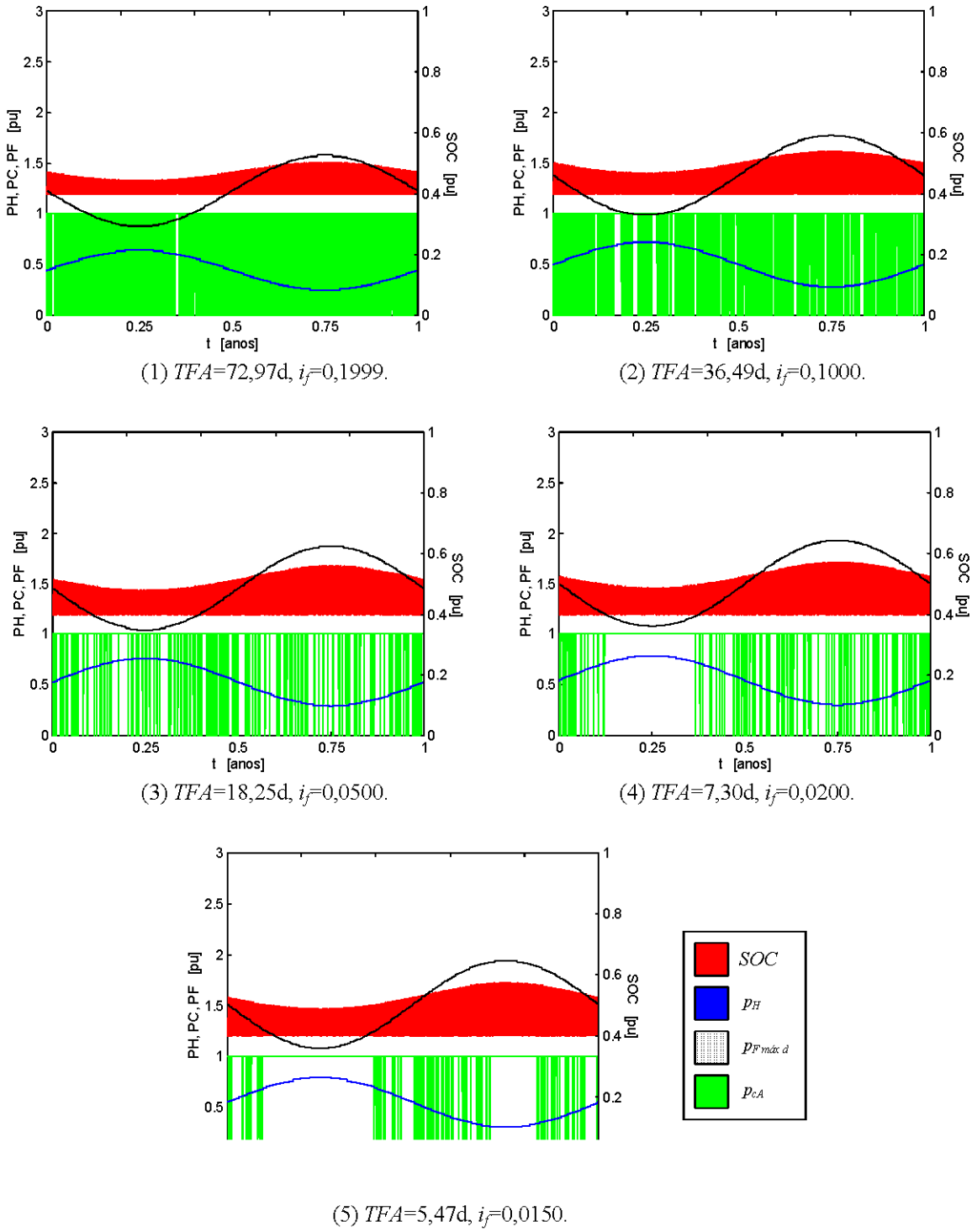

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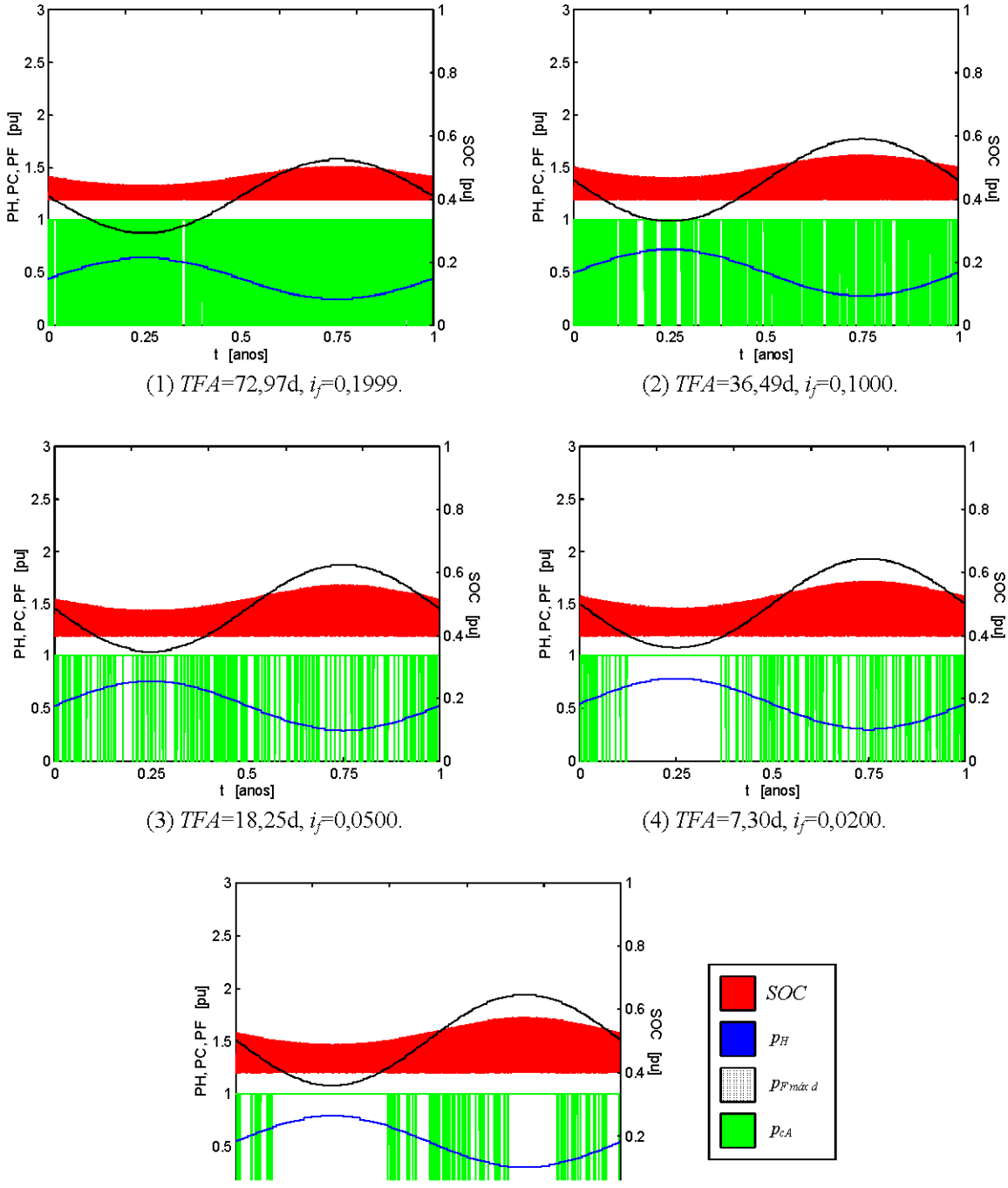
FIGURE 2. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



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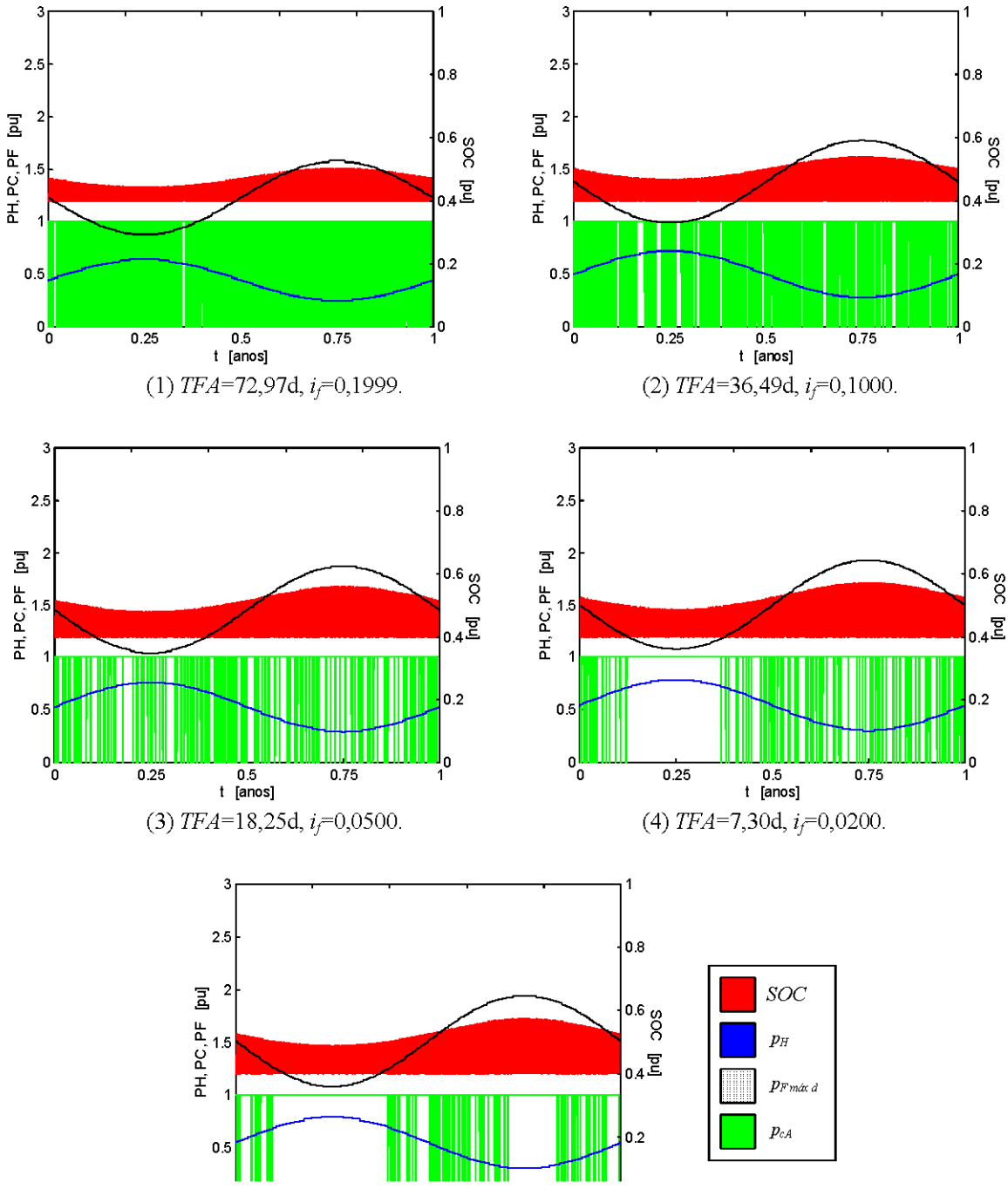

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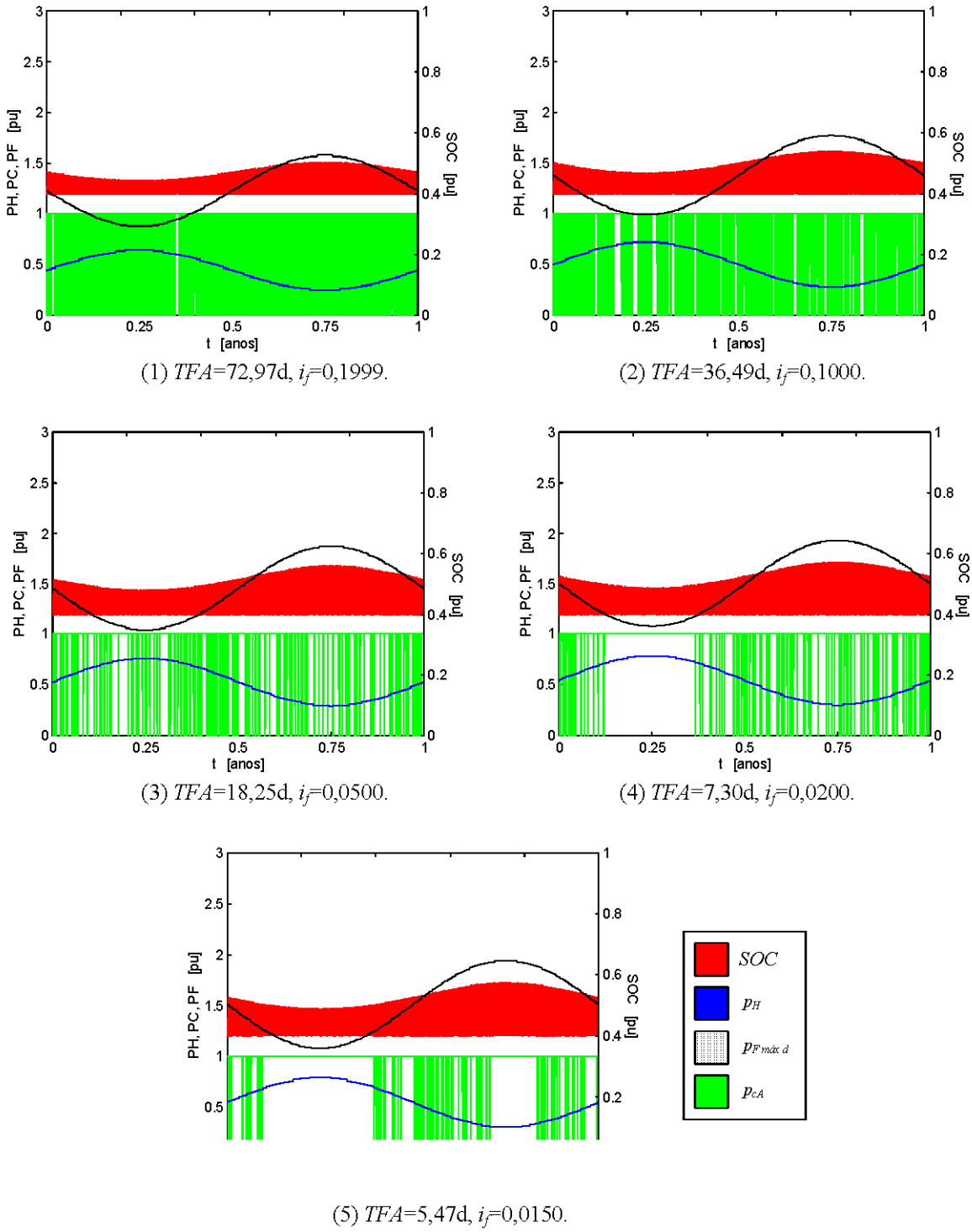
FIGURE 4. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



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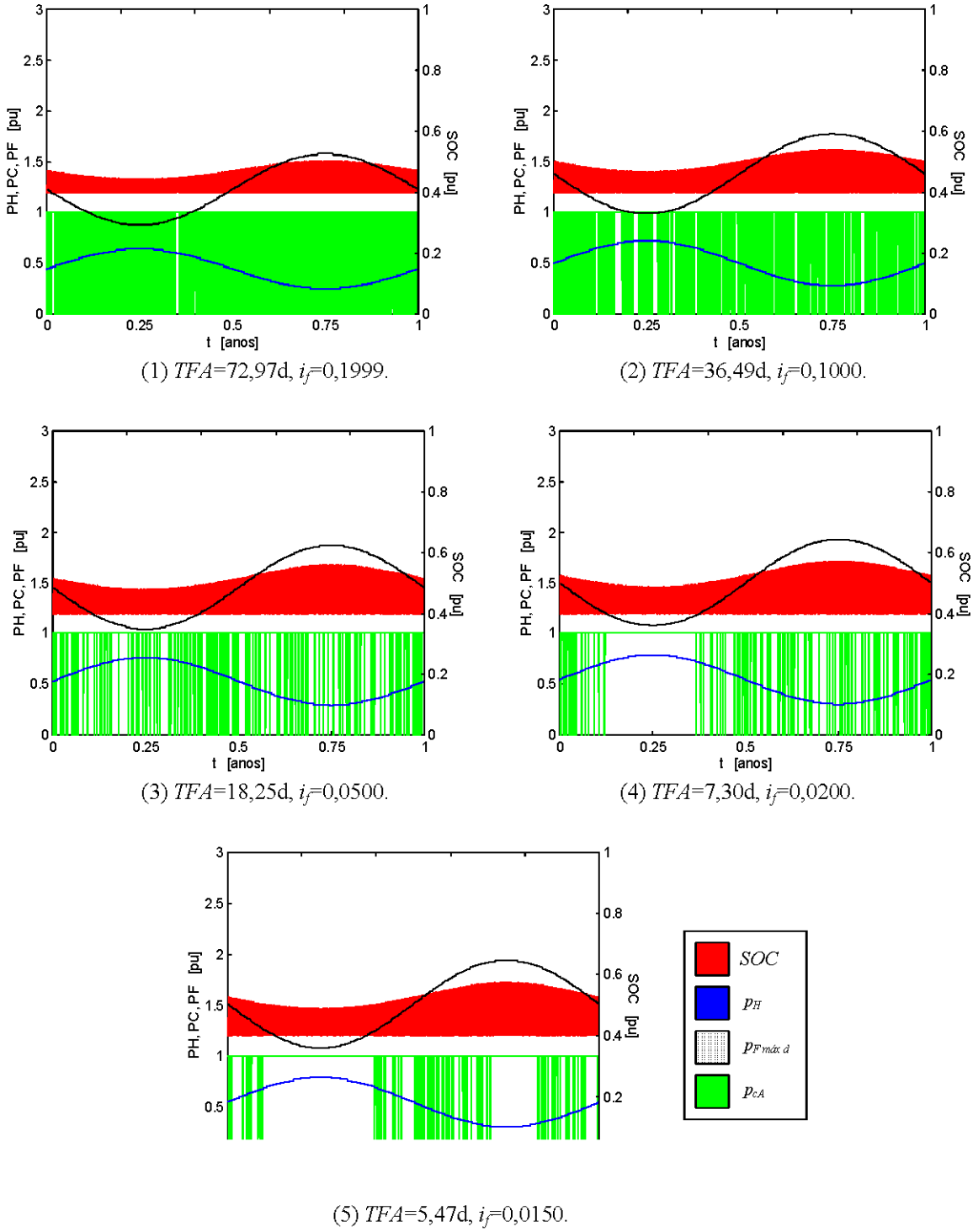

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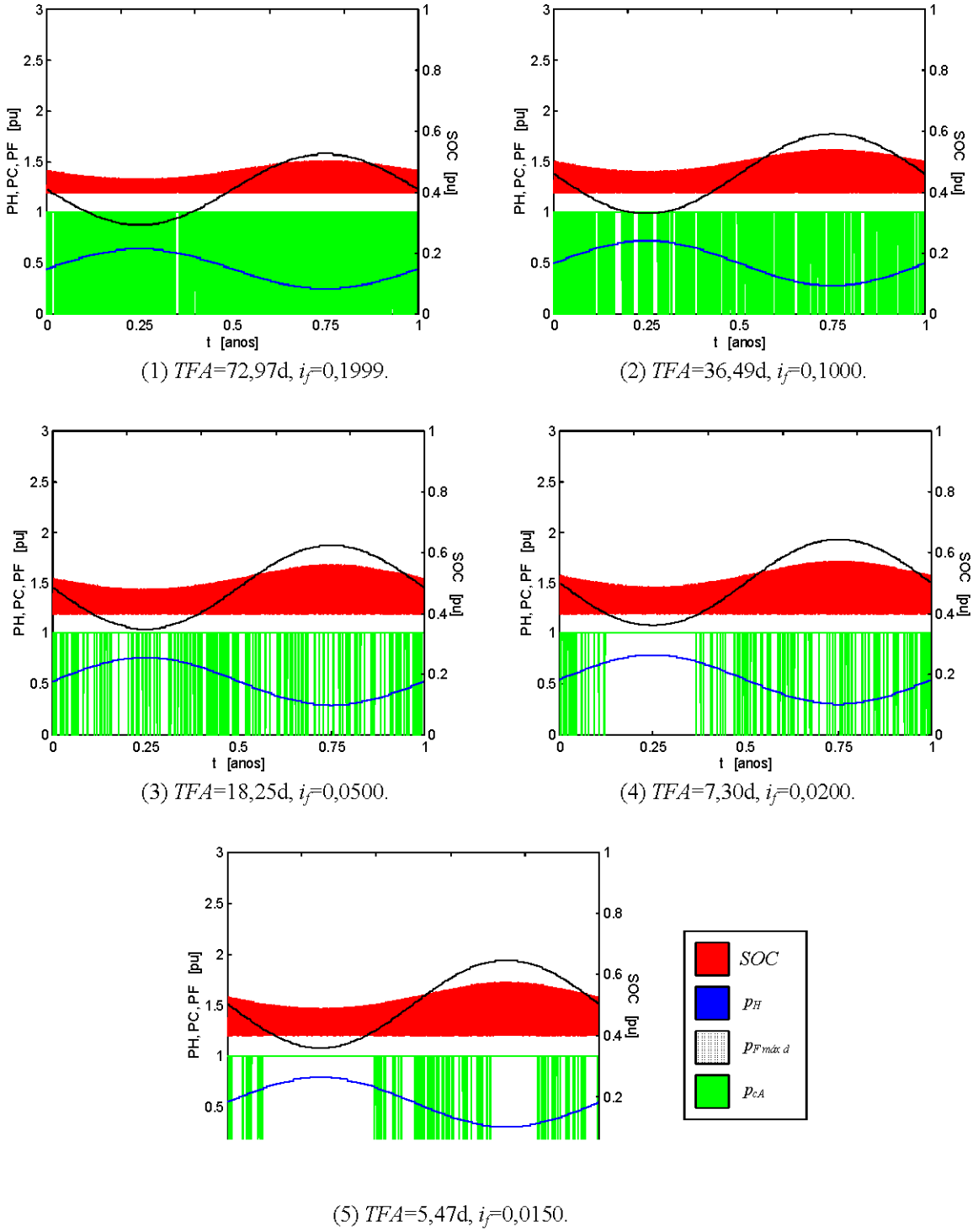
FIGURE 6. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



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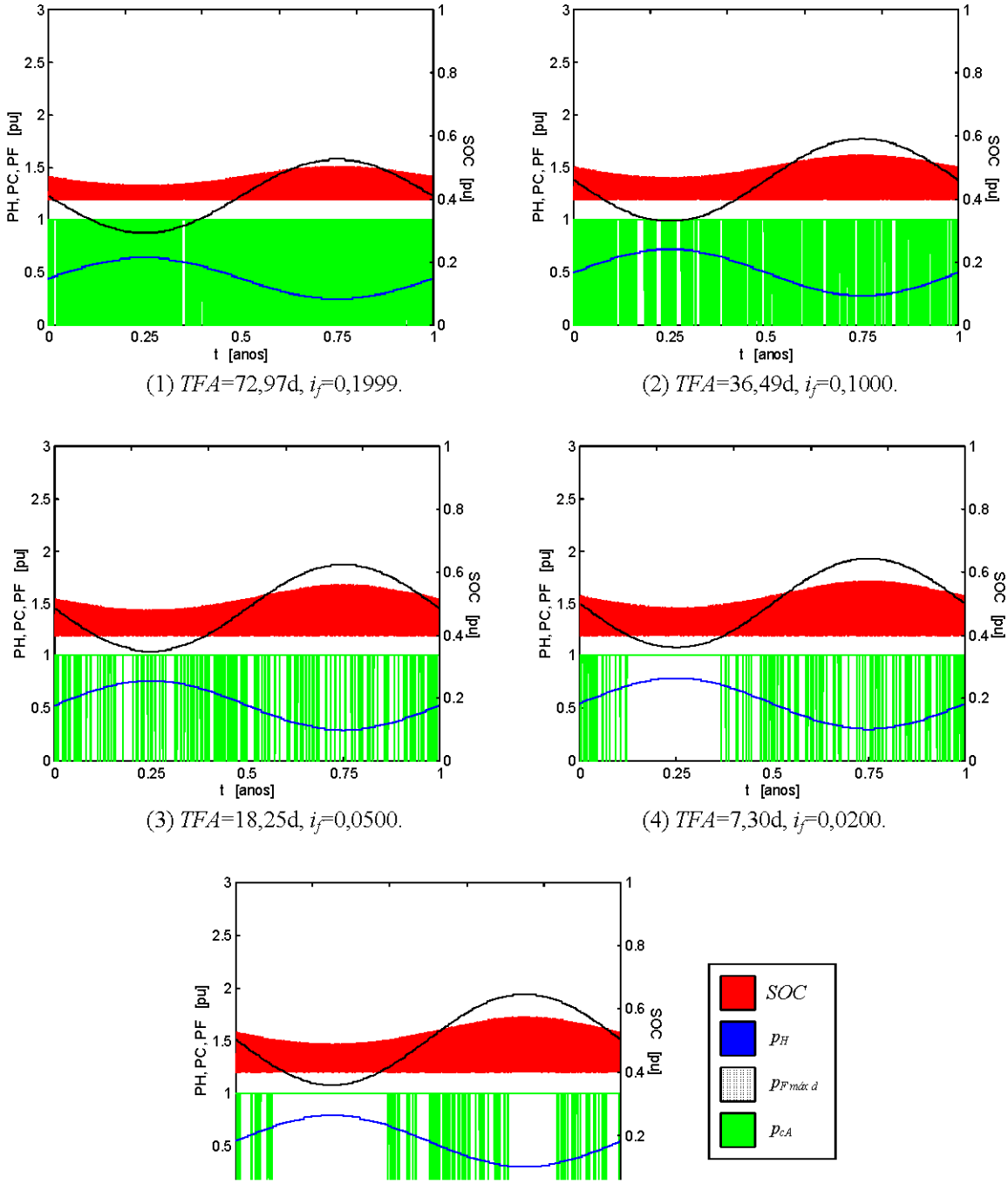

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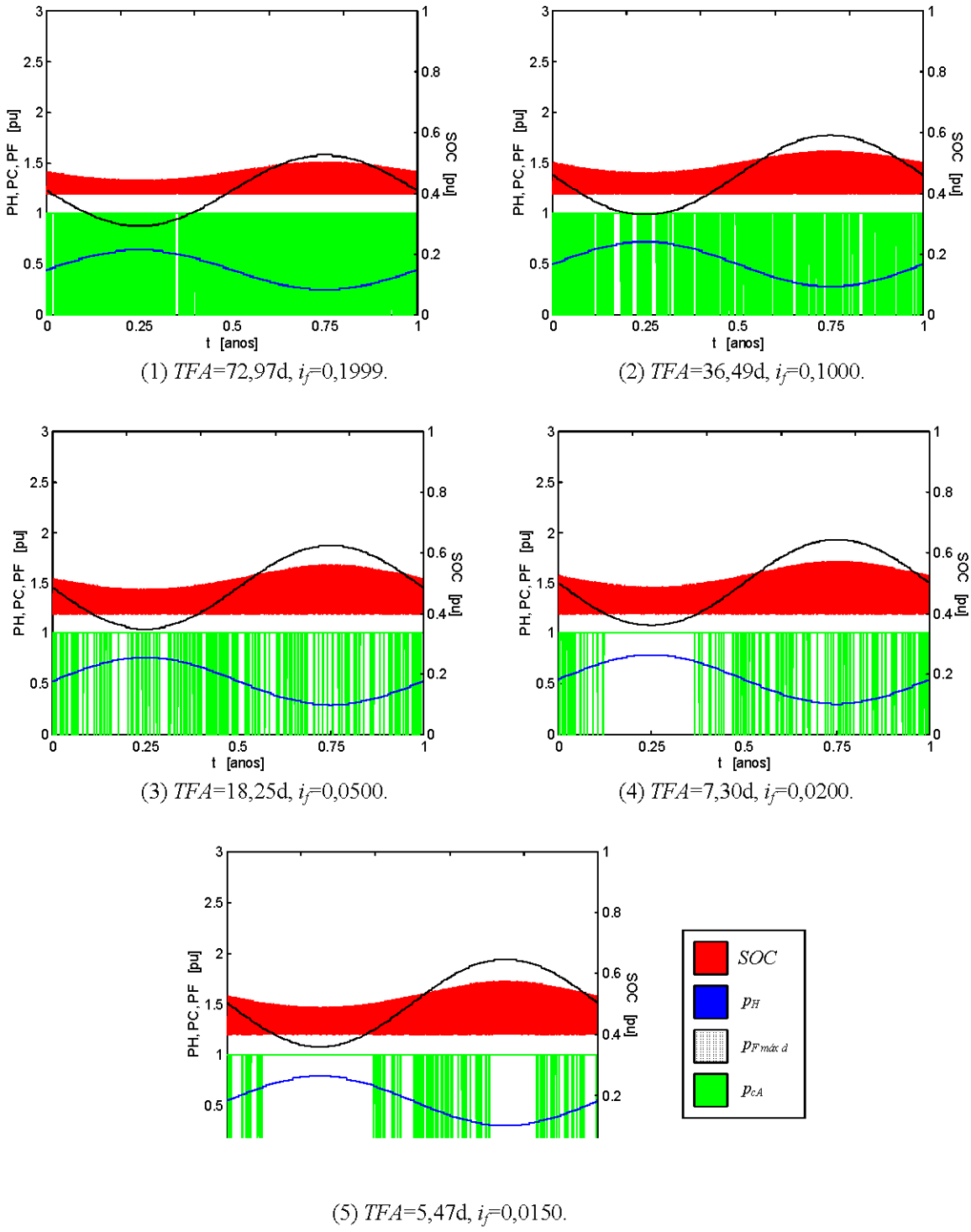

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FIGURE 9. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.

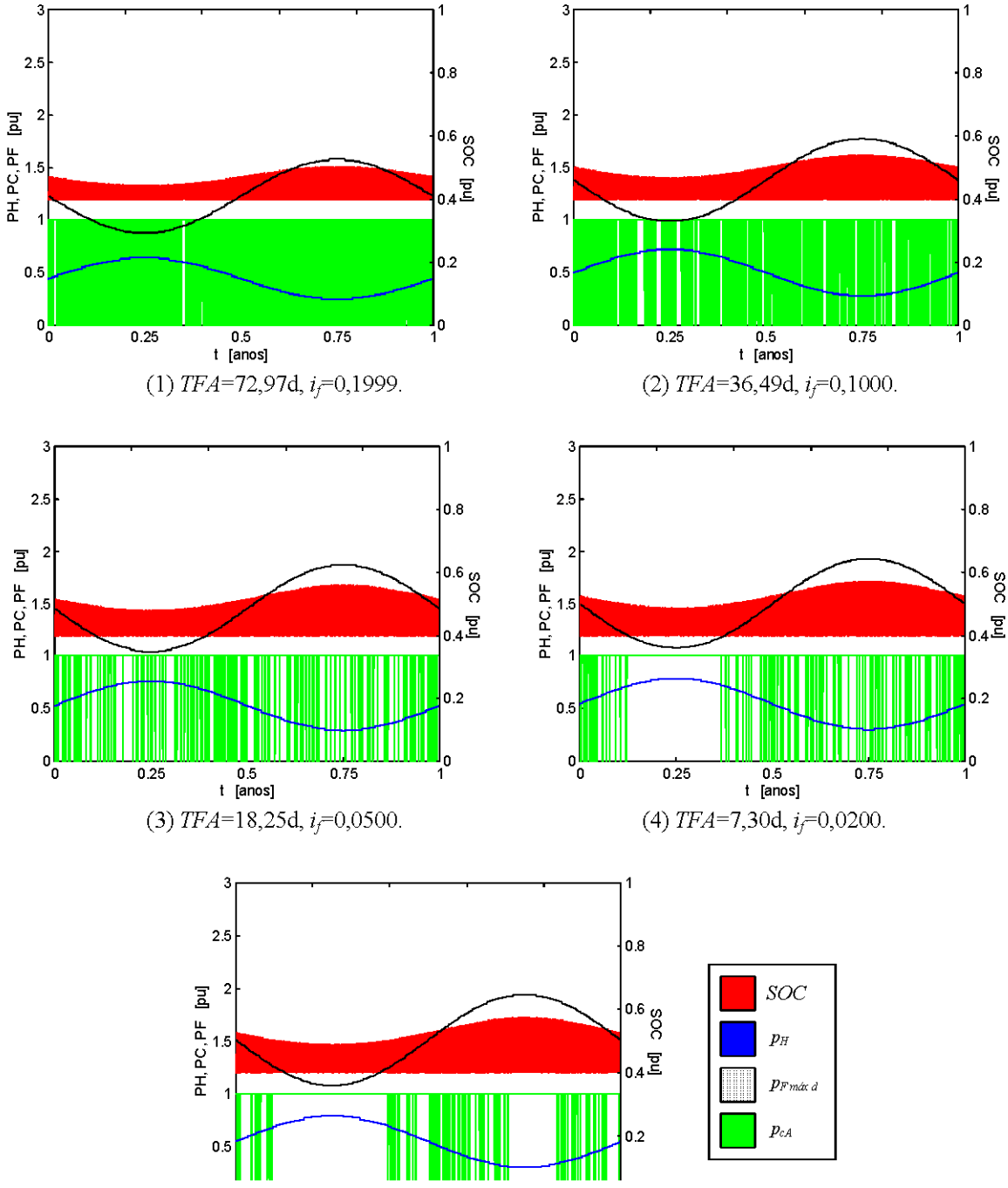

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FIGURE 10. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.

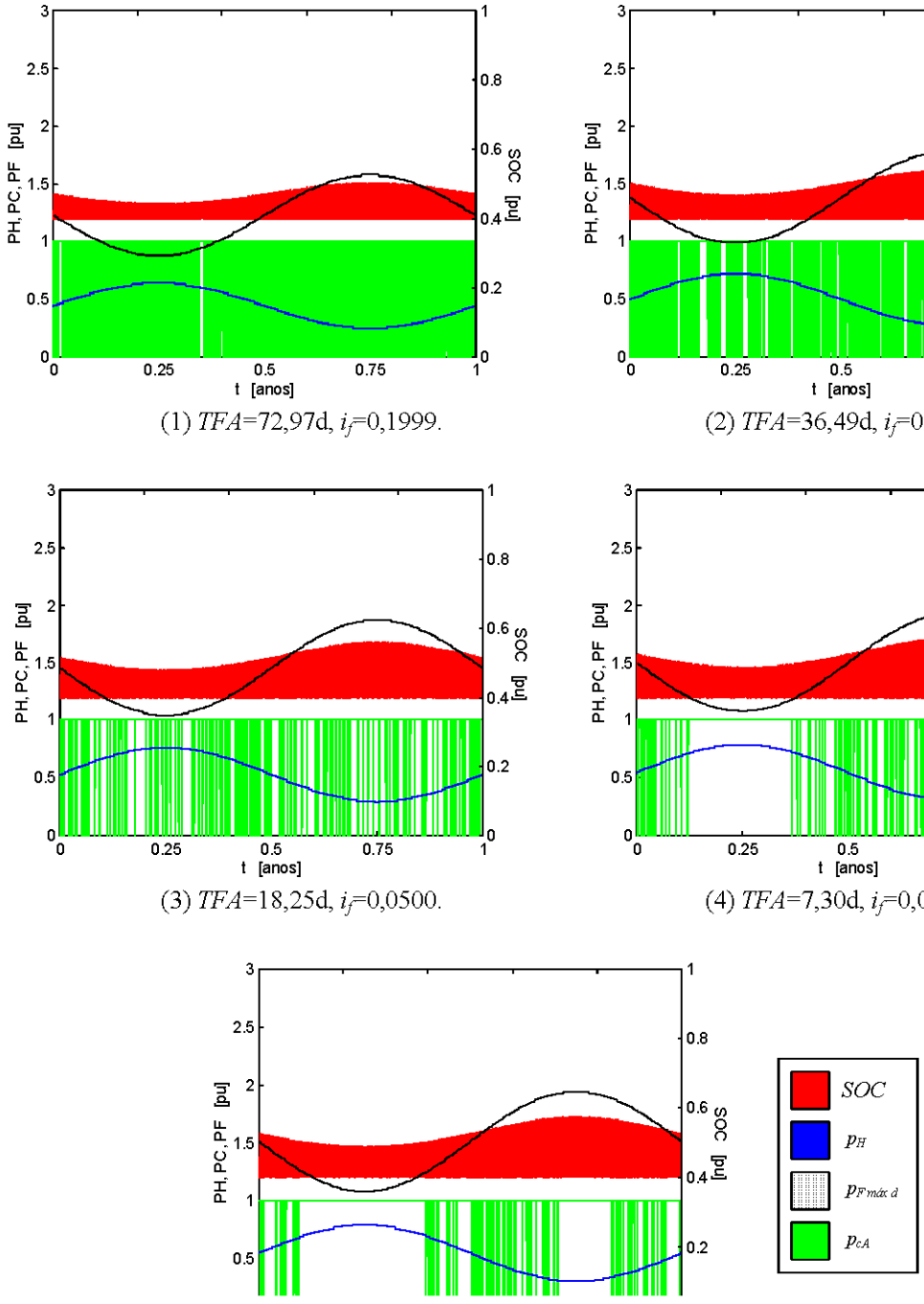

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FIGURE 11. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.

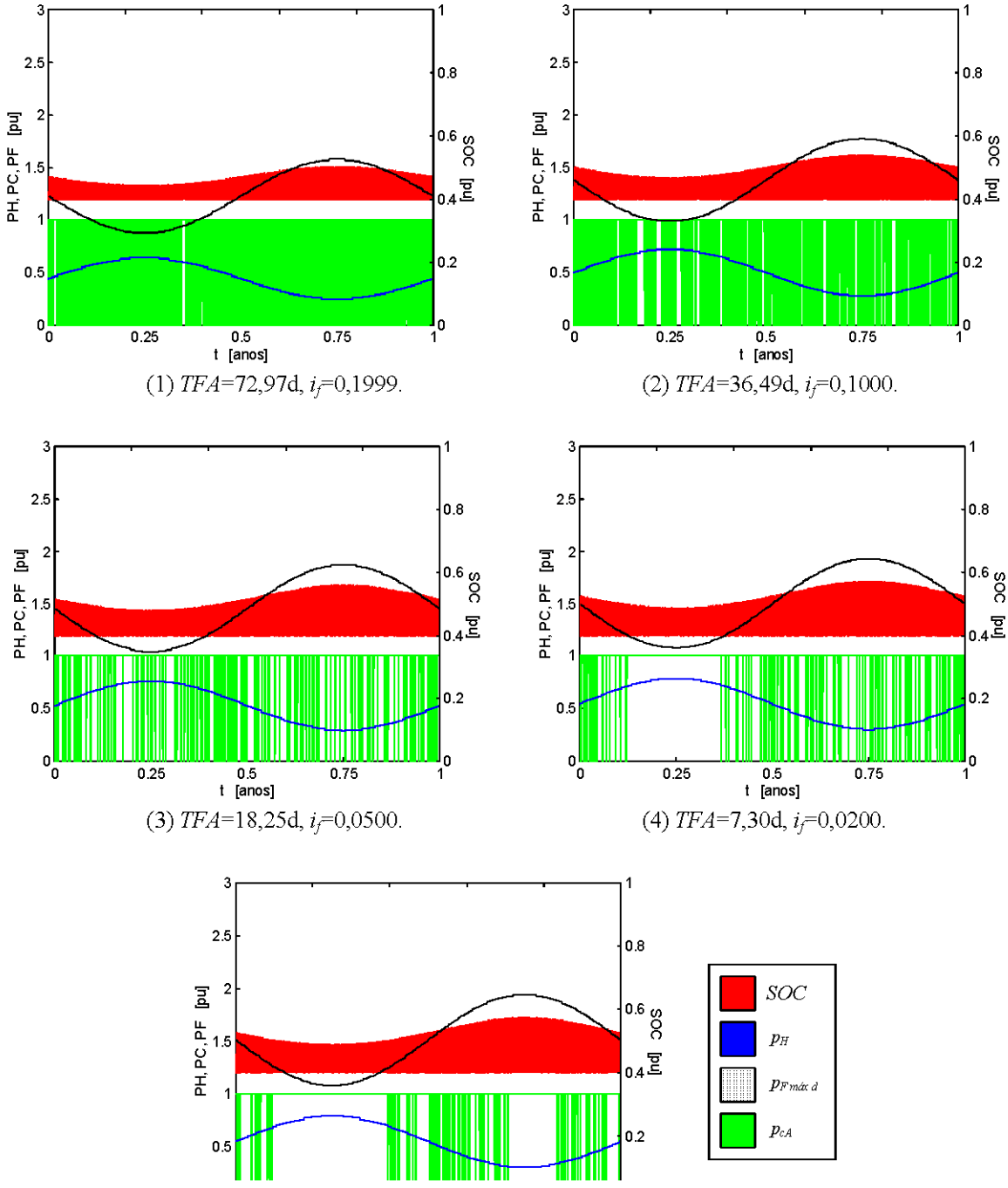

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FIGURE 12. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.

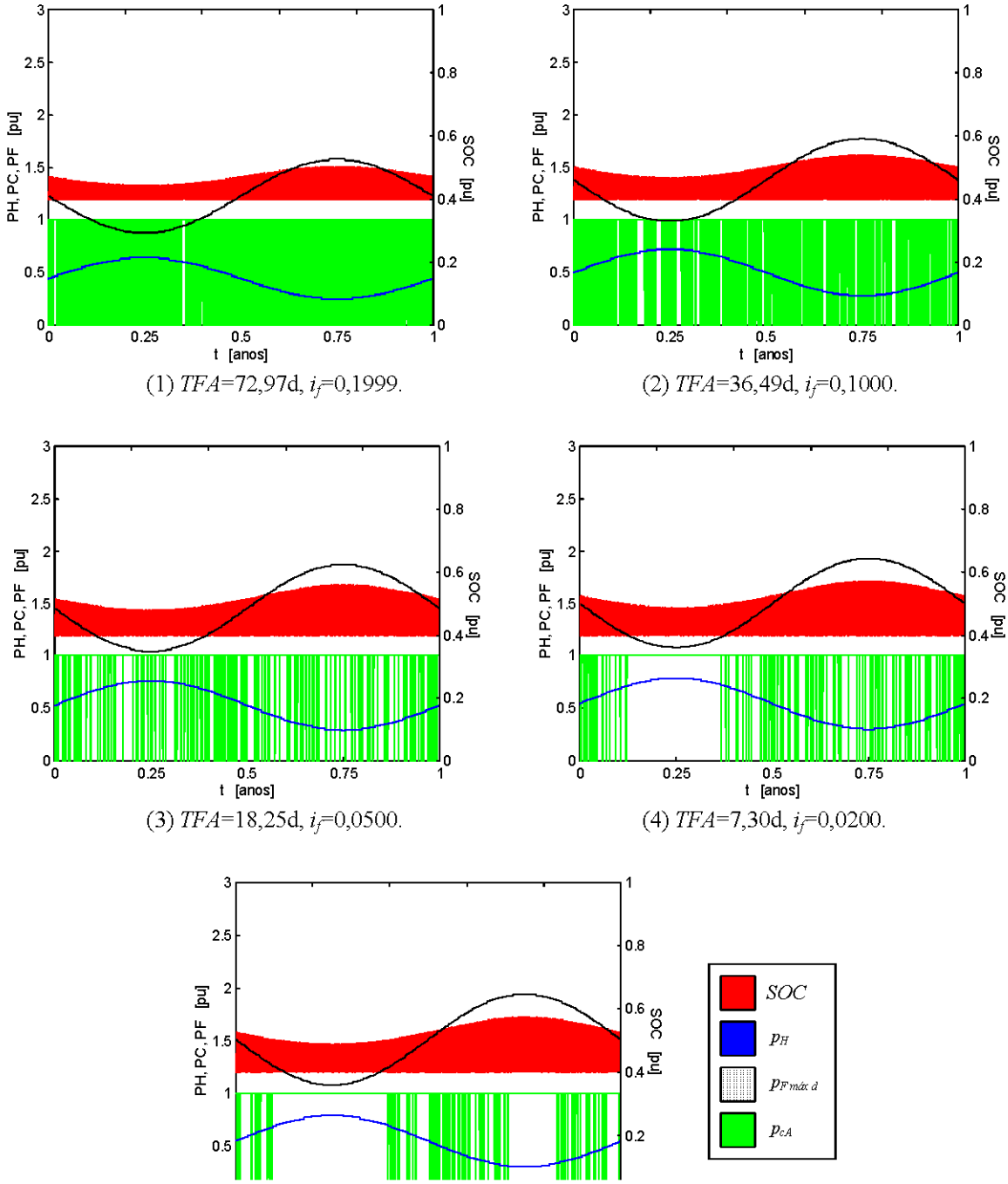

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FIGURE 13. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.

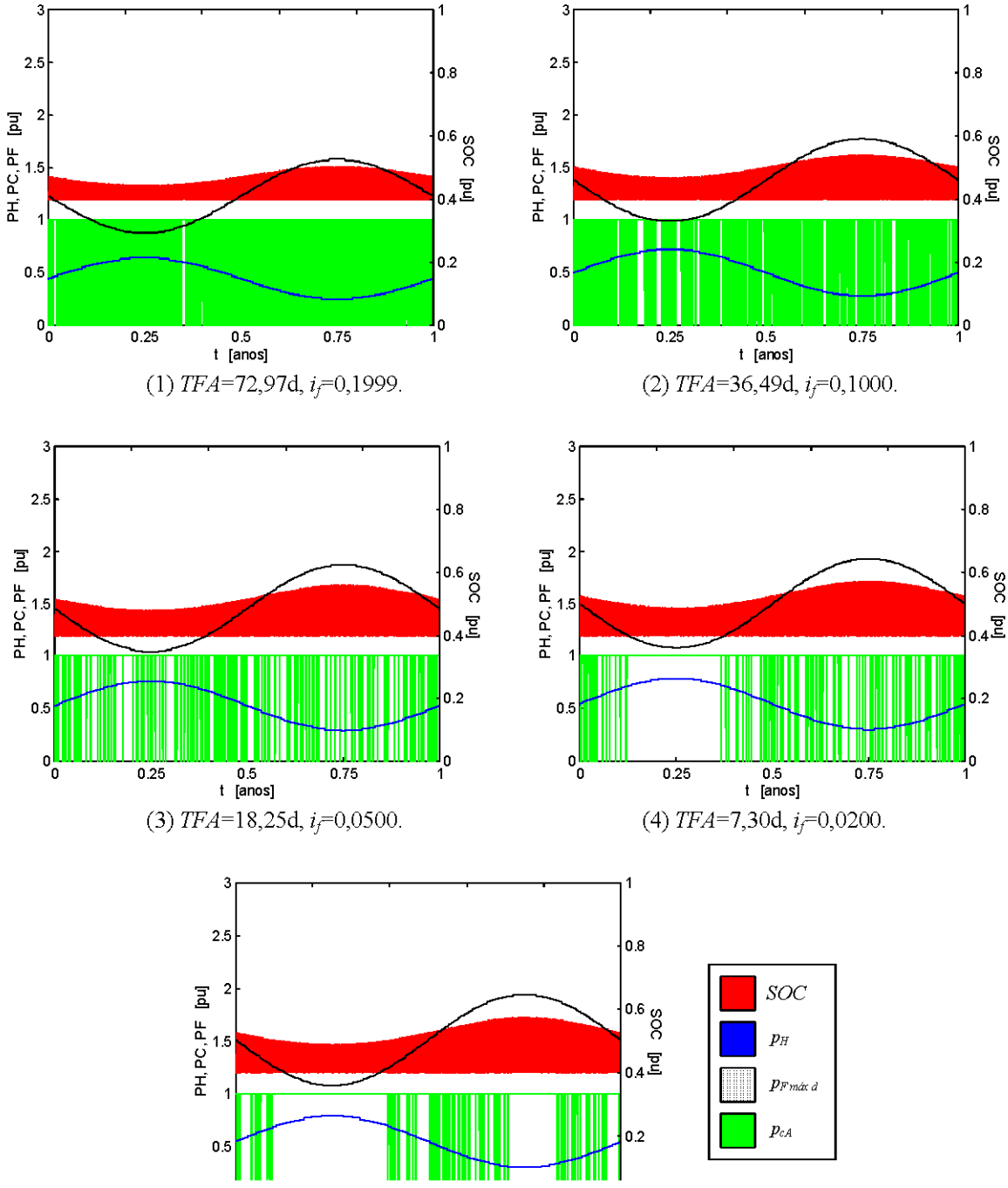

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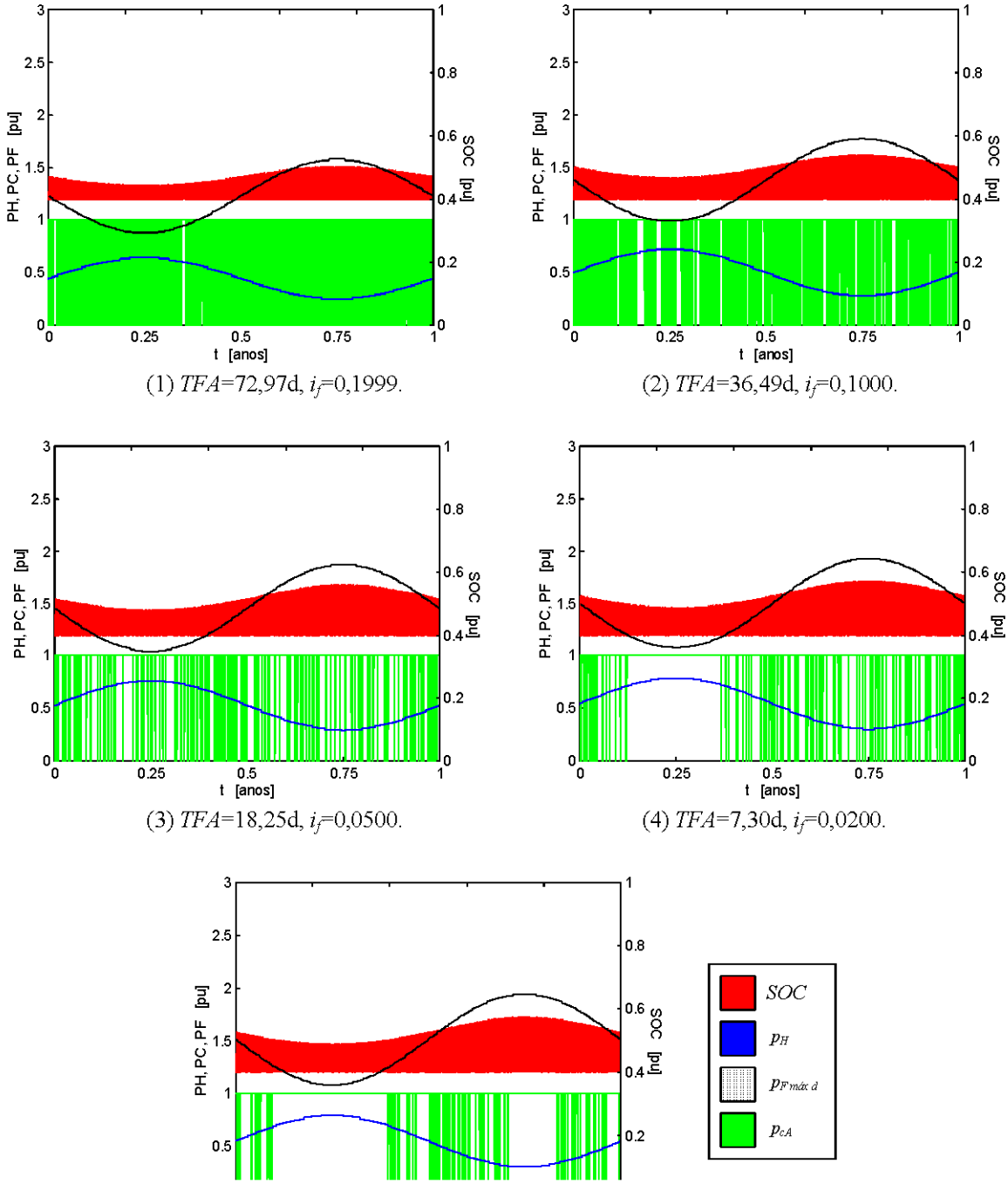
FIGURE 14. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



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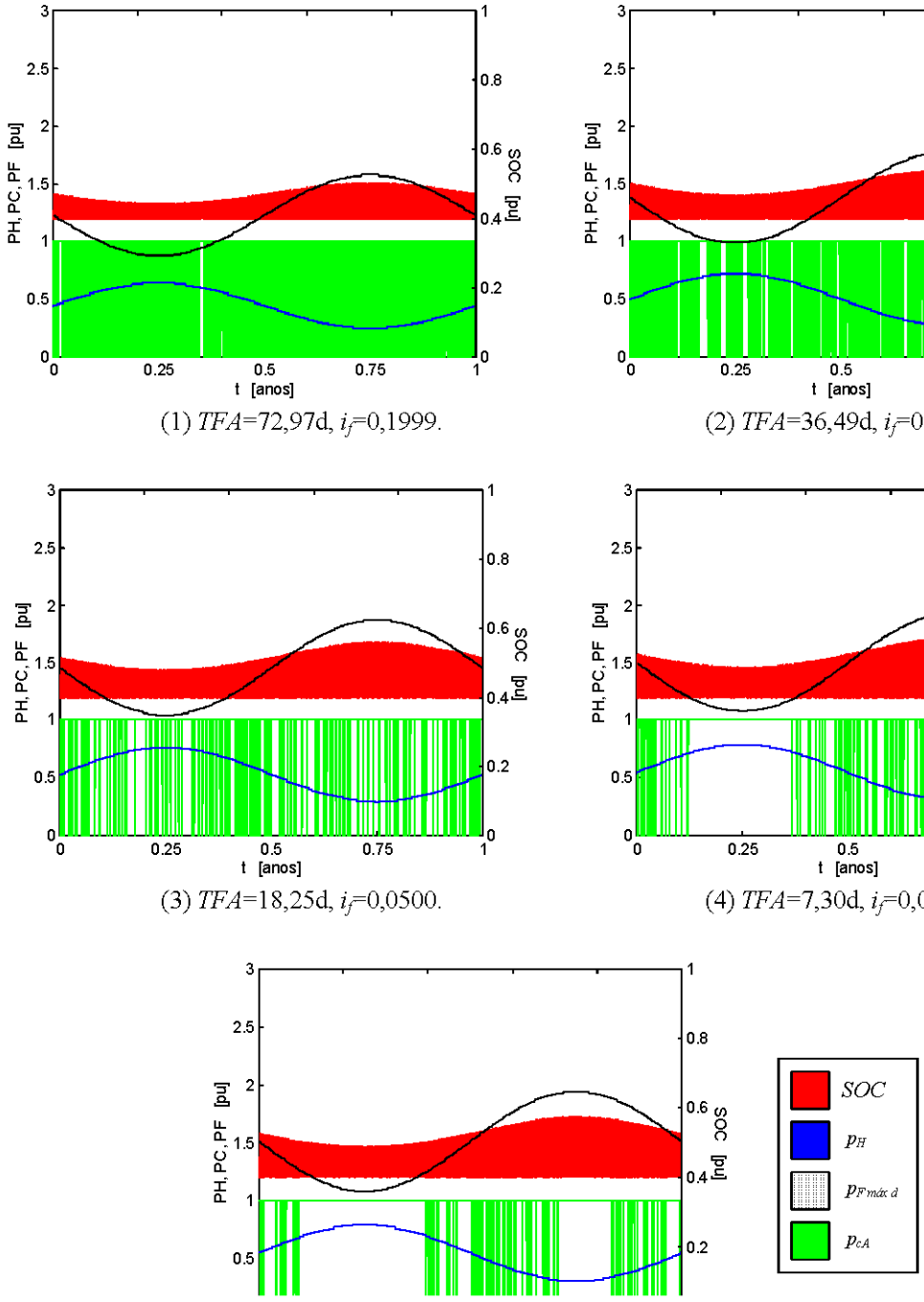
(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 15. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

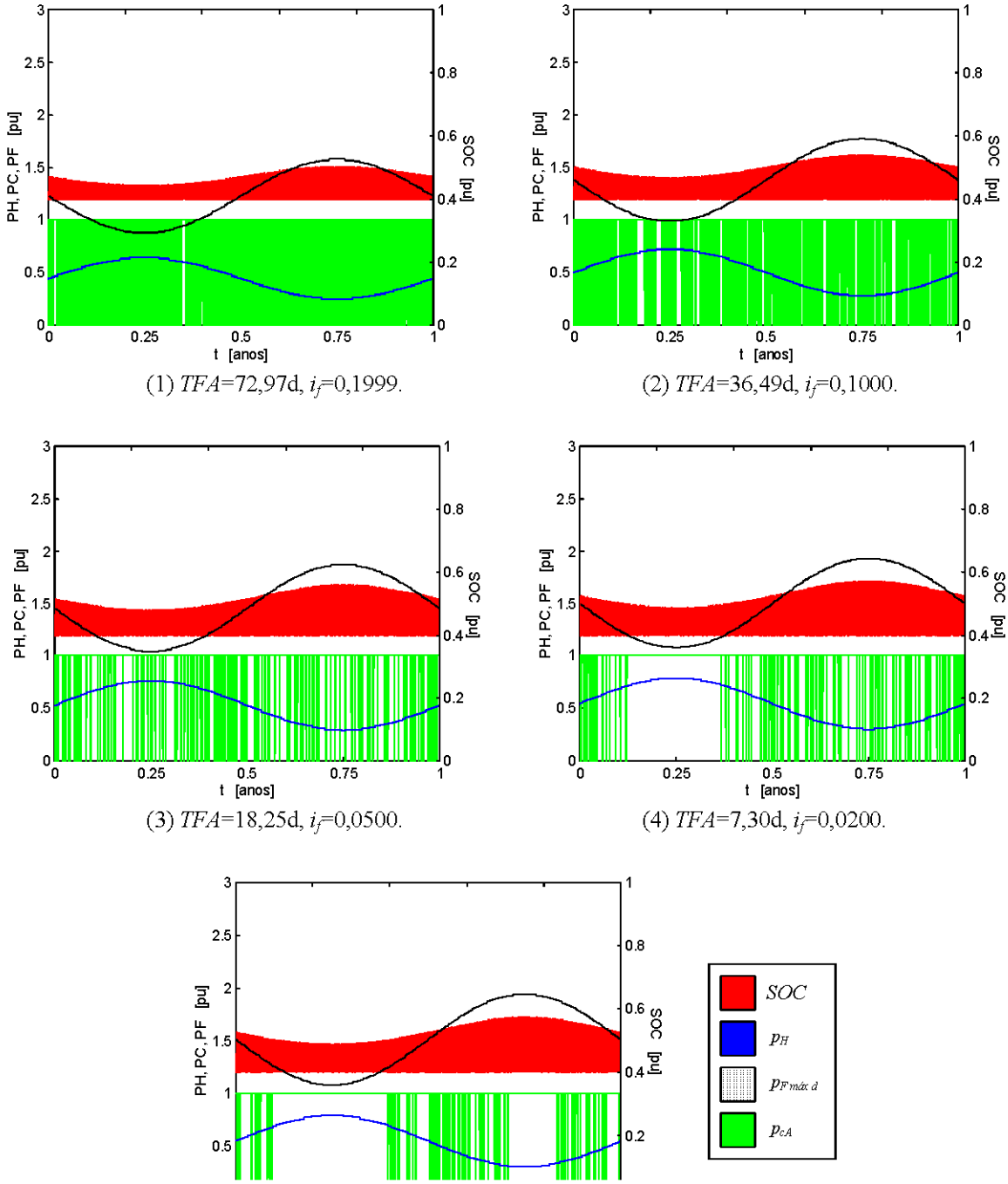
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 16. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

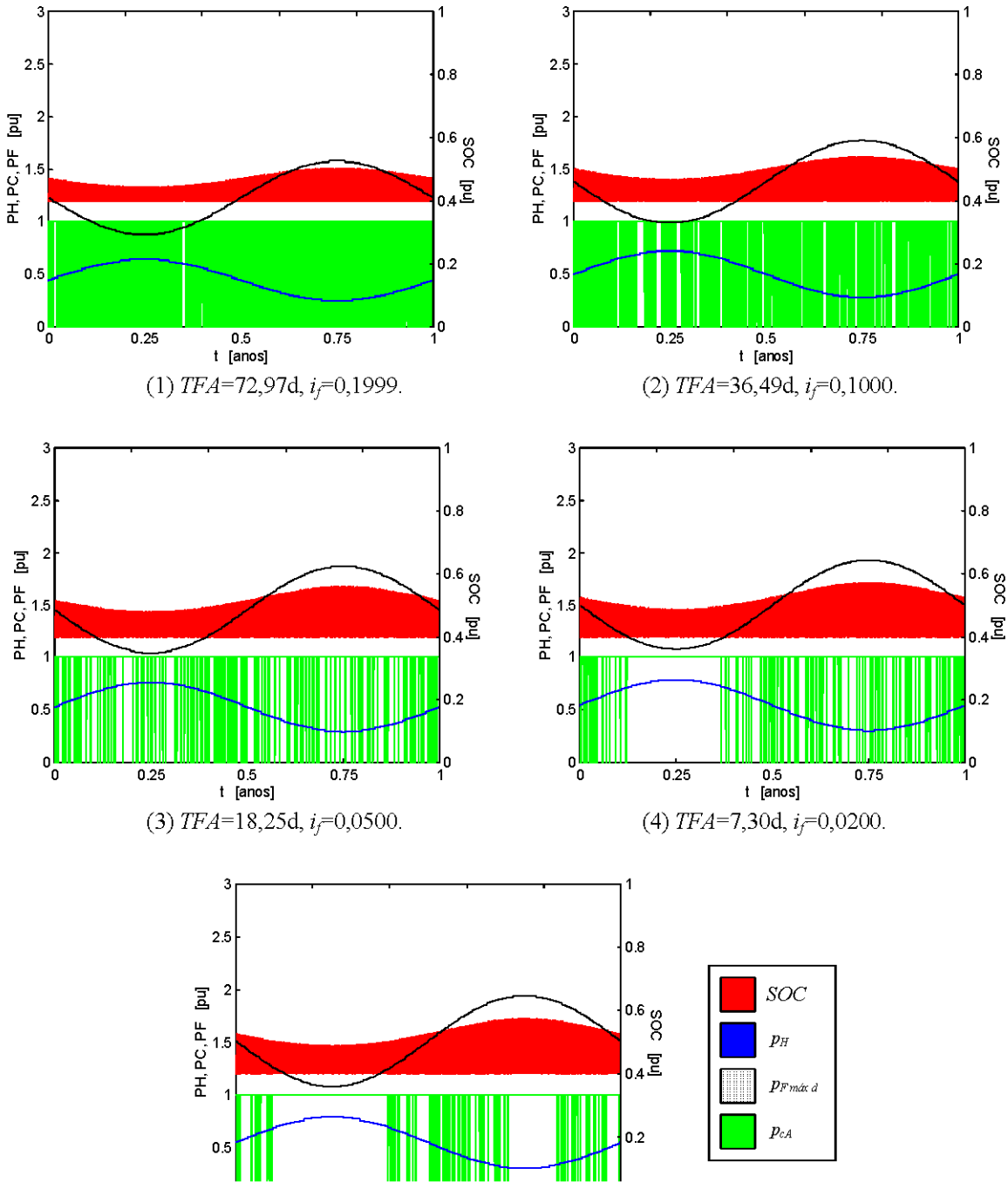
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 17. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

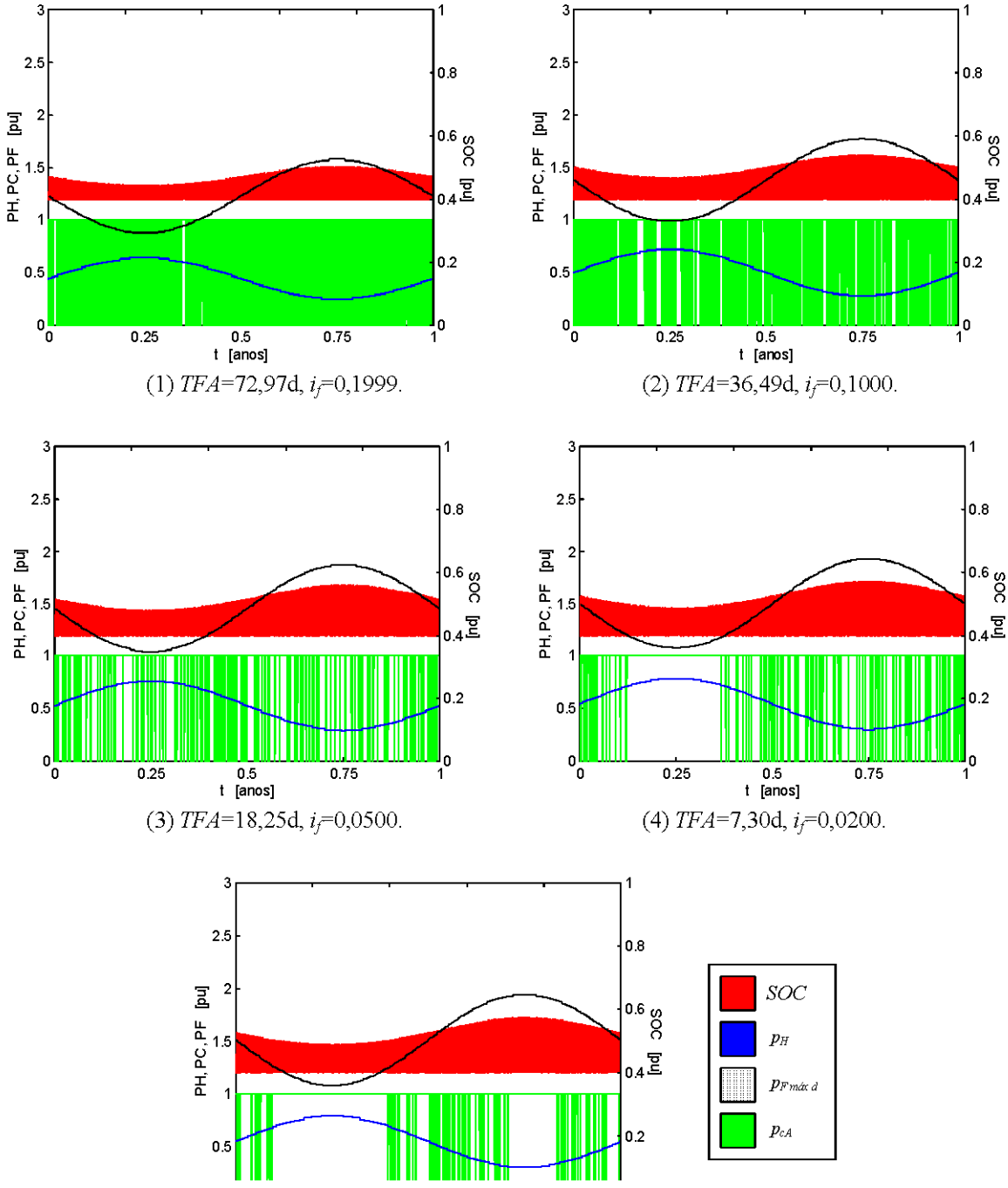
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 18. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

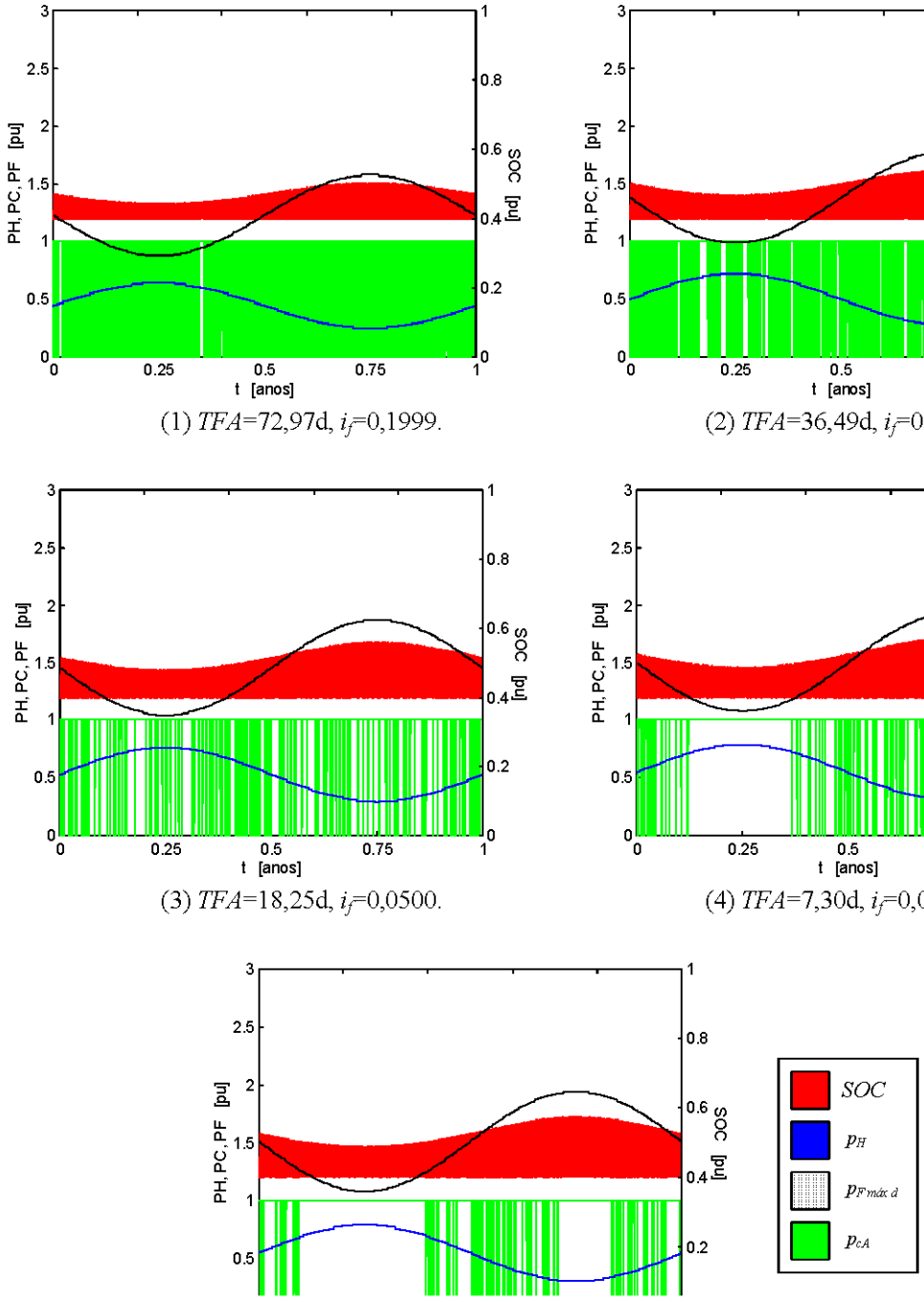
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 19. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

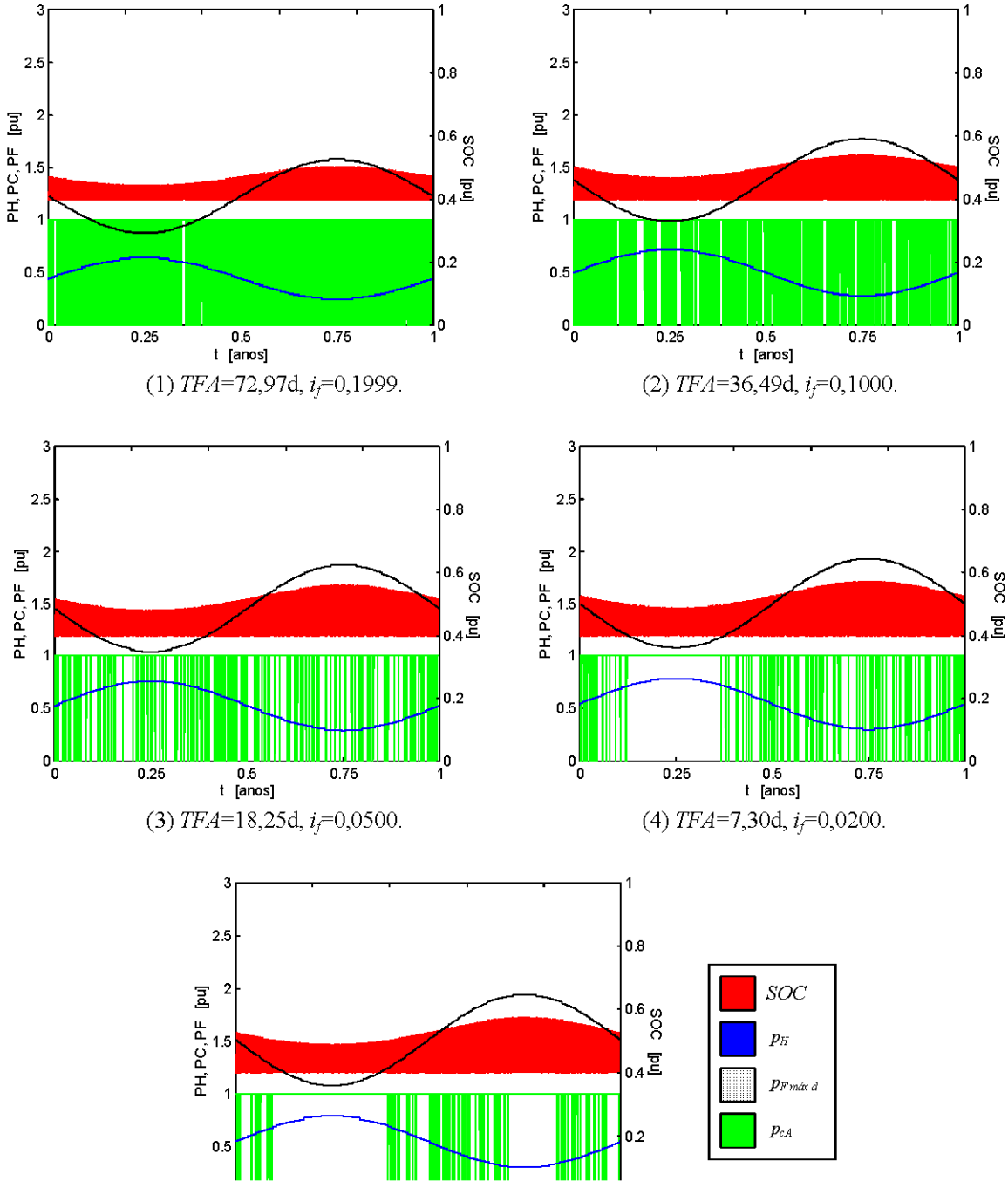
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 20. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

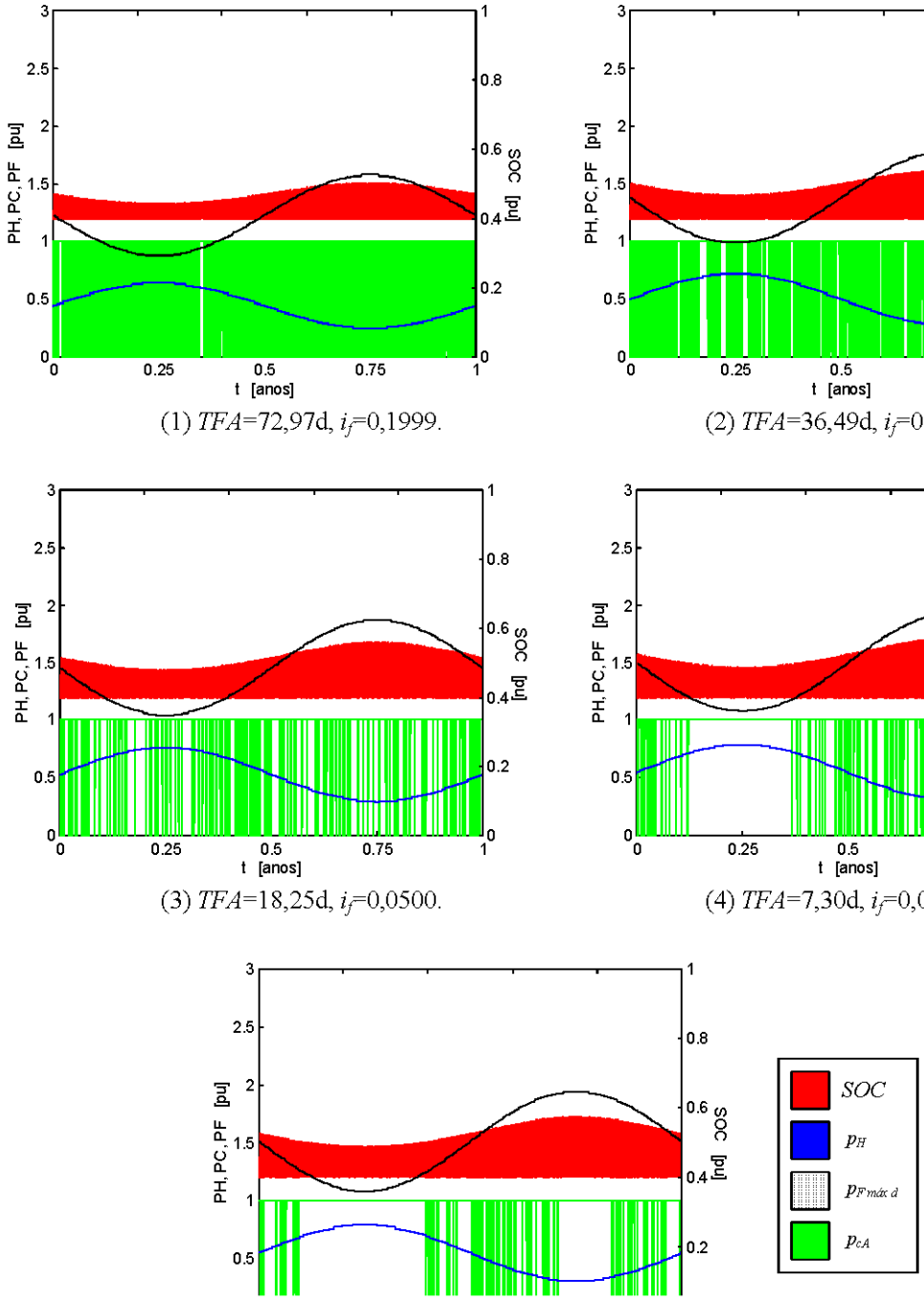
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 21. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

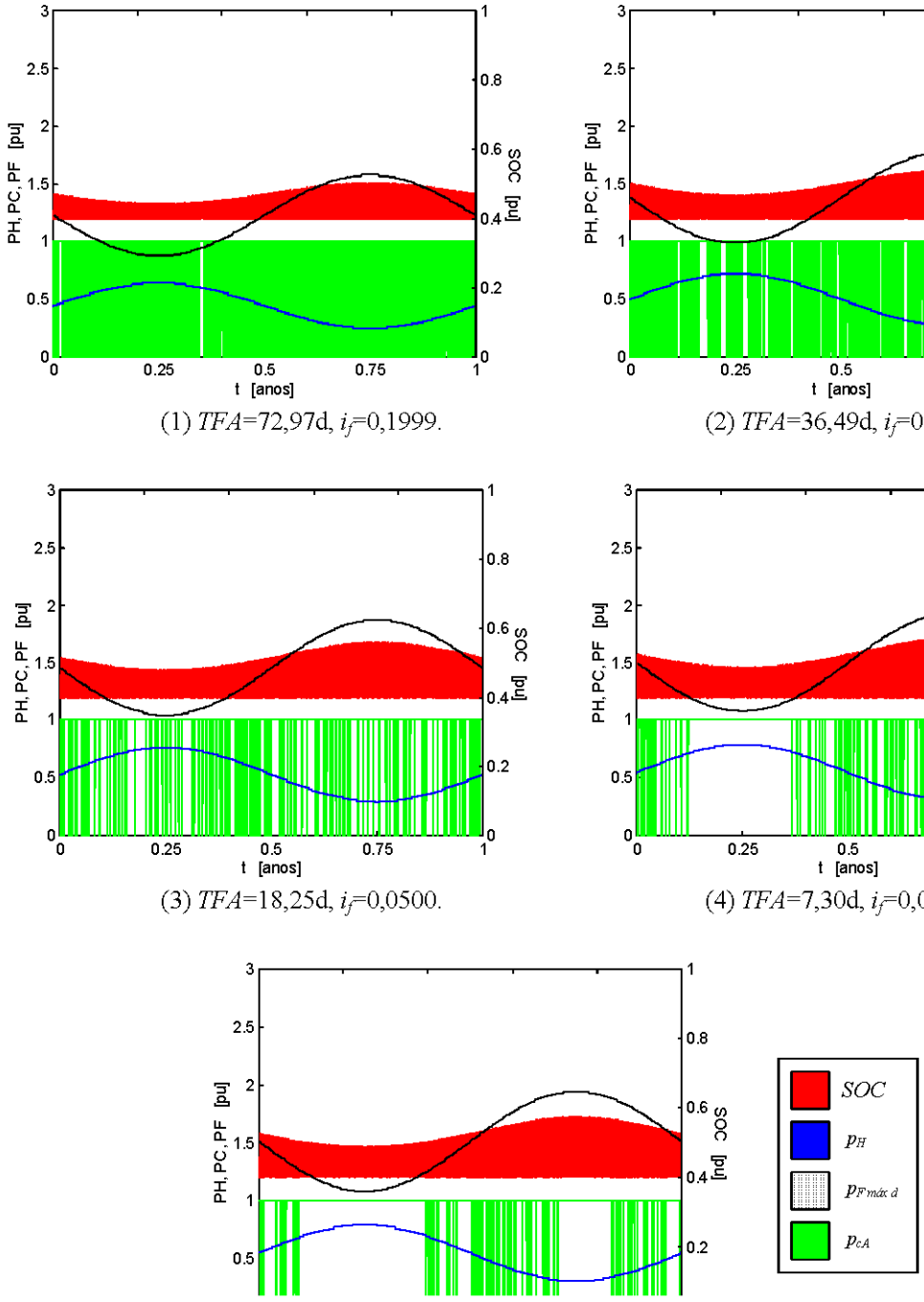
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 22. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

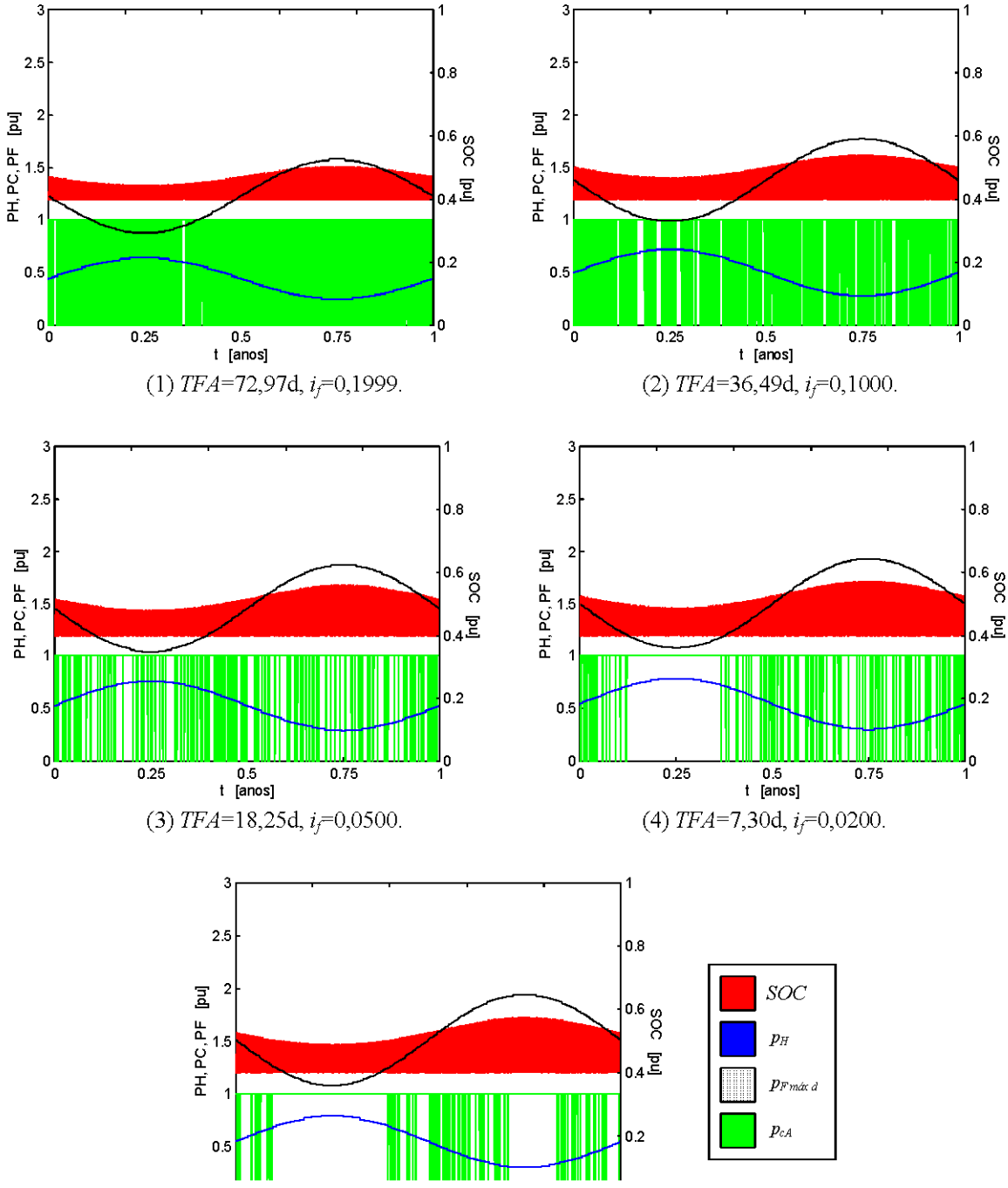
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 23. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

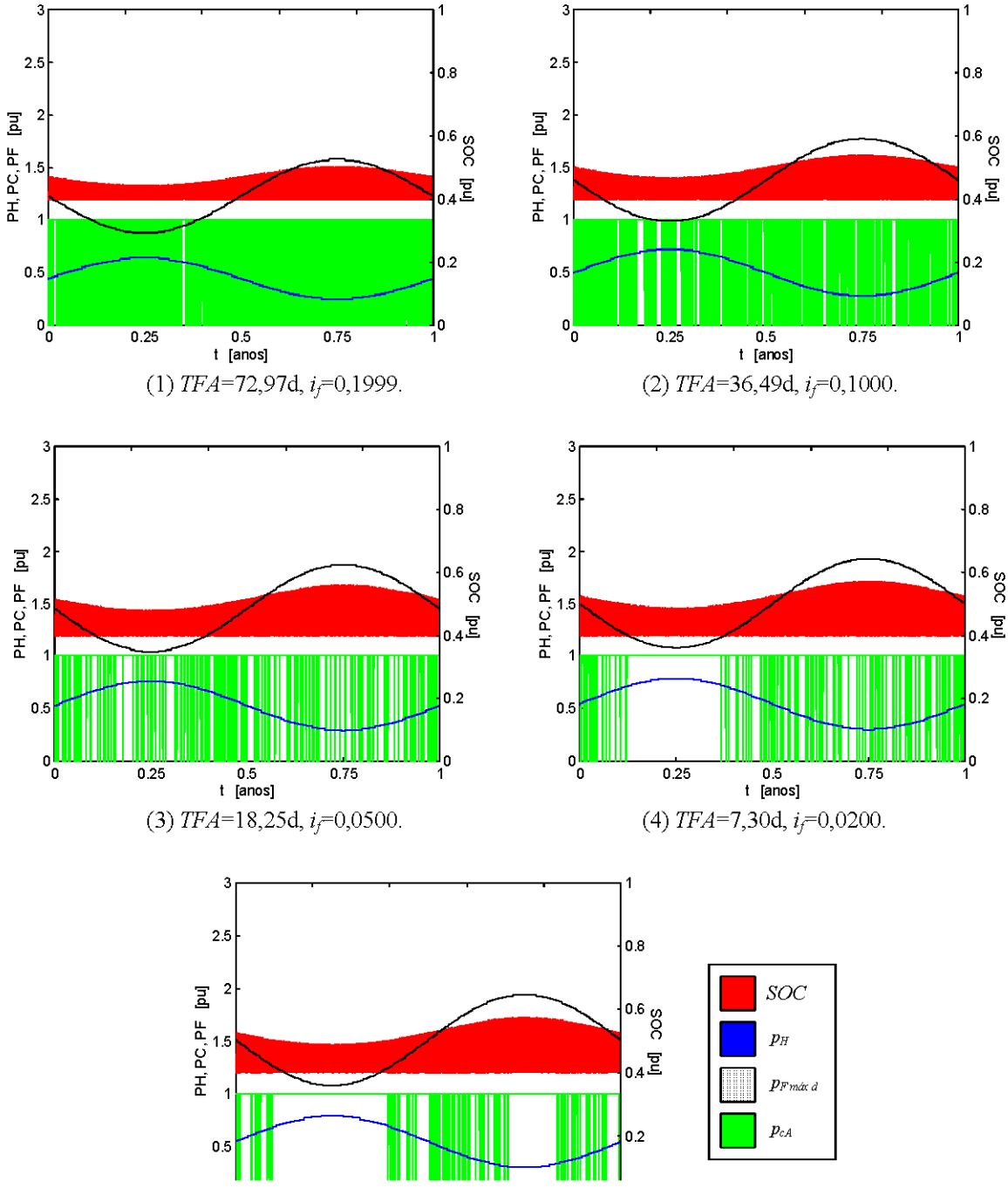
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 24. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

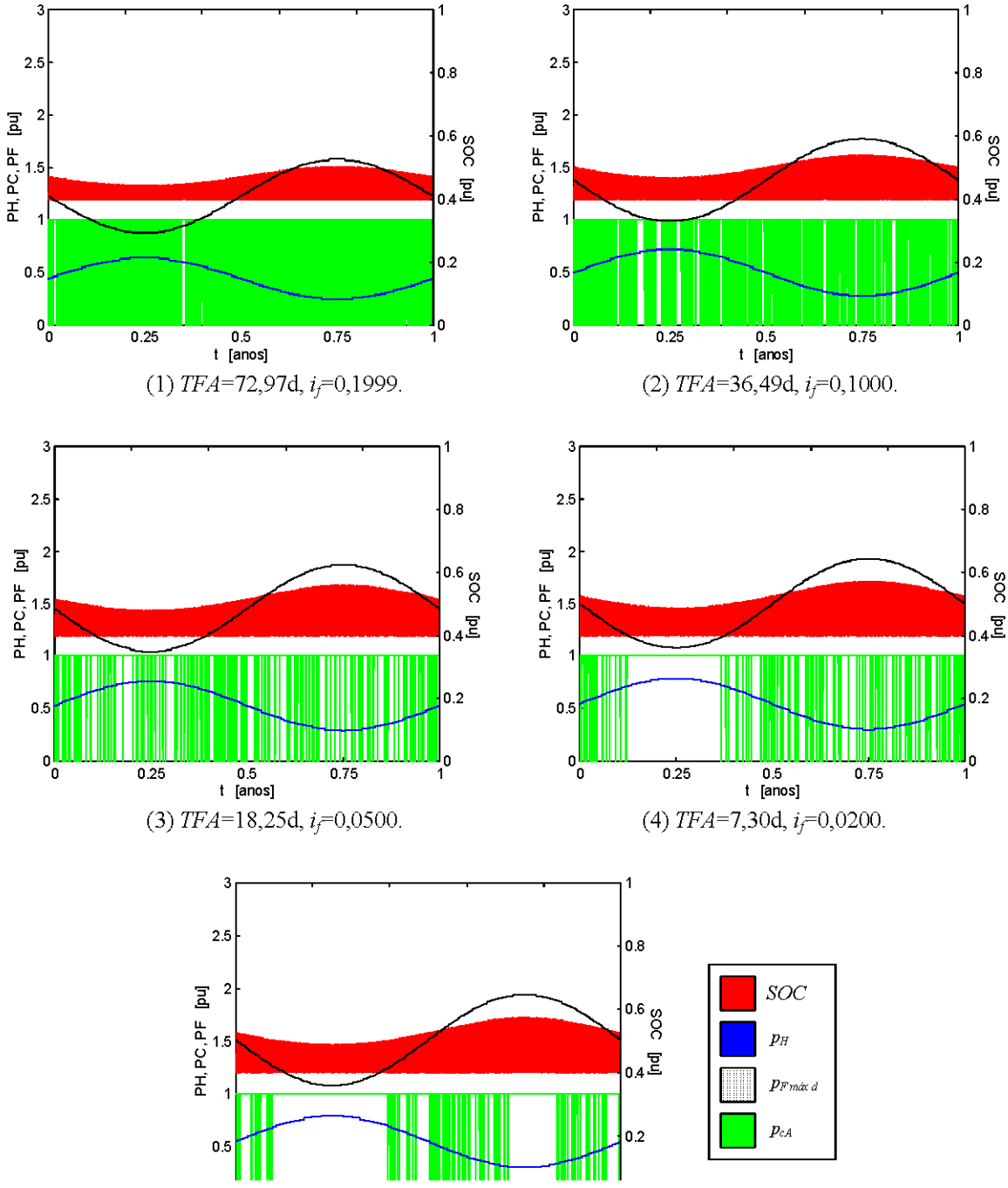
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 25. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

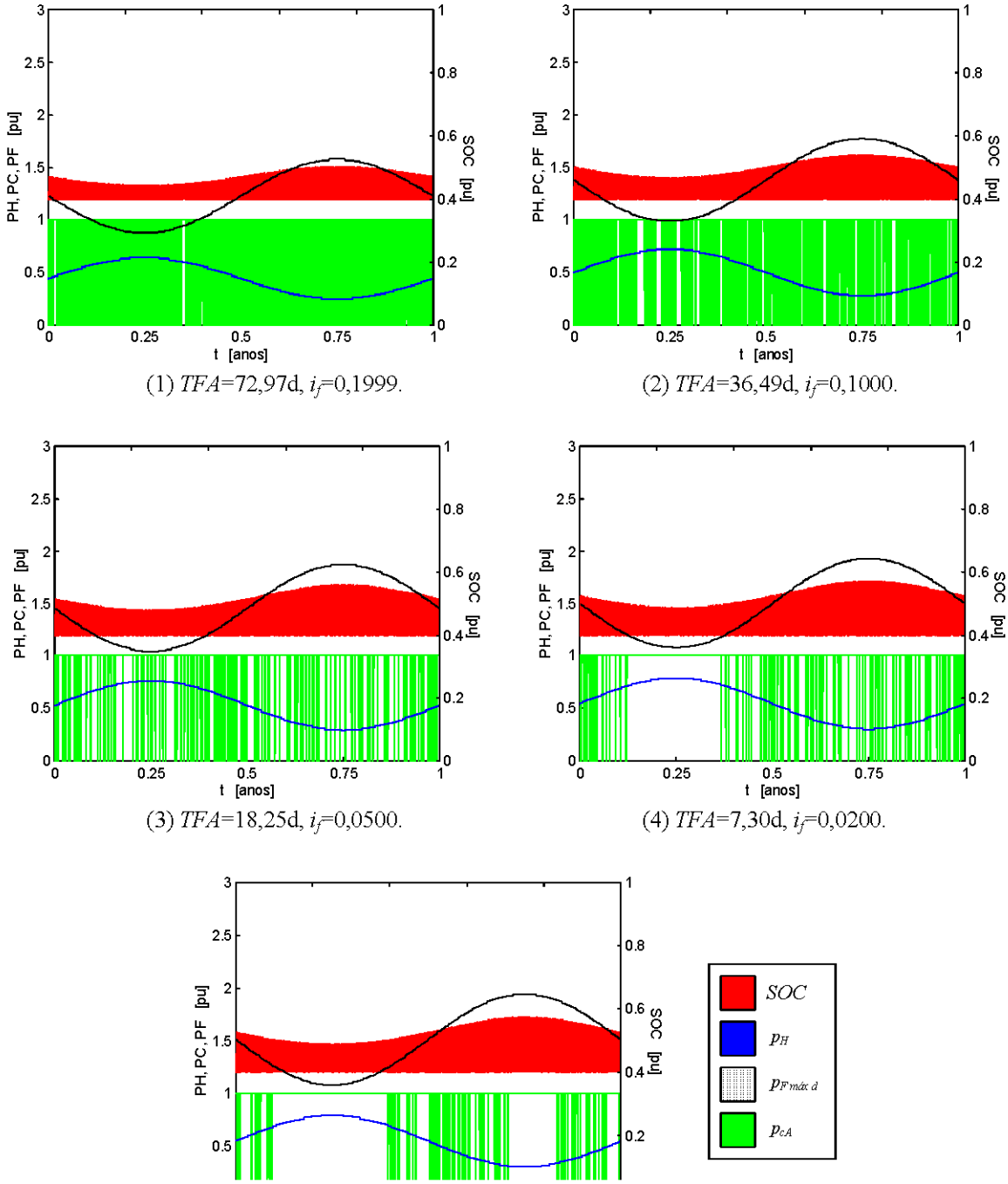
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 26. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

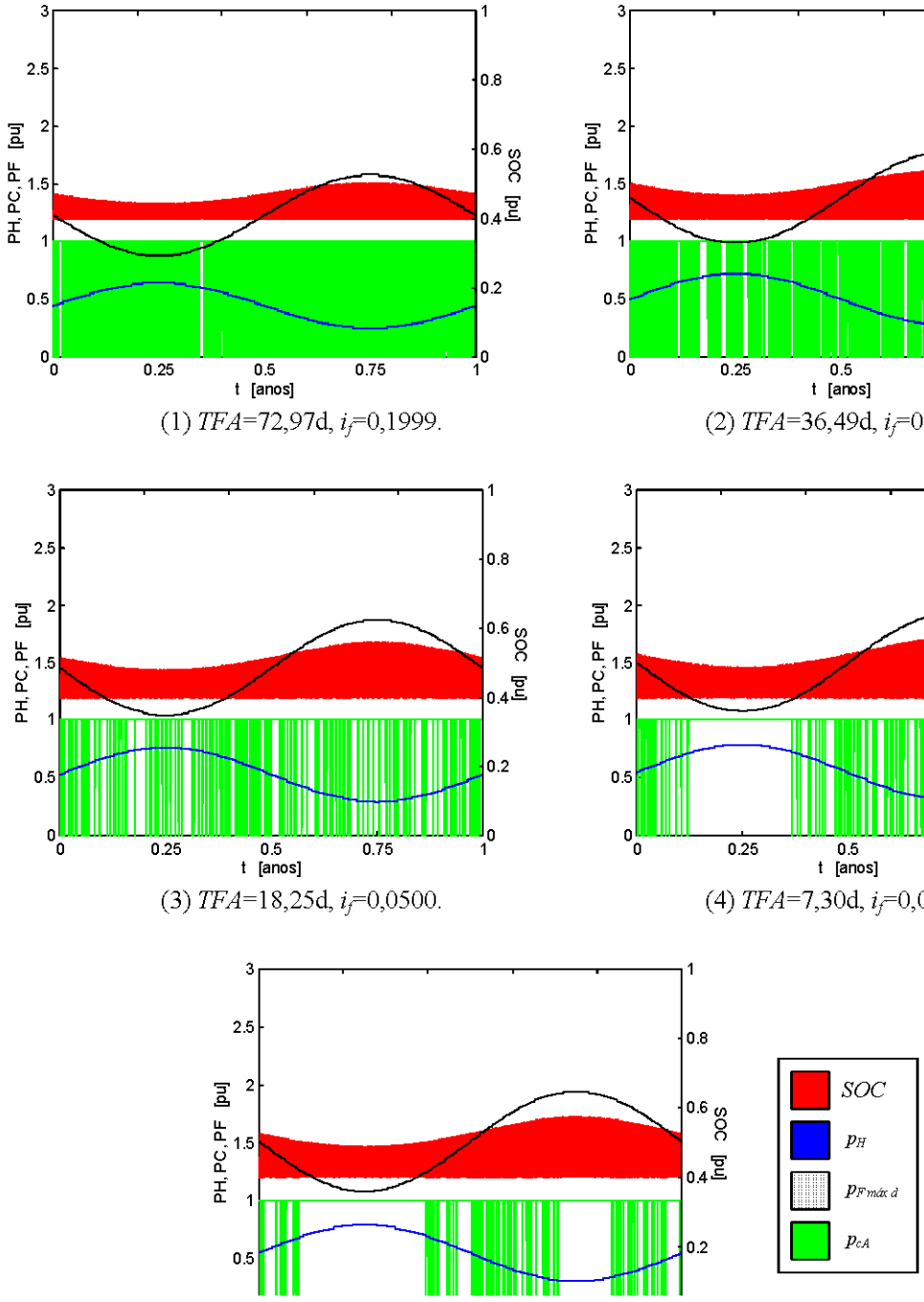
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 27. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

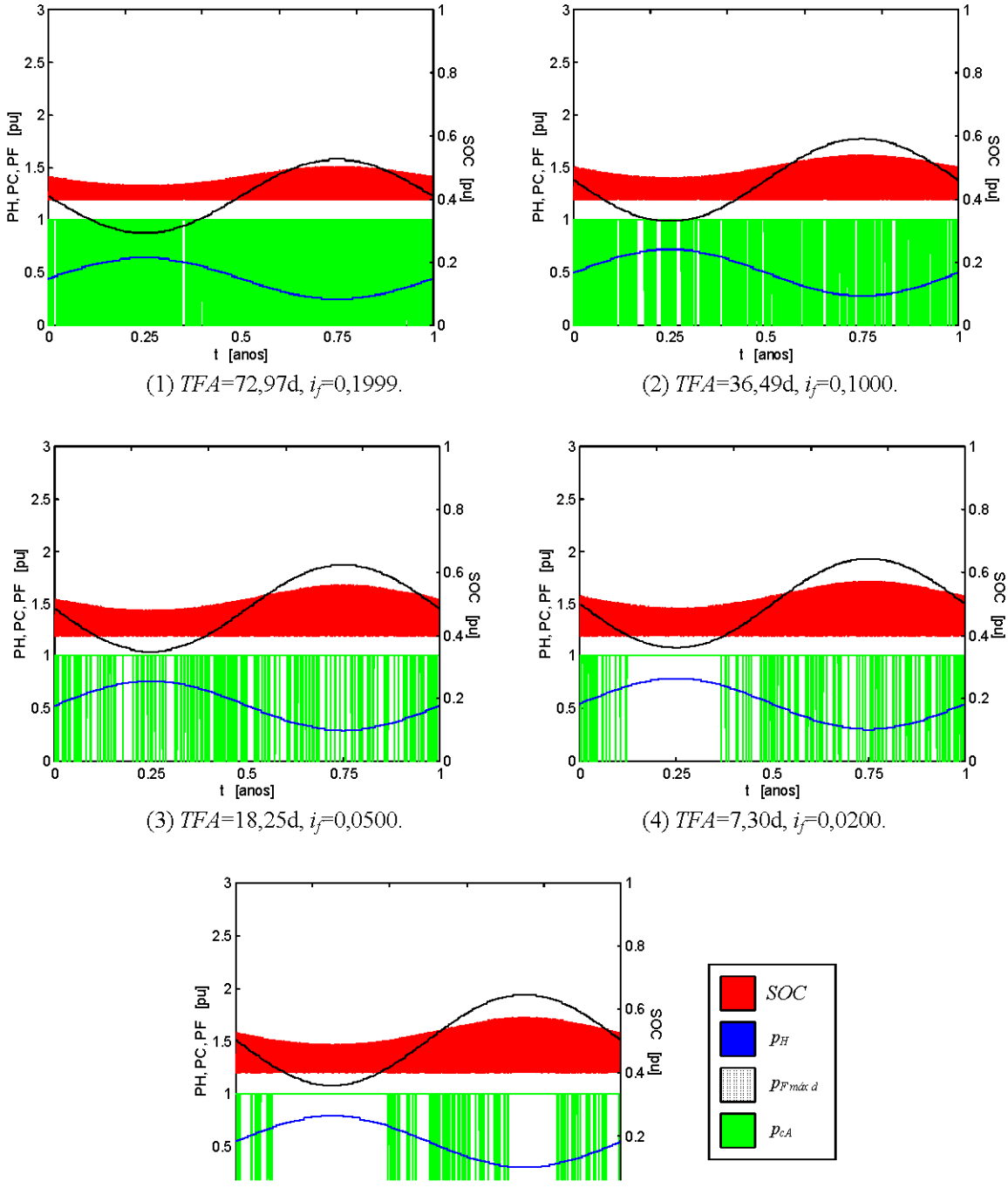
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 28. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=72,97d, i_f=0,1999.

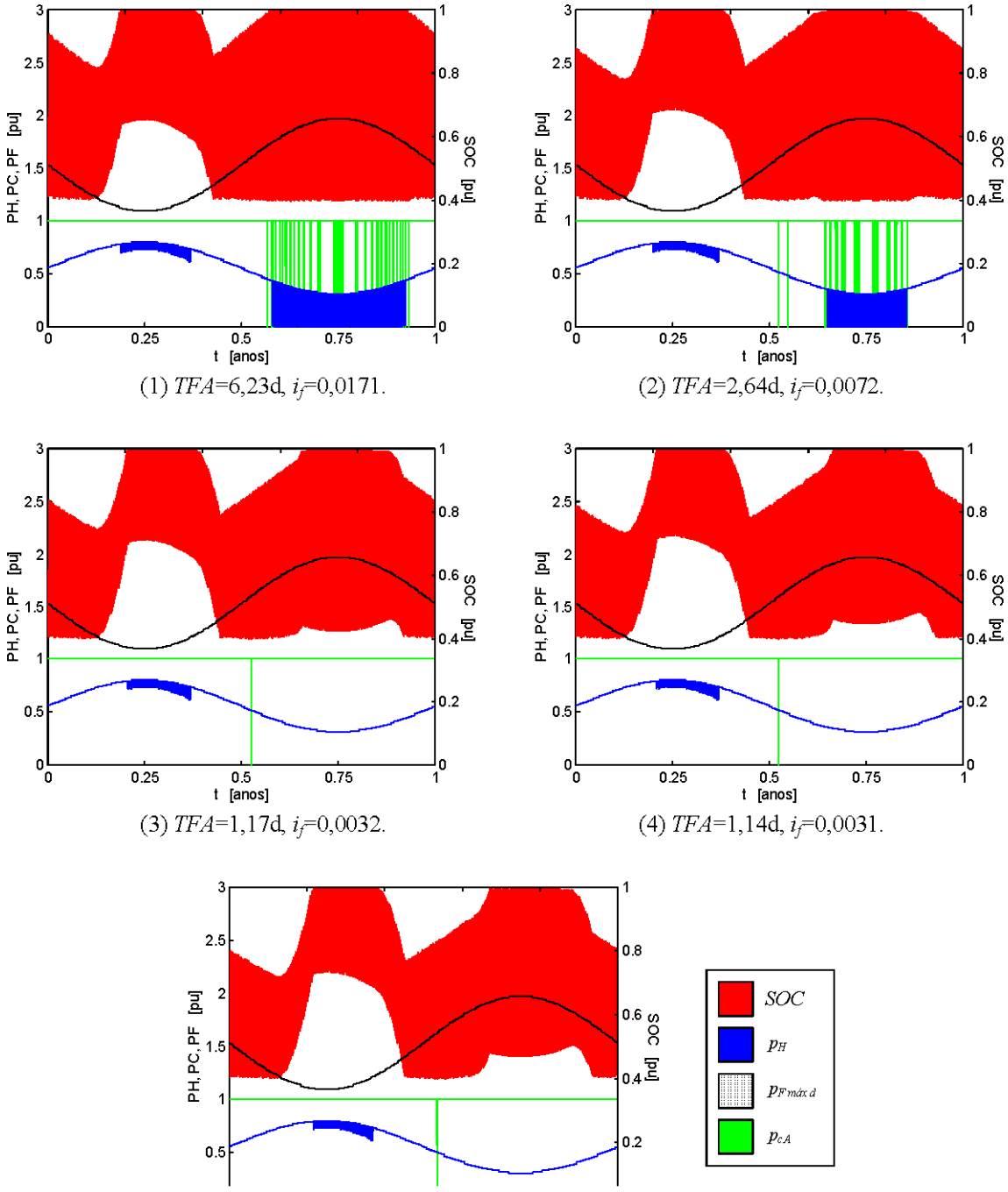
(2) *TFA*=36,49d, i_f=0,1000.

(3) *TFA*=18,25d, i_f=0,0500.

(4) *TFA*=7,30d, i_f=0,0200.

(5) *TFA*=5,47d, i_f=0,0150.

FIGURE 29. Effects of different proportions between energy available for consumption and energy demanded by loads (p_{dd}) on the performance of a system with κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$, with bank of batteries with capacity for 2 days, with discharge until 40% and charge until 100% of maximum capacity, without water reservoir and with constant load demand profile. Proportions: (1) p_{dd}=0,8000, a_f=19,69, (2) p_{dd}=0,9000, a_f=22,15, (3) p_{dd}=0,9500, a_f=23,38, (4) p_{dd}=0,9800, a_f=24,12 and (5) p_{dd}=0,9850, a_f=24,25. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.



(1) *TFA*=6,23d, i_f=0,0171.

(2) *TFA*=2,64d, i_f=0,0072.

(3) *TFA*=1,17d, i_f=0,0032.

(4) *TFA*=1,14d, i_f=0,0031.

(5) *TFA*=1,11d, i_f=0,0030.

FIGURE 30. Effects of different dimensions of bank of batteries on the performance of a system with p_{dd}=1,00, κ_t=1,00, κ_e=1,00 [p_{sh}=1,00], κ_a=1,00 [p_{Mm}=1,00, df=1,1496, dh=df], κ=1,00, with $p_{he\,máx}$=$p_{c\,máx}$ and a_f=24,61, without water reservoir and with constant load demand profile. Banks of batteries with capacity for (1) 0,500 day, (2) 0,550 day, (3) 0,600 day, (4) 0,625 day and (5) 0,650 day, with discharge until 40% and charge until 100% of maximum capacity. Conventions: SOC: state of charge of the batteries, p_H: power made available by the hydro generator set, $p_{F\,máx\,d}$: maximum daily power made available by the PV generator set, p_{cA}: power delivered to the loads.

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