



The dark side of feed-in restrictions for nature-inclusive solar parks

Bas van Aken, Kay Cesar | 26-9-2025 5E03.5

Why solar on land?

- **Autonomous**
- **Renewable**
- **Cost-effective**
- **Speed**
- **Challenges for people and nature**
 - **Opportunity: multiple functions**

Motto: Speed without regrets



Triple strength: Autonomous + Renewable Energy +

Light for nature ~ 30-40%

Nature-inclusive solar parks
+ Nature restoration



Agri-PV

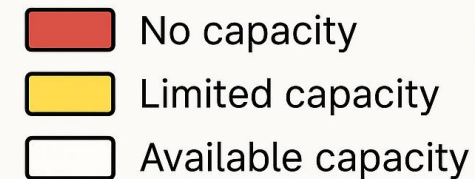
+ Food production

Light for crops ~ 60-90%
Up to 3x more land with panels

Solar development in the Netherlands

- Solar covers 18% electricity demand 2024
- High PV penetration & low flex demand induce low capture prices ¹
- 540 hr/yr non-positive clearing prices 2024
- Severe shortage of new grid connections
- Feed-in restrictions as in Germany ²

New Grid Connections for Solar Parks: Scarce and Unevenly Distributed



<https://data.partnersinenergie.nl/capaciteitskaart/totaal/invoeding>

[1] **Marginal Effect of Variation in Photovoltaic System Configuration's Generation Profiles on Price Stabilisation in the Netherlands Compared with Deployment of Flexible Demand and Supply**, B.B. Van Aken et al. Sol. RRL, 6, 2100484 (2022). <https://doi.org/10.1002/solr.202100484>

[2] **Feed-in power limitation of grid-connected PV battery systems with autonomous forecast-based operation strategies**, J. Bergner et al. , Proc EU PVSEC (2014).

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- High PV penetration & low flex demand induce low capture prices ¹
- 540 hr/yr non-positive clearing prices 2024
- Severe shortage of new grid connections
- Feed-in restrictions as in Germany ²
- Ground coverage ratios 75 - 98%
- Subsidy scheme demands nature-inclusive solar parks



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Land lease, soil quality and eco-label

Lease contract: Maintain soil quality!

2022- First irradiance rules published ¹

2025 - Transparent bifacial modules most cost-effective ²

2025 - Ground irradiance rules in Dutch eco-label ³



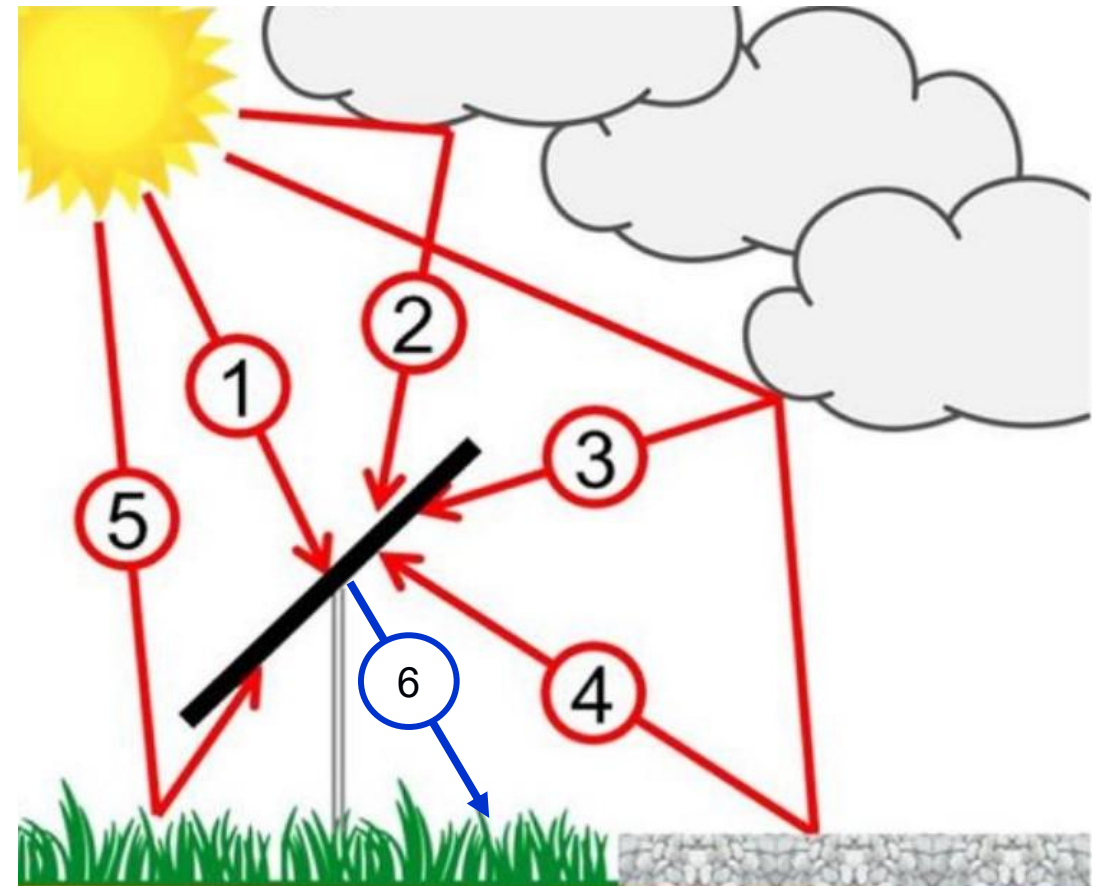
[1] **Nieuwe ontwerpvoorschriften verankert bodemkwaliteit in zonneparken**, Cesar et al., Bodem (April 2022)

[2] **Evaluation method and module design for cost-effective compliance with irradiance guidelines to maintain soil quality in solar parks**, Cesar et.al, EPJ Photovoltaics **16**, 13 (2025), <https://doi.org/10.1051/epjpv/2025003>

[3] **EcoCertified Solar Parks. Openbare eindrapportage**, Krijgsveld et al., (September 2025) Doi:10.18174/699847

Yield, ground irradiance and LCoE

- Simulation considers ¹:
 - Direct beam and diffuse components
 - Full 3D view-factor
 - Non transparent modules
 - Albedo 25%
- Cost model ^{2,3}
 - 3P south fixed tilt system,
 - Capex, OPEX, depending on tilt en GRC
 - WACC 4%, Degradation 0.5%/year
 - Land lease 8000 €/ha/year



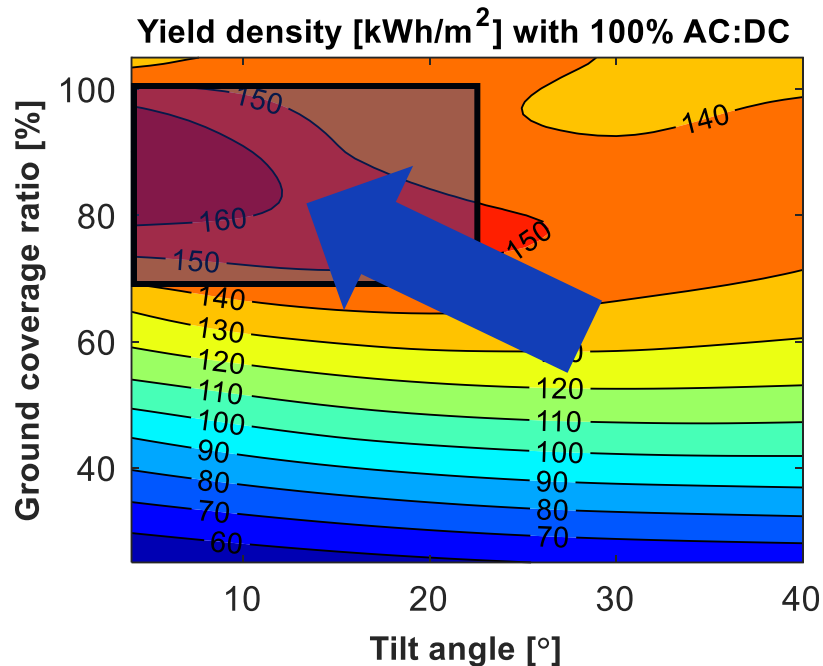
TNO BIGEYE PV yield and ground irradiance platform

[1] **BIGEYE – simulation under shadow conditions**, A.R. Burgers, Proc. 6th Workshop Bifacial PV, Amsterdam, the Netherlands (2019).

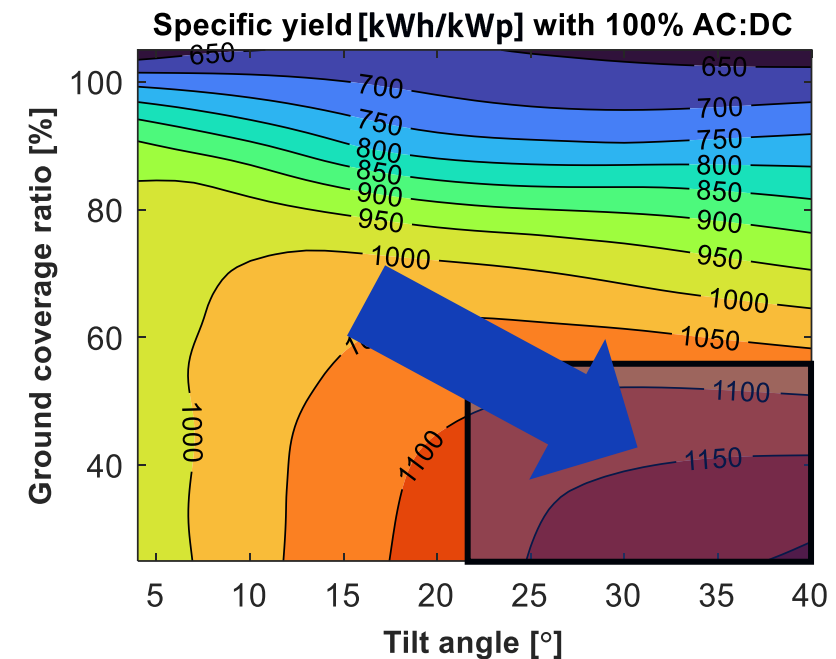
[2] **Evaluation method and module design for cost-effective compliance with irradiance guidelines to maintain soil quality in solar parks**, Cesar et.al, EPJ Photovoltaics 16, 13 (2025), <https://doi.org/10.1051/epjpv/2025003>

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Solar park: the basics without feed-in restriction



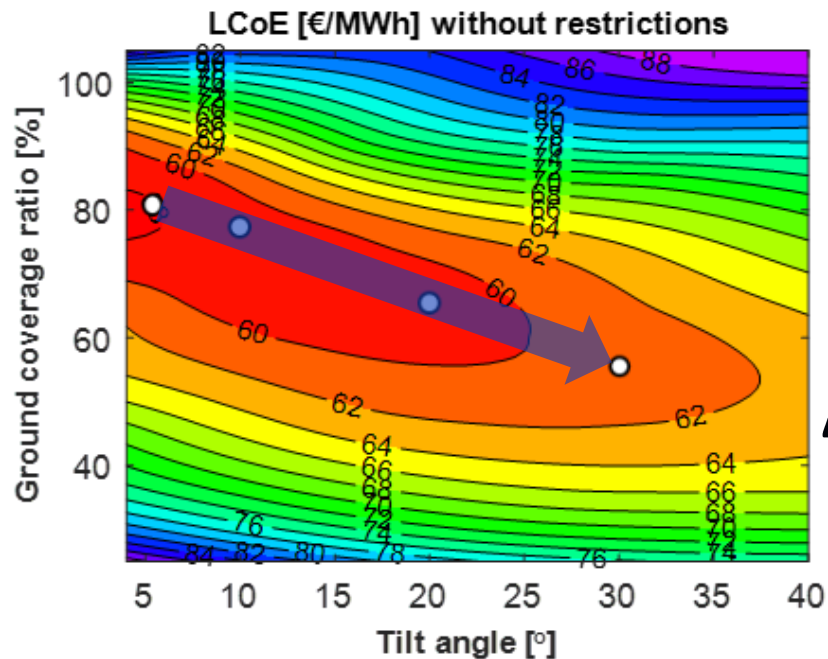
- Highest yield per unit area at **high** GCR and **low** tilt
- Typical monofunctional solar park in Netherlands



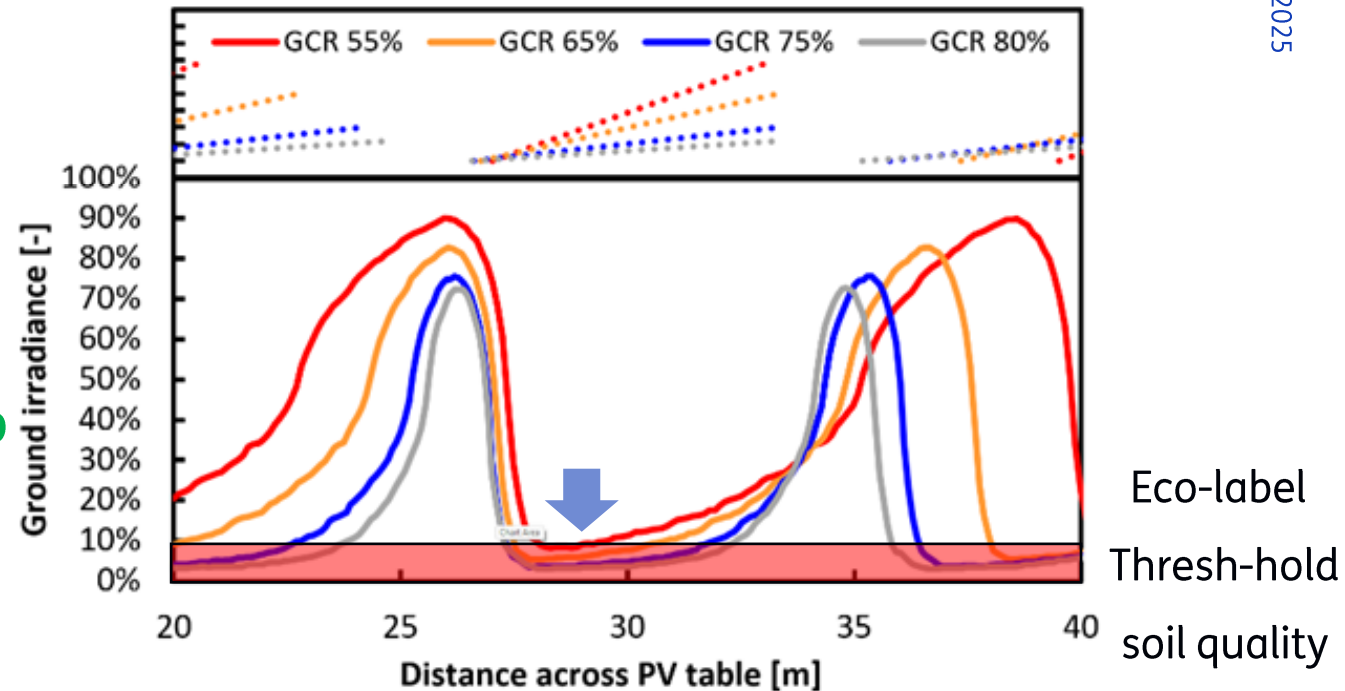
- Highest yield per panel at **low** GCR and **high** tilt
- Highest ground irradiance
- Highest return on CO₂ investment per panel
- Capex increases ~25% and OPEX doubles

Solar park: LCoE without feed-in restriction

26 September 2025



$\Delta +3\%$



Without feed-in restriction

- LCOE increase 3% over broad range of GCR and tilt values

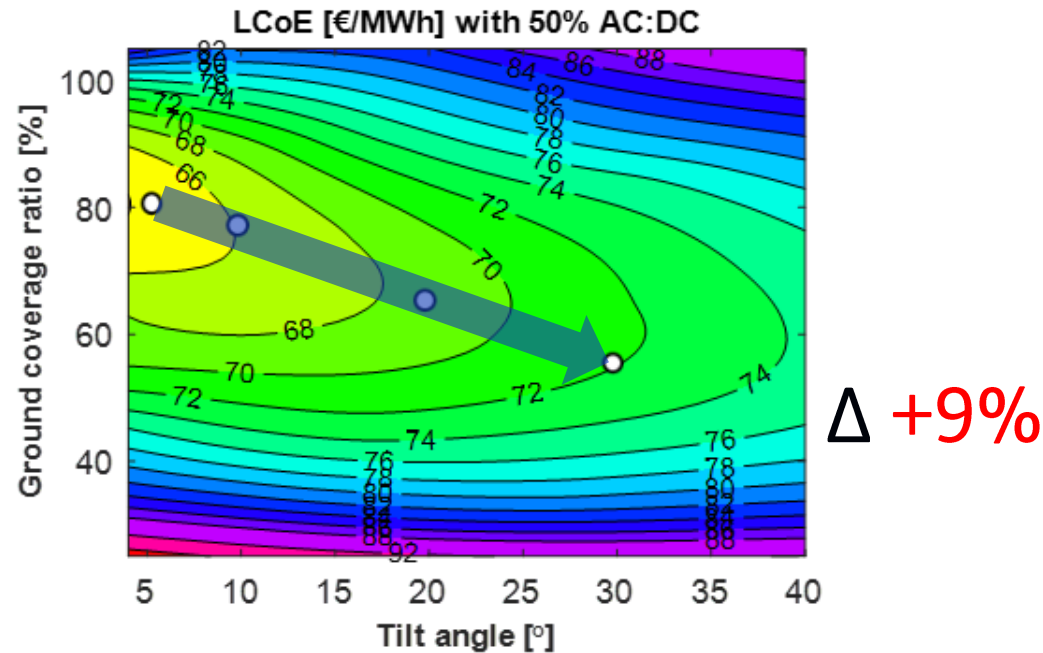
With increasing tilt angle and decreasing GCR

- Minimum irradiance increases from 3% to 8%
- Photons more equally shared between plants and PV
- Broader, brighter regions between PV tables

These effects support nature-inclusive solar parks

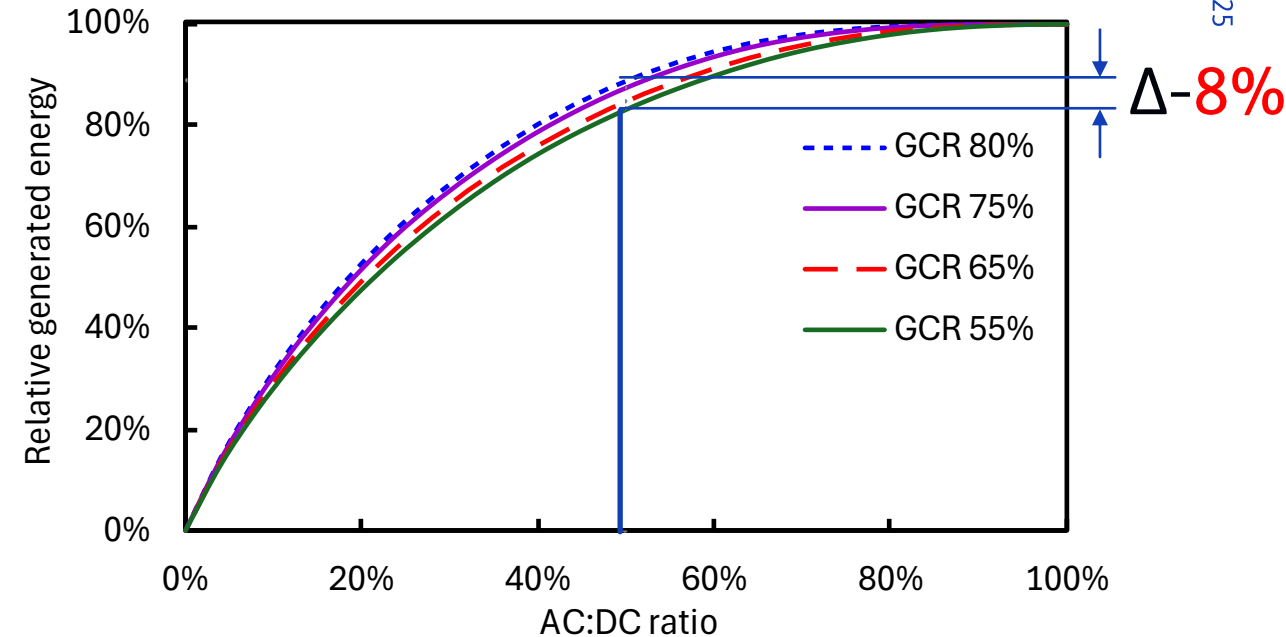
Solar park: LCoE with feed-in restriction

26 September 2025



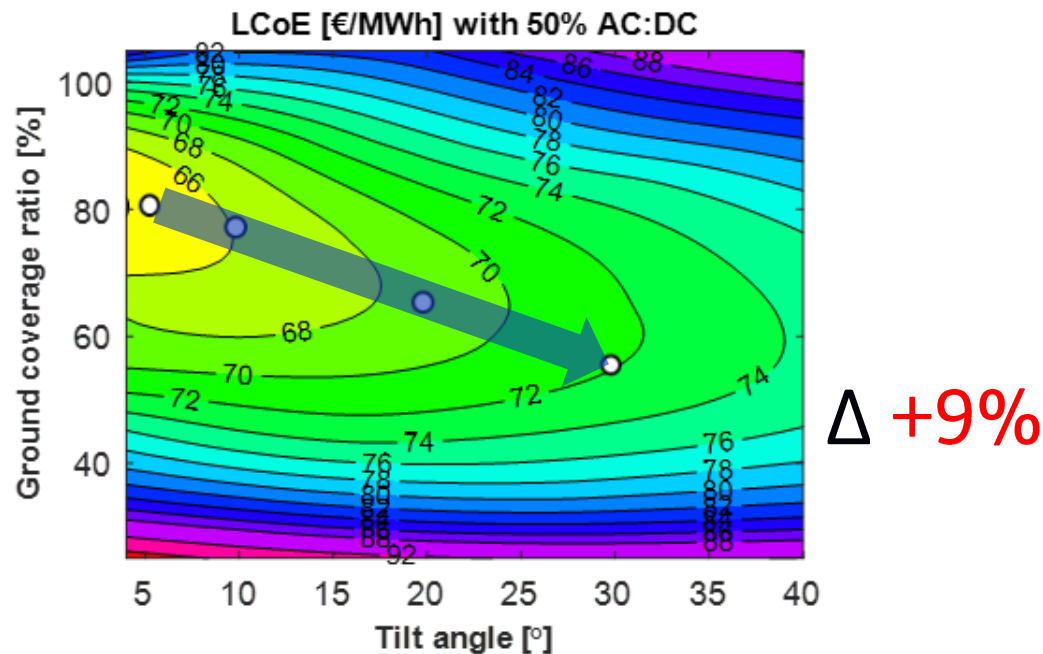
With 50% AC/DC ratio limitation:

- LCOE increases 9% in same range



- Annual yield nature-inclusive solar park is 8% lower than industrial park due to clipping losses
 - 80% GCR produces 89% of annual yield
 - 55% GCR produces 82% of annual yield
- Co-located BESS could mitigate this loss and make nature-inclusive solar park more competitive → future work

Solar park: Capture price w/wo feed-in restriction



With 50% AC/DC ratio limitation:

- Business case does **not** allow for sufficient light sharing
- Nature-inclusive solar parks under feed-in restriction **needs** compensation

Capture prices for two years for four solar park designs, with 100% and 50% AC:DC

GCR	Tilt angle	Capture price 2019 [Euro/MWh]		Capture price 2024 [Euro/MWh]	
		100%	50%	100%	50%
55%	30°	38.4	39.2	57.9	60.4
65%	20°	38.4	39.1	57.9	60.1
75%	10°	38.4	39.0	58.2	60.0
80%	6°	38.4	39.0	58.4	60.0

$\Delta <1\%$

- Extra revenues nature-inclusive park (GCR 55%) <1%
- 9% higher LCOE is main problem for business case

Conclusions

- Nature restoration is guaranteed with new Eco-label for solar parks
- High penetration of solar PV in congested grids results in feed-in restrictions
- Feed-in restriction promotes high panel densities and increases LCoE of nature-inclusive solar parks



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Future work:

- Solar parks + BESS are likely to improve the competitiveness of nature-inclusive solar parks



Questions?



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Partners SolarEcoPlus:

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