



การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY



PQSynergy 2016

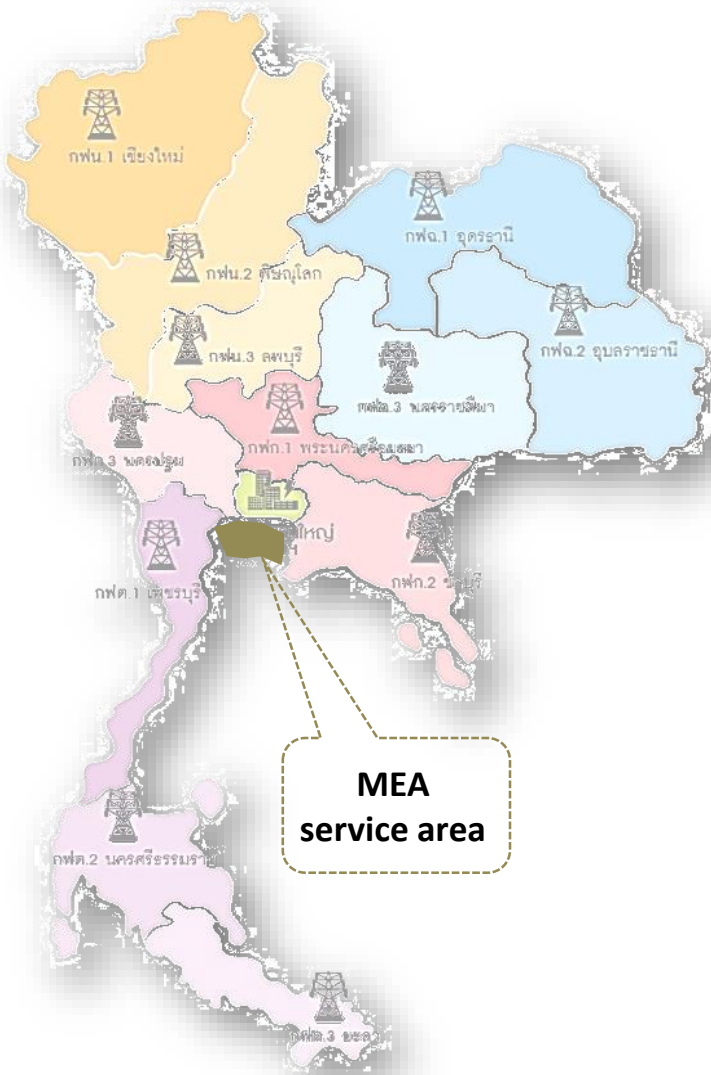
Thailand Integrates Large-Scale Wind Farms



Chakphed Madtharad, Ph.D.
Provincial Electricity Authority (PEA)

<http://tdworld.com/renewables/thailand-integrates-large-scale-wind-farms>

PEA's service area and customer



MEA
service area

Area : 510,000 km² (approx. 99%)

Province : 74 provinces
933 offices

Customer : 80,033 villages
18.06 million households
18.6 MW_{peak}

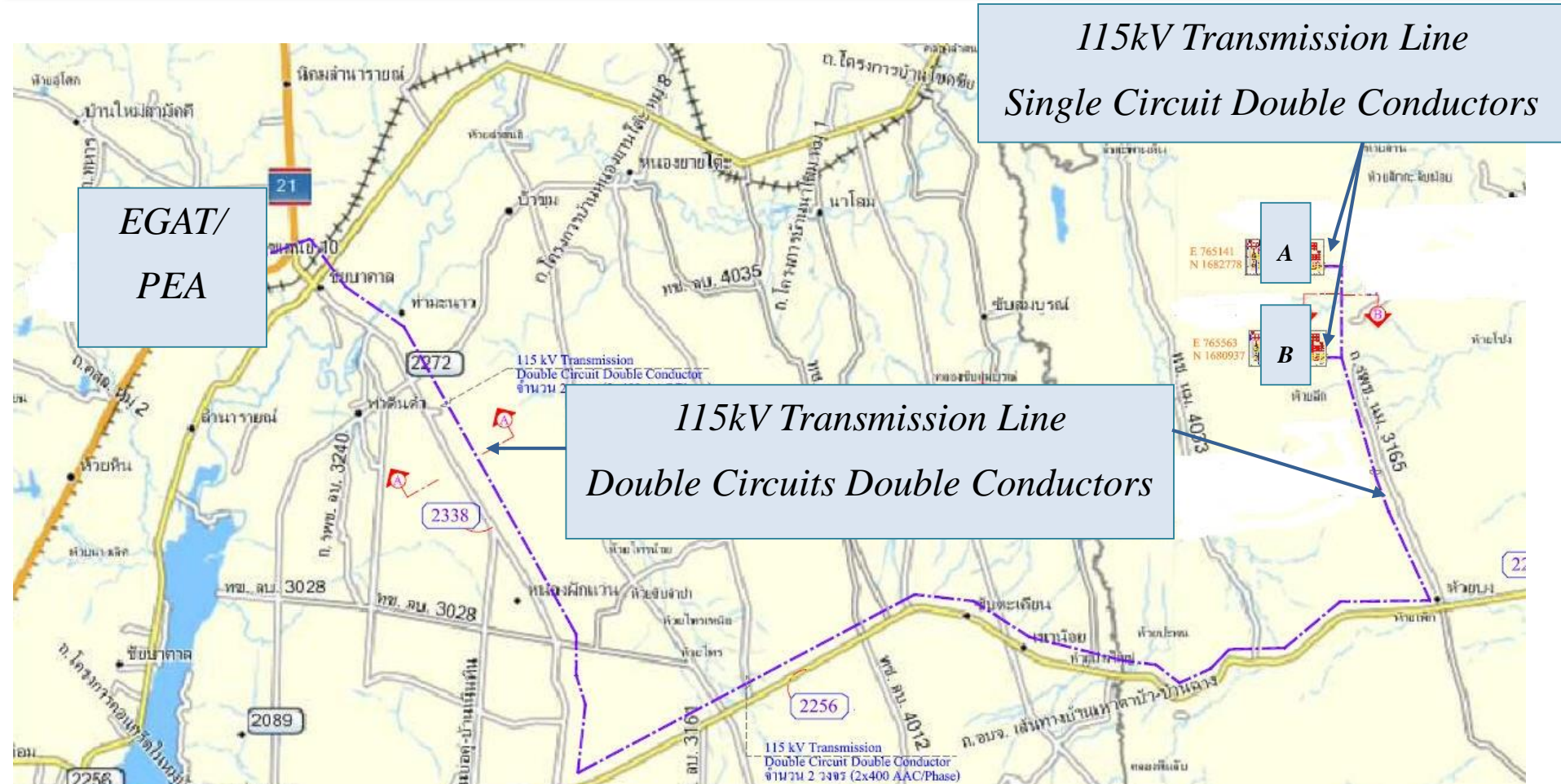
Electrified customer :
99.98% (village) / 99.63% (household)

PEA's VISION

To provide efficient and reliable electricity services for quality of life and sustainability of economy and society

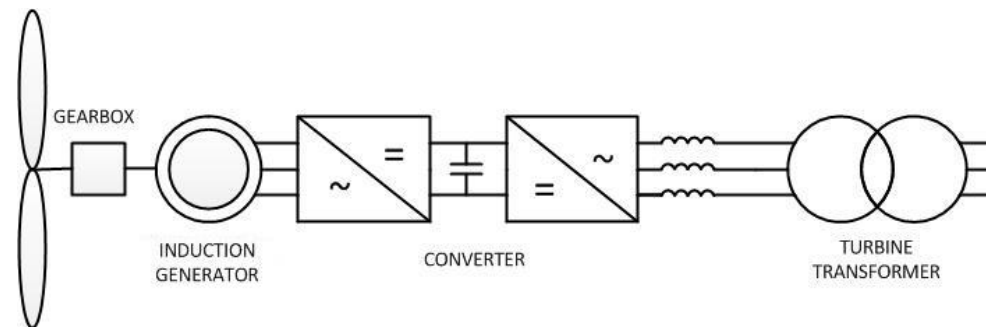


First wind farm in Kingdom of Thailand

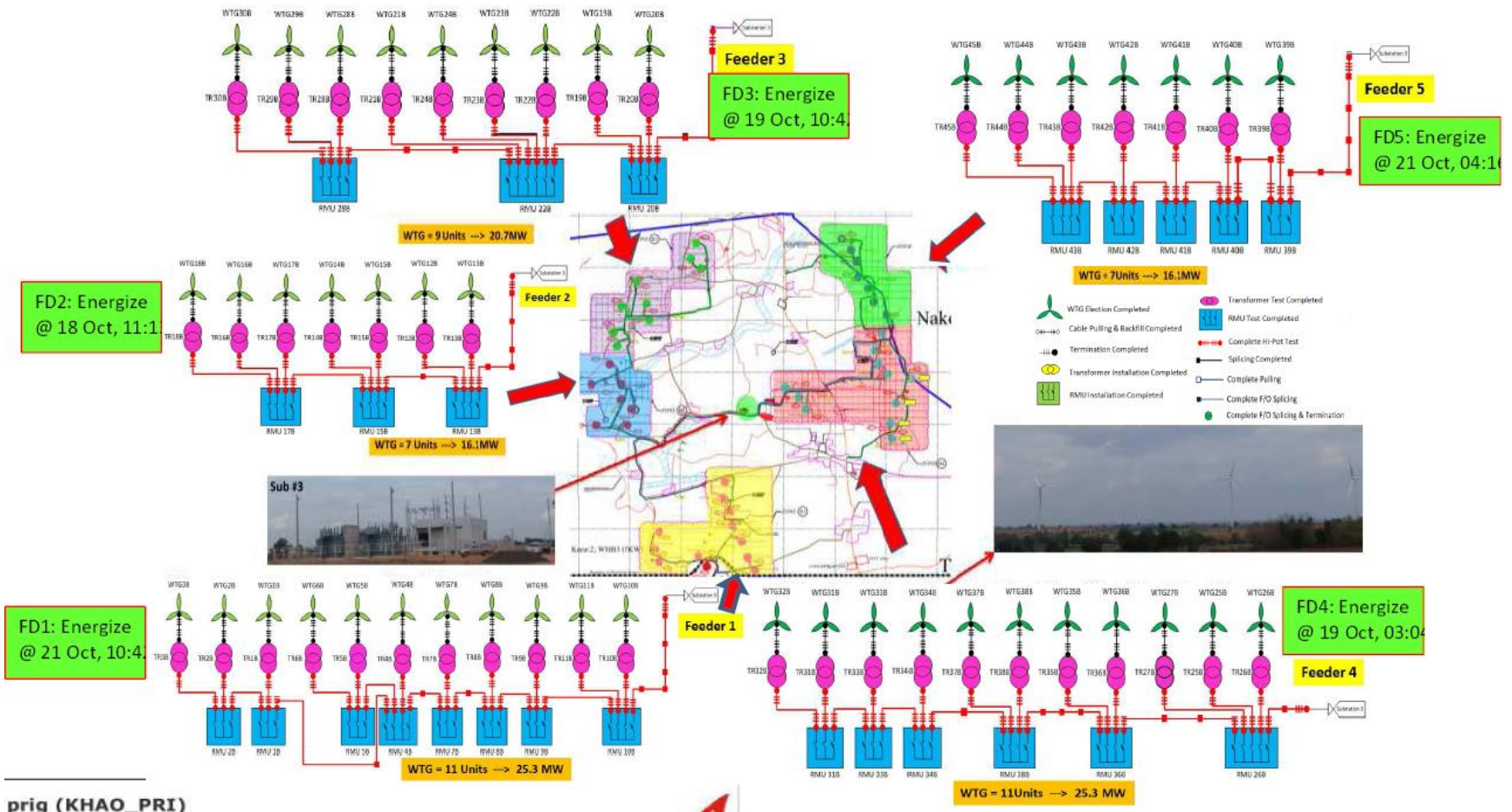


First wind farm in Kingdom of Thailand

- 2 farms of 90 MW [PCC at 115kV]
- Wind Turbine Generator (WTG)
 - 2.3MW **SWT-2.3-101**
 - Fully Converter [IEC 61400-27Type 4]
- Each farm 45 × WTG

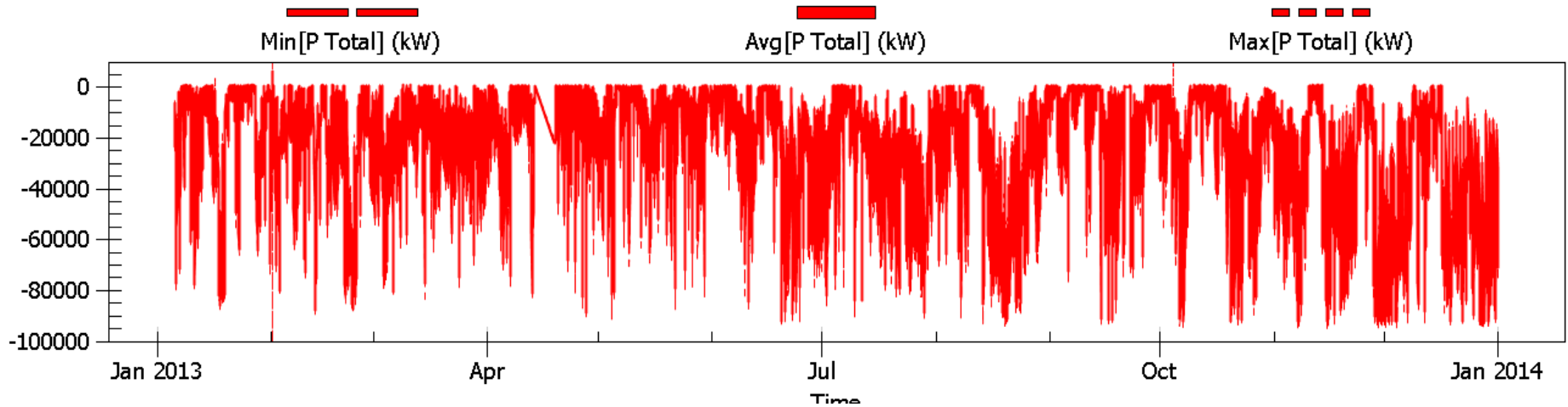


Overall diagram

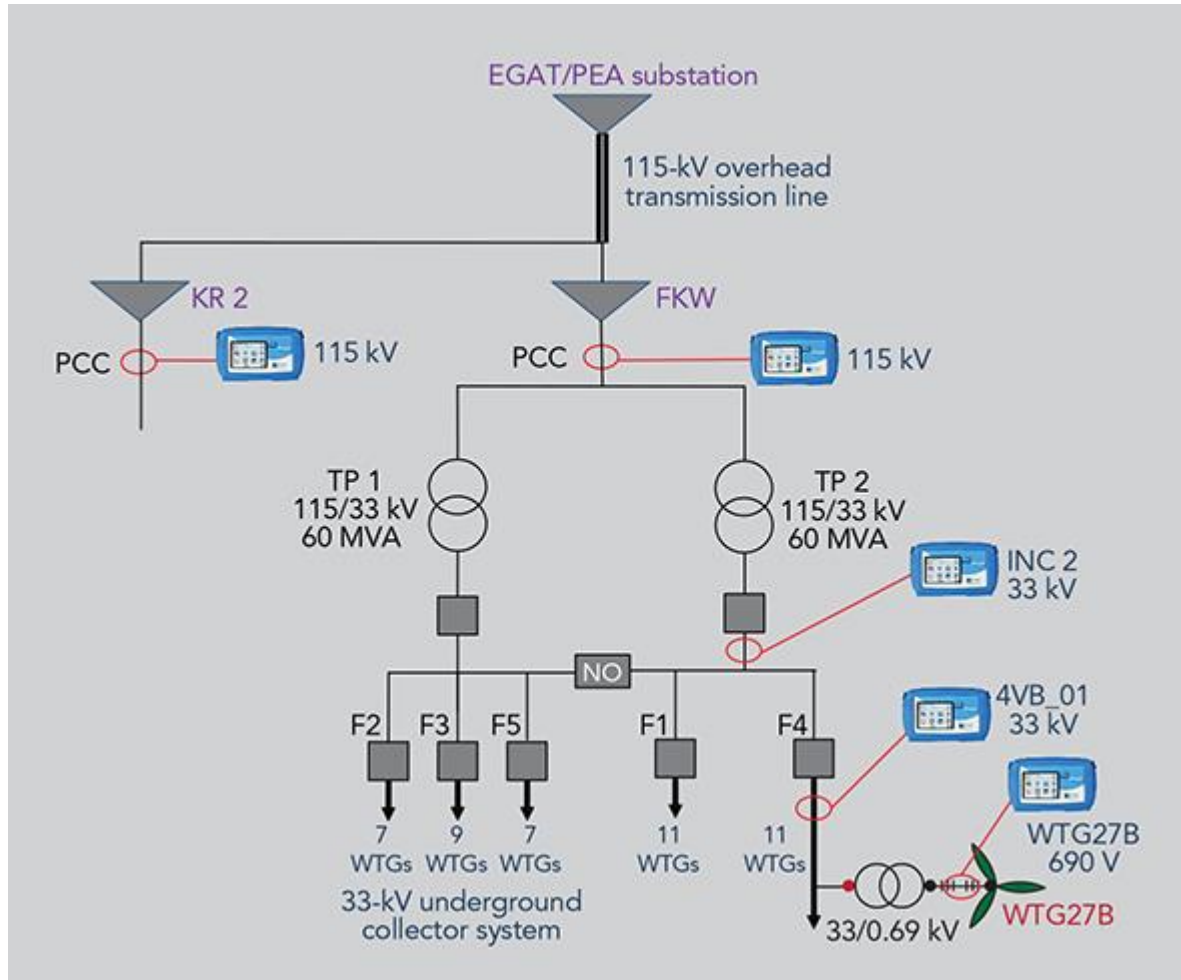


Output power of wind farm [90 MW]

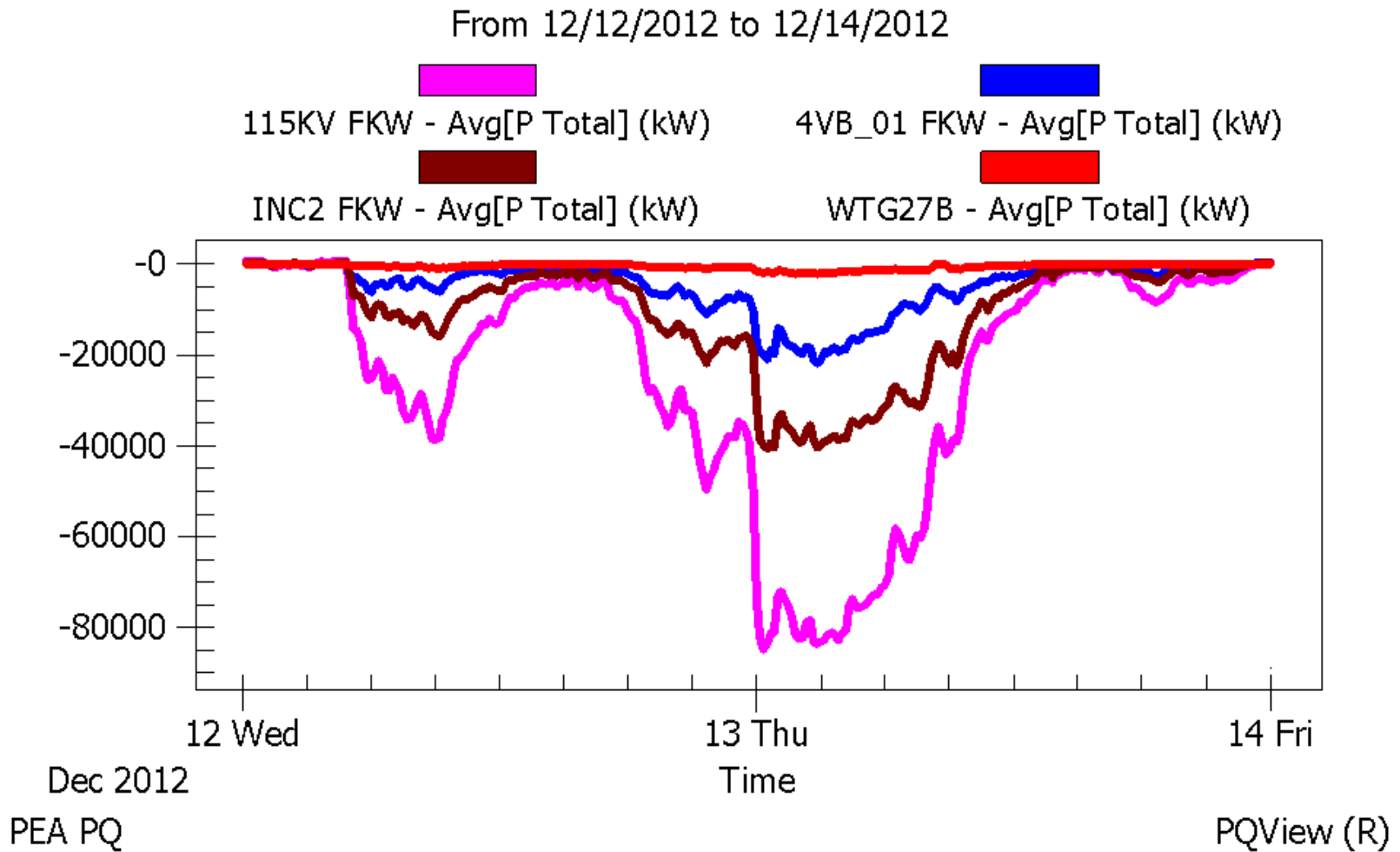
115KV FKW - P Total
From 1/1/2013 to 1/1/2014



Power quality (PQ) meter location



Example of the monitoring results at the 4 locations

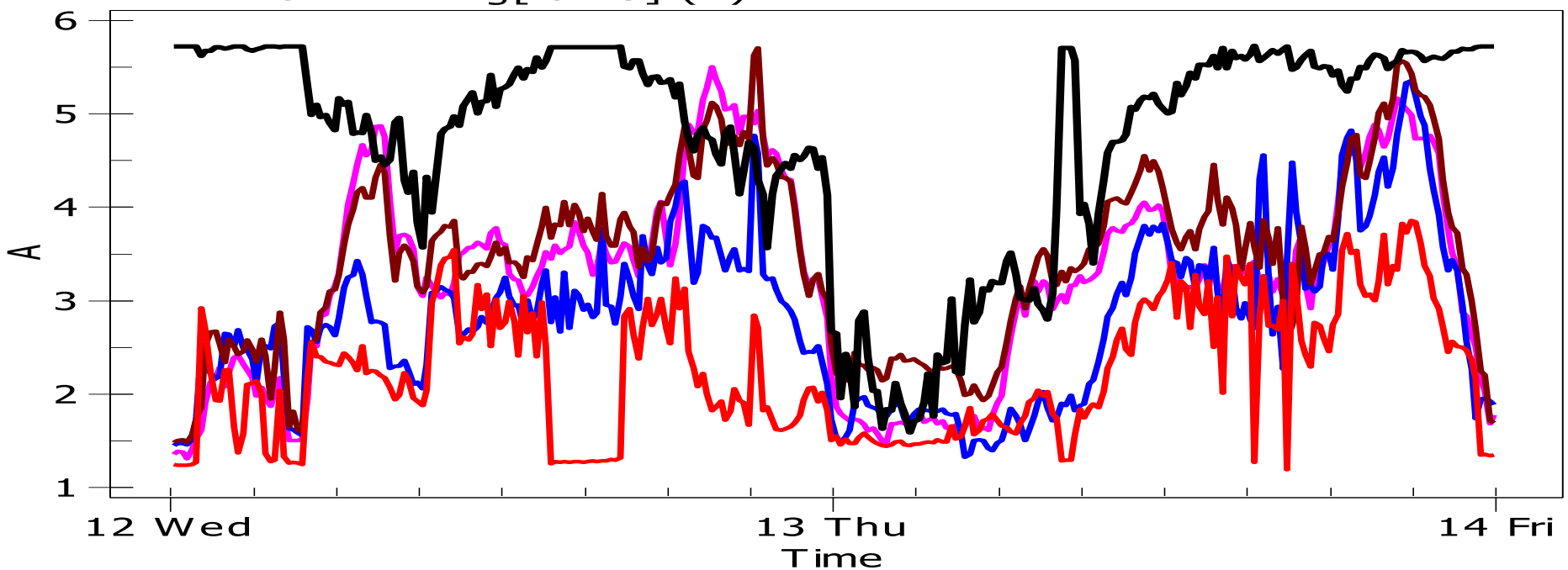


Example of the monitoring results at the 4 locations

Trend

From 12/12/2012 to 12/14/2012

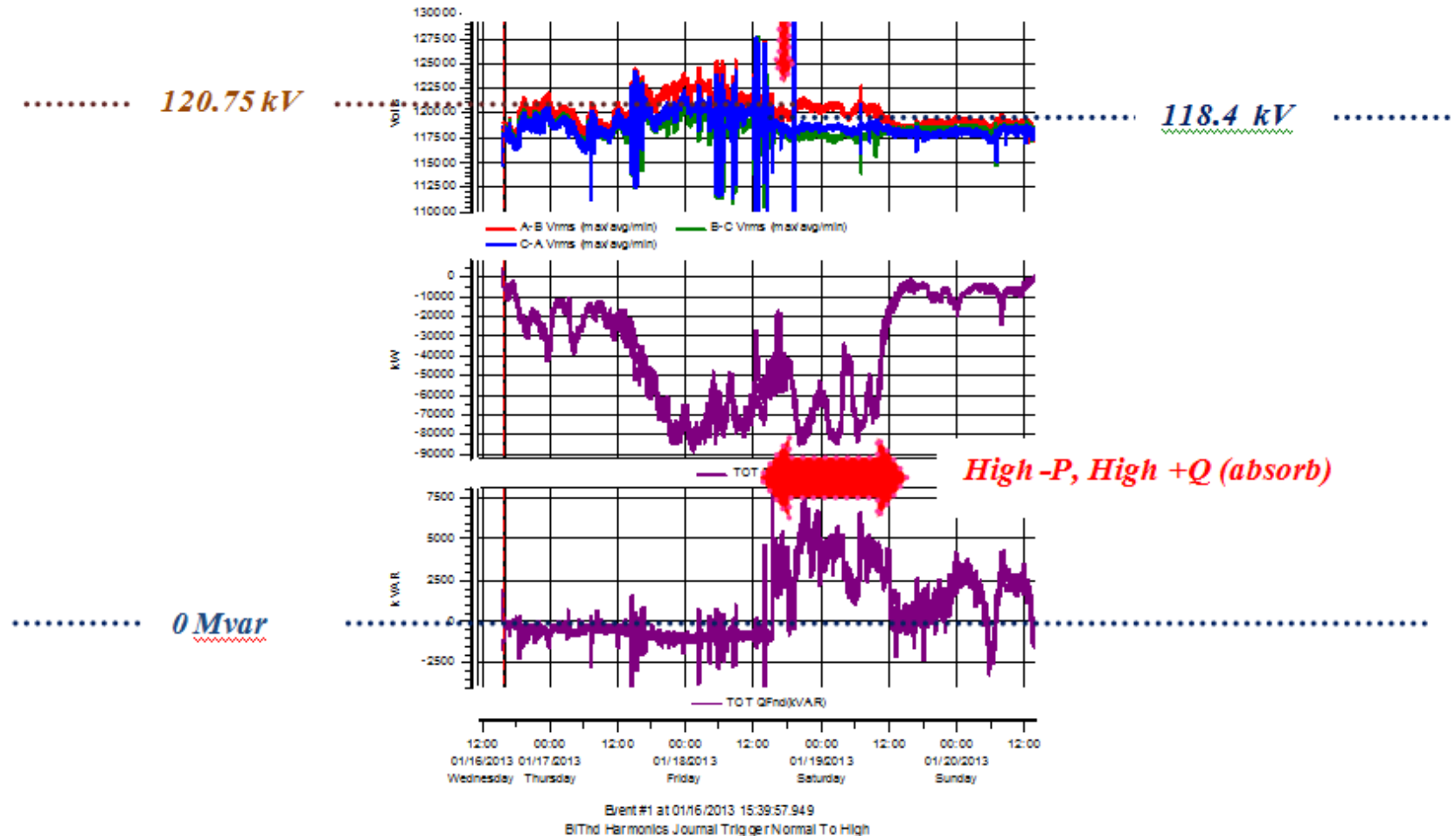
- █ 115KV FKW - Avg[Ia H5] (A)
█ INC2 FKW - Avg[Ia H5] (A)
█ WTG27B - Avg[Ia H5] (A)
- █ 4VB_01 FKW - Avg[Ia H5] (A)
█ WTG27B - Avg[P Total] (kW)

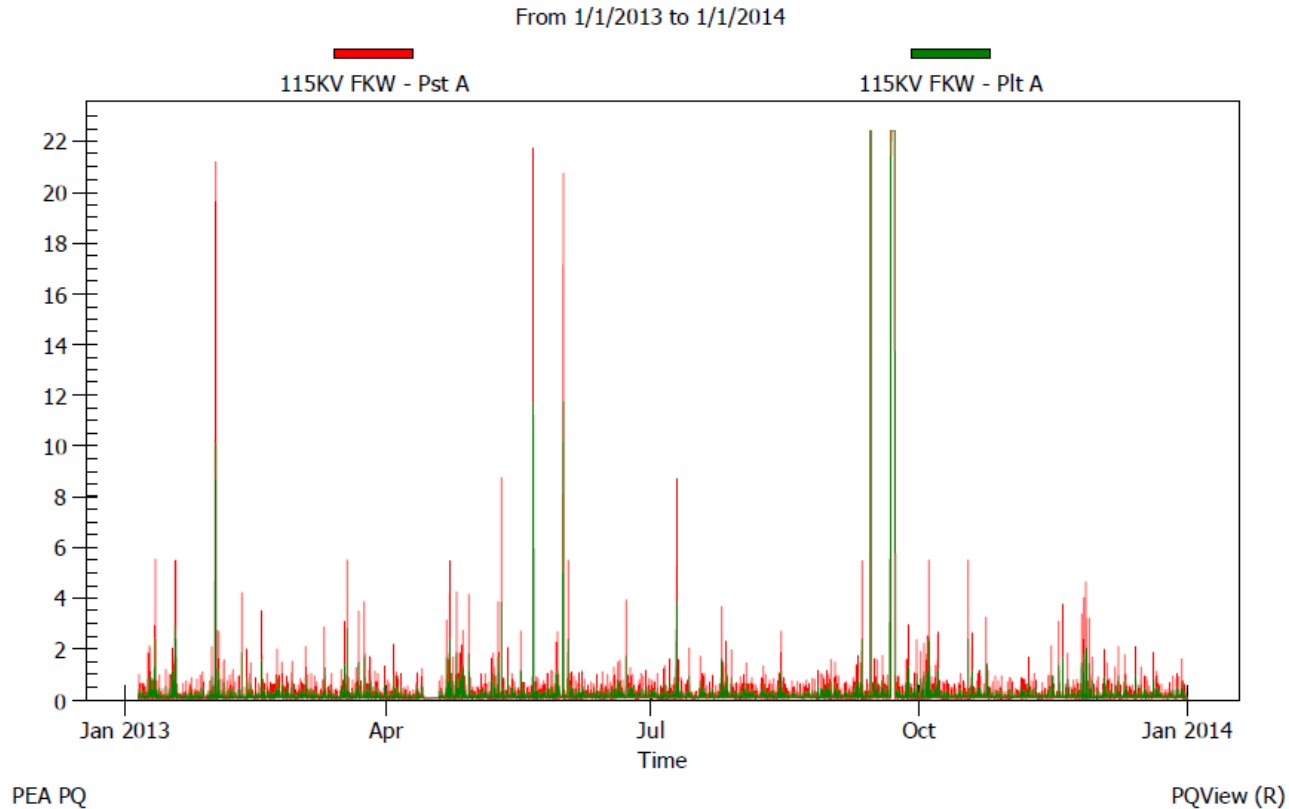


PQView (I

Impact of wind farm to voltage level at PCC

Reactive power control to voltage control 18 Jan 2013

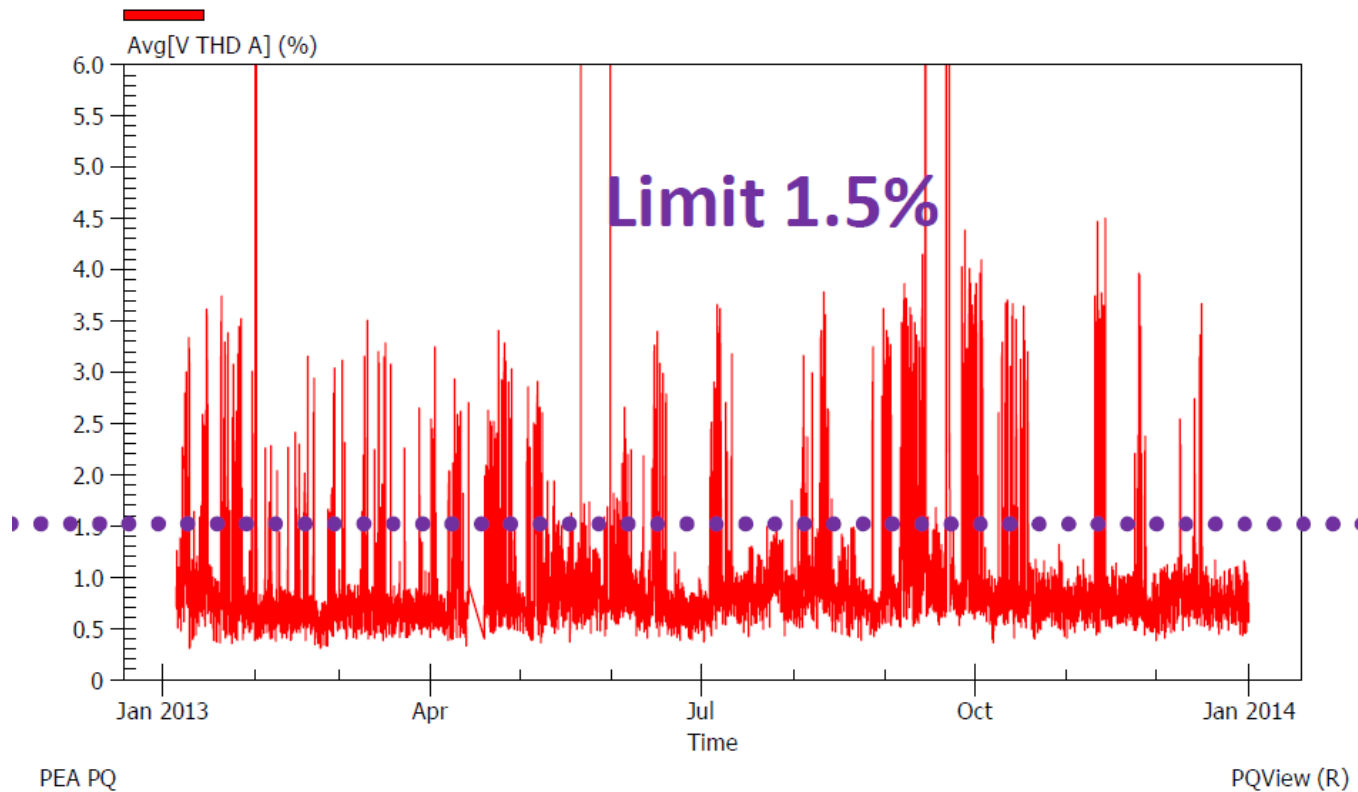




$$\text{CP95 of } P_{st} = 0.22, P_{lt} = 0.46$$

Impact of wind farm to harmonics: THDv

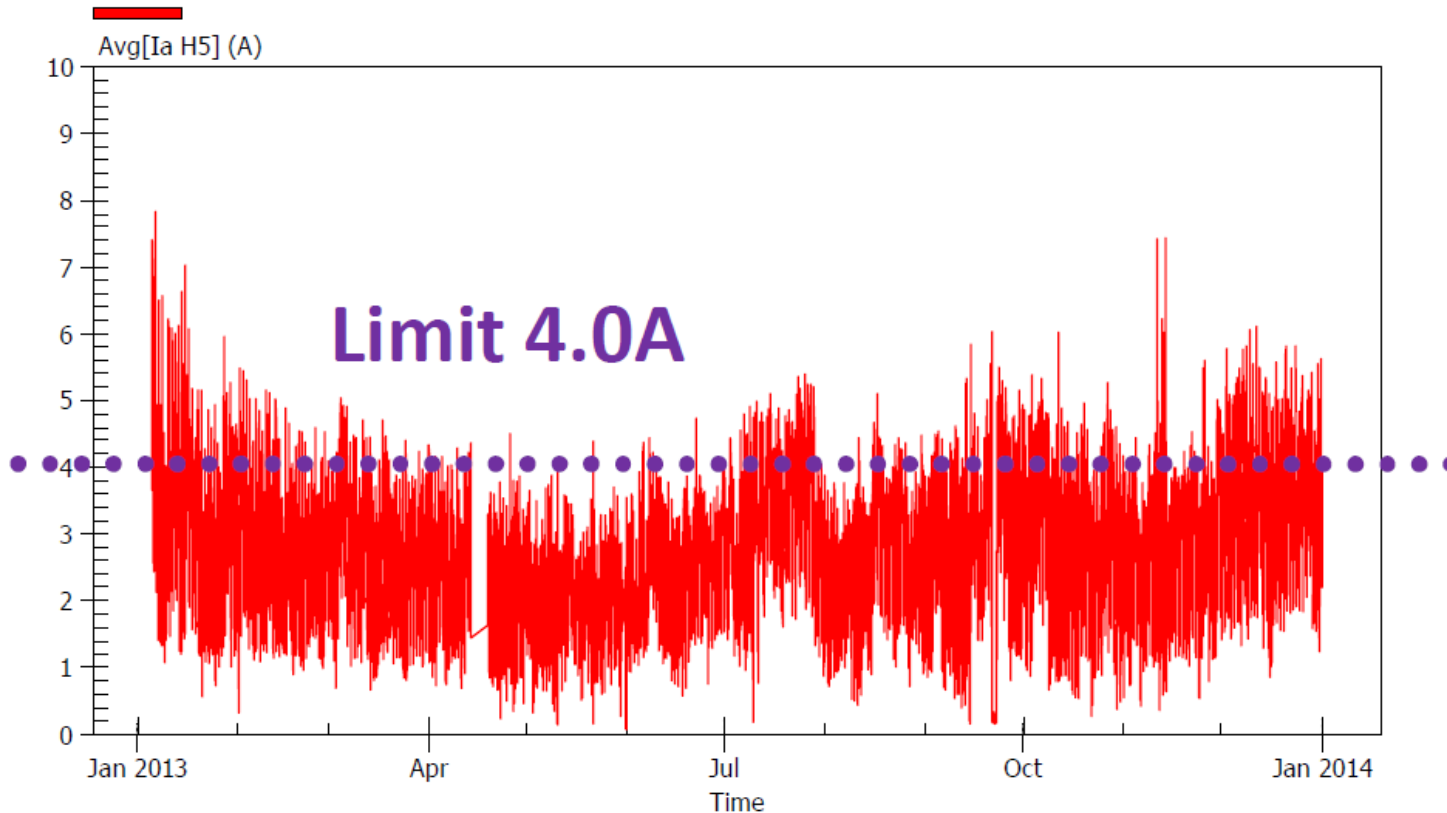
From 1/1/2013 to 1/1/2014



CP95 of THDv = 2.24%

Impact of wind farm to harmonics: Ih

From 1/1/2013 to 1/1/2014

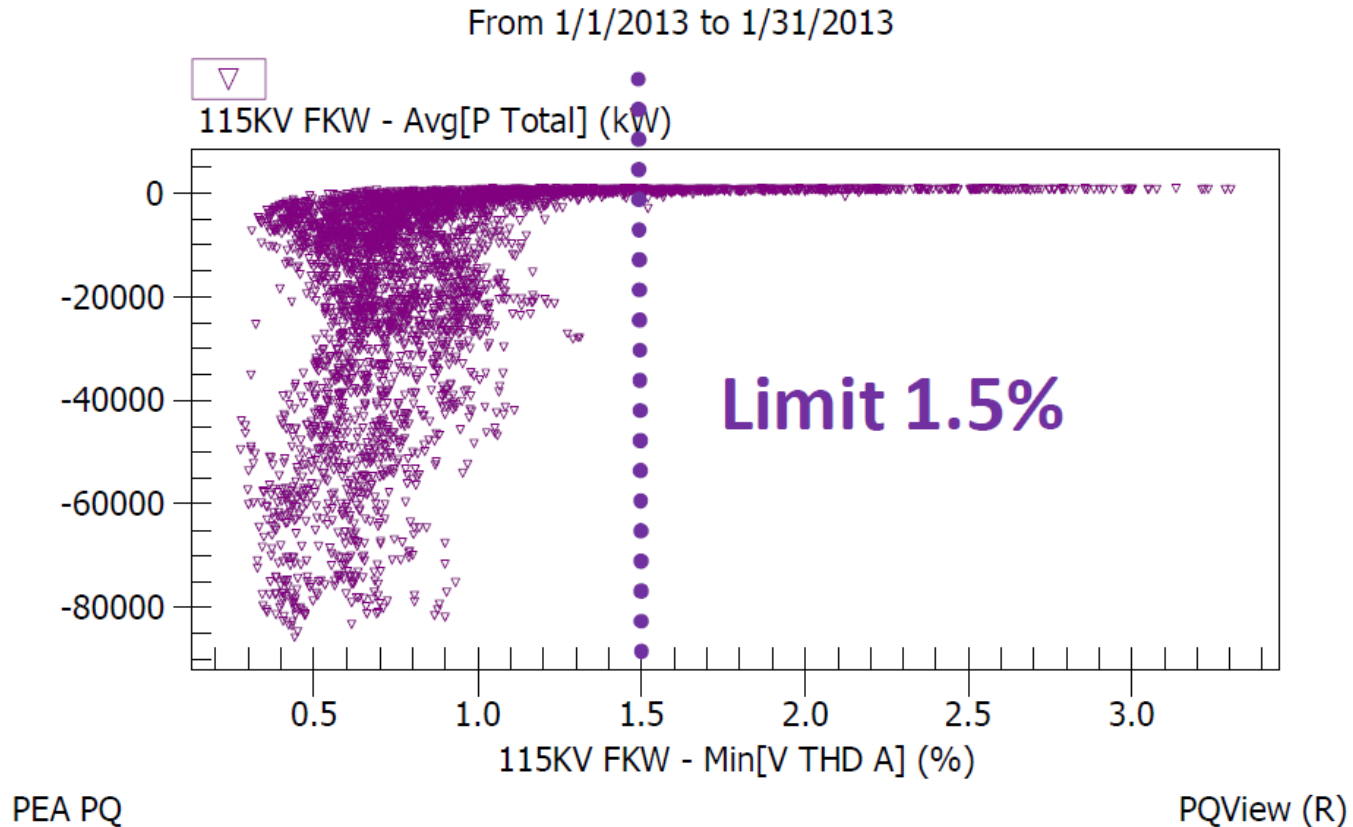


PEA PQ

PQView (R)

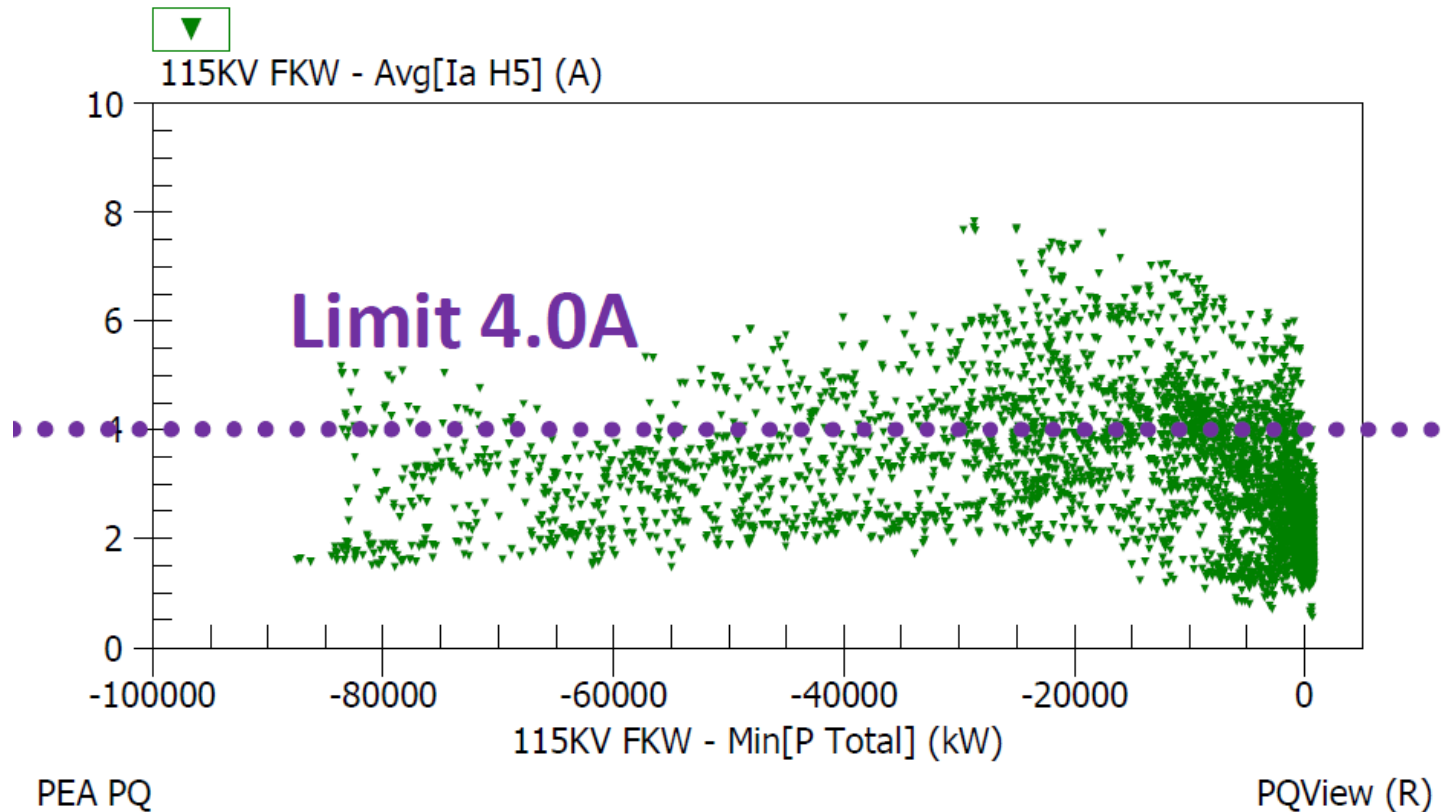
CP95 of $I_{h5} = 4.51A$

Scatter plot of output power (kW) with THDv

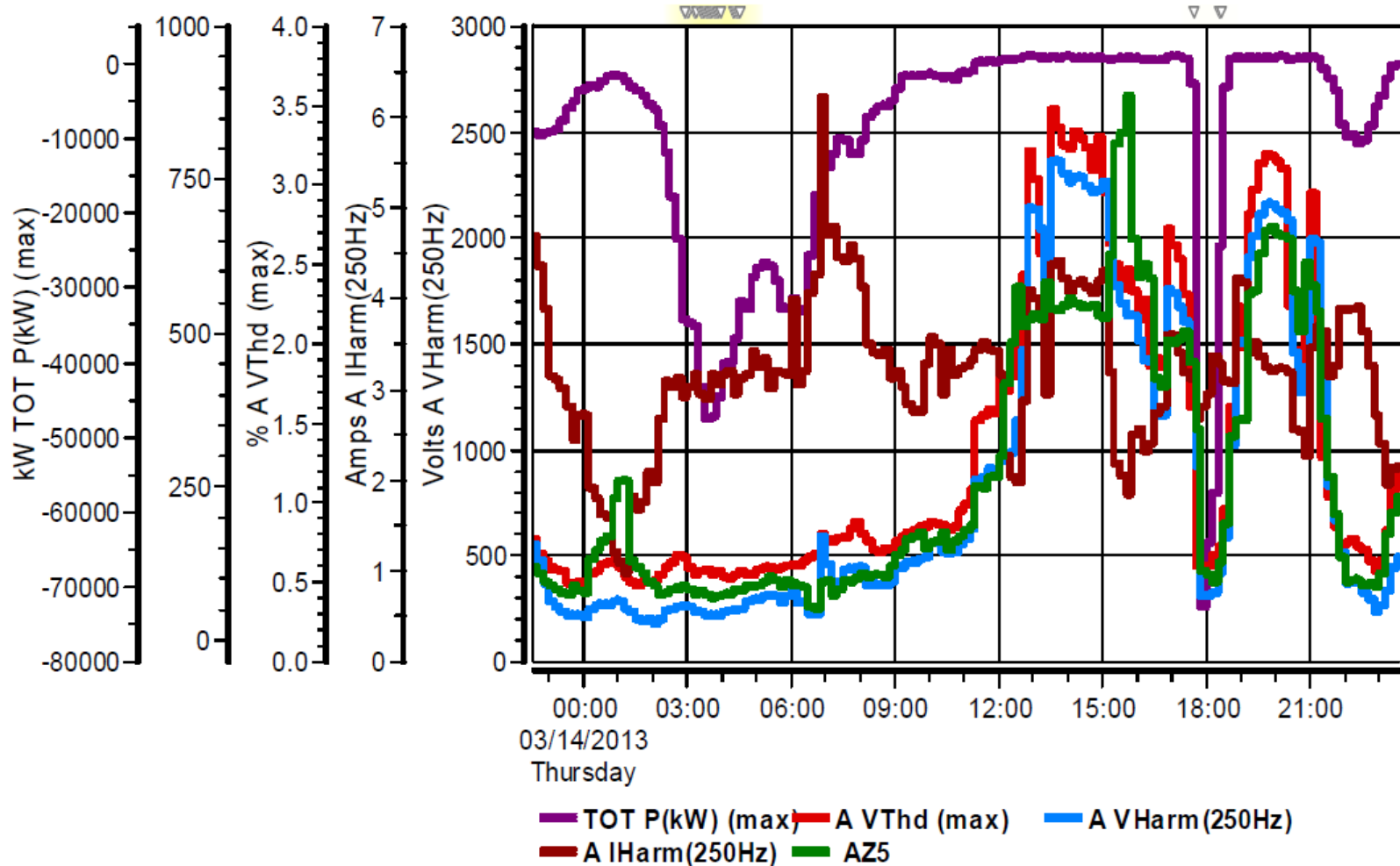


Scatter plot of output power (kW) with Ih5

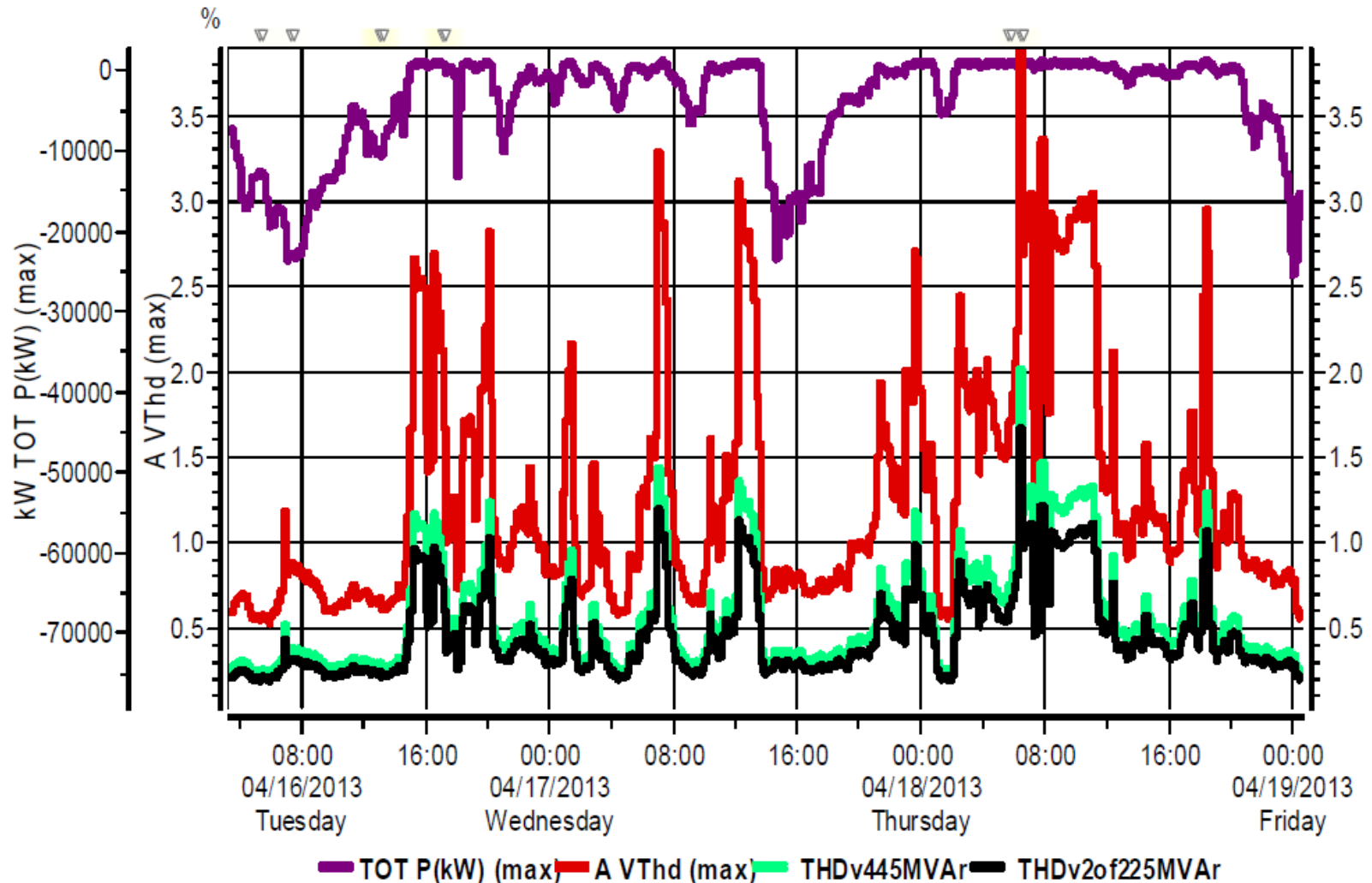
From 1/1/2013 to 1/31/2013



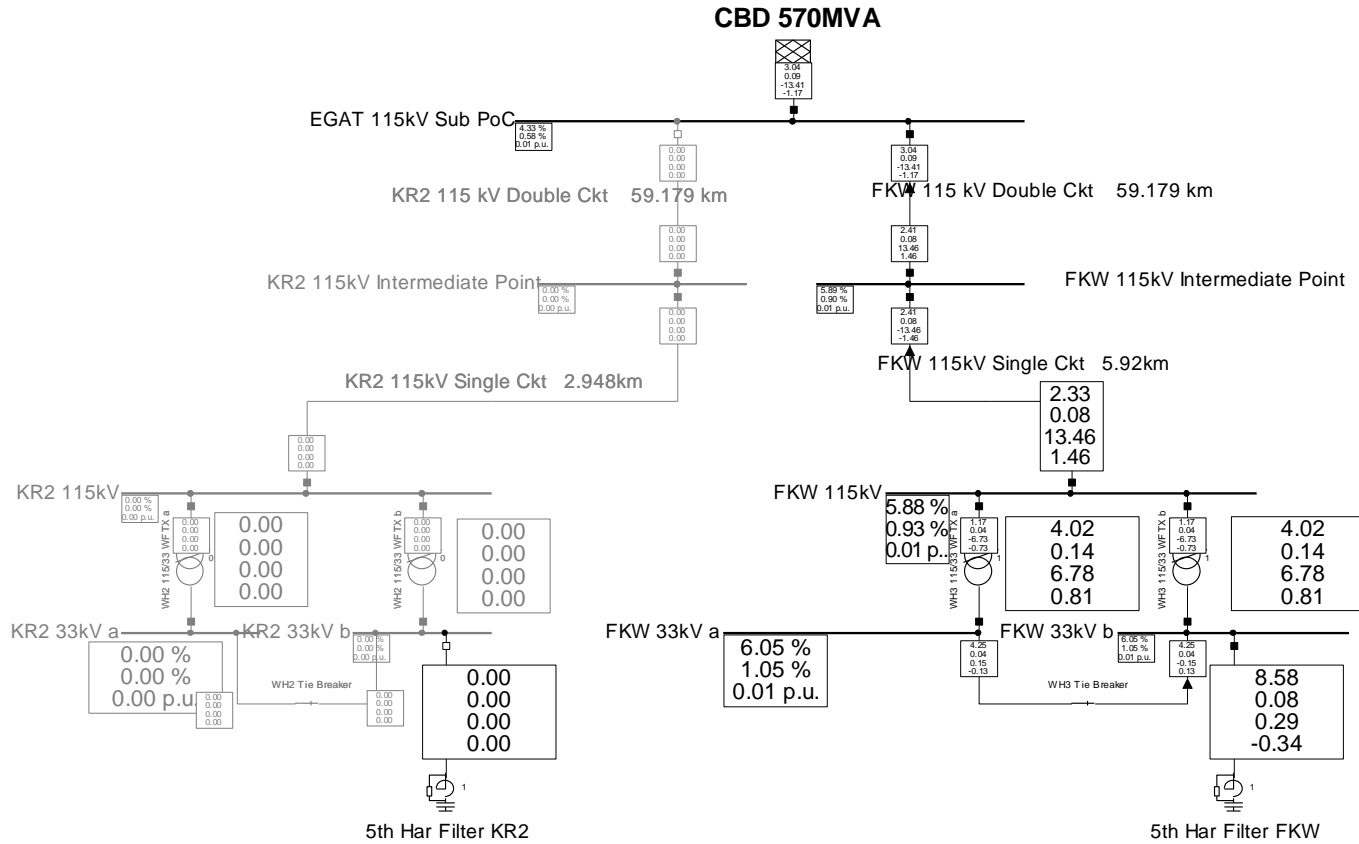
Output power P (purple), THDv (red), Vh5 (blue), Ih5 (brown) and Zh5 (green).



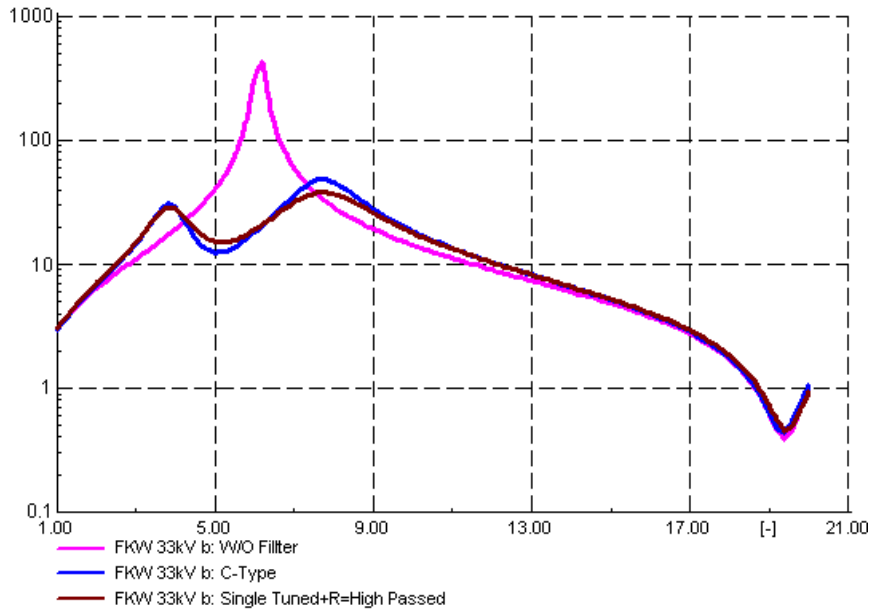
Expected THDv with fifth harmonic filter (blue/green)



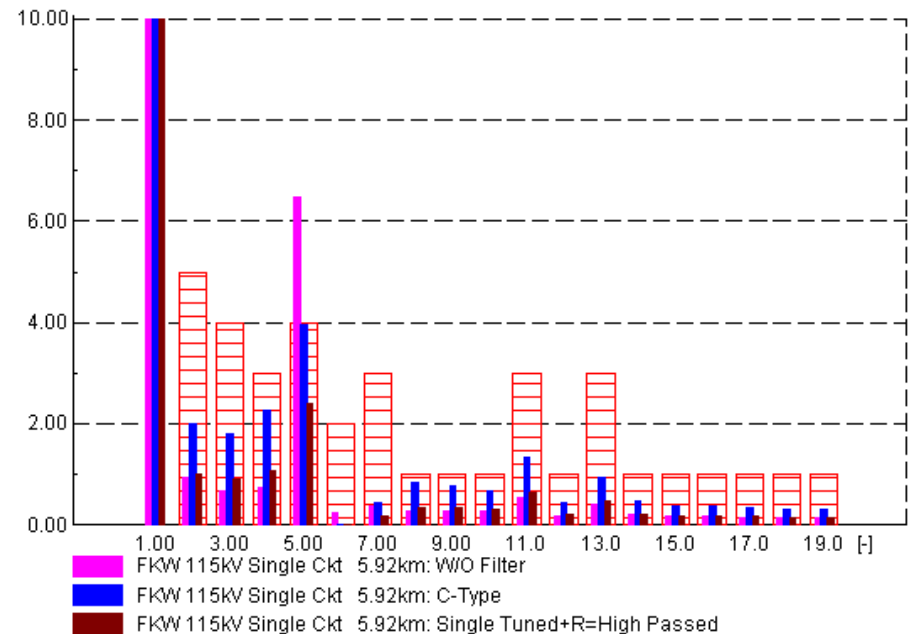
Harmonic Filter Design



Harmonic Filter Design



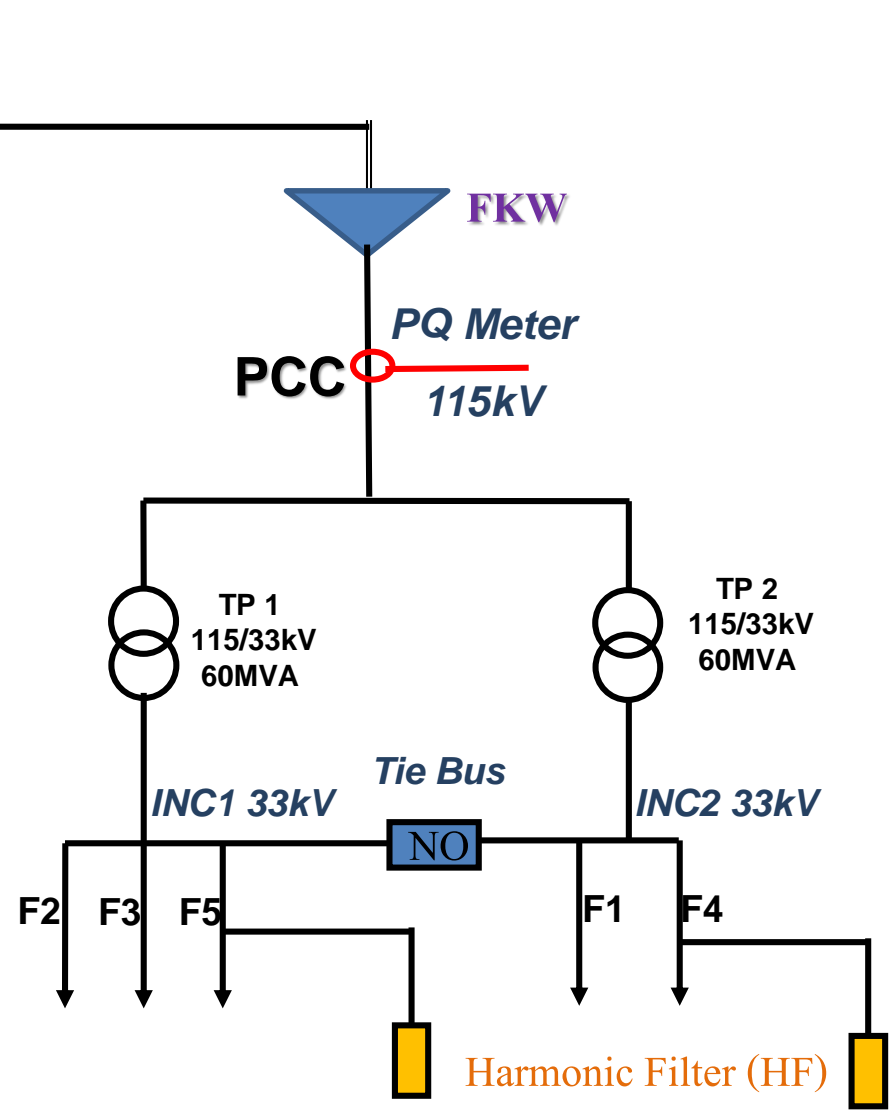
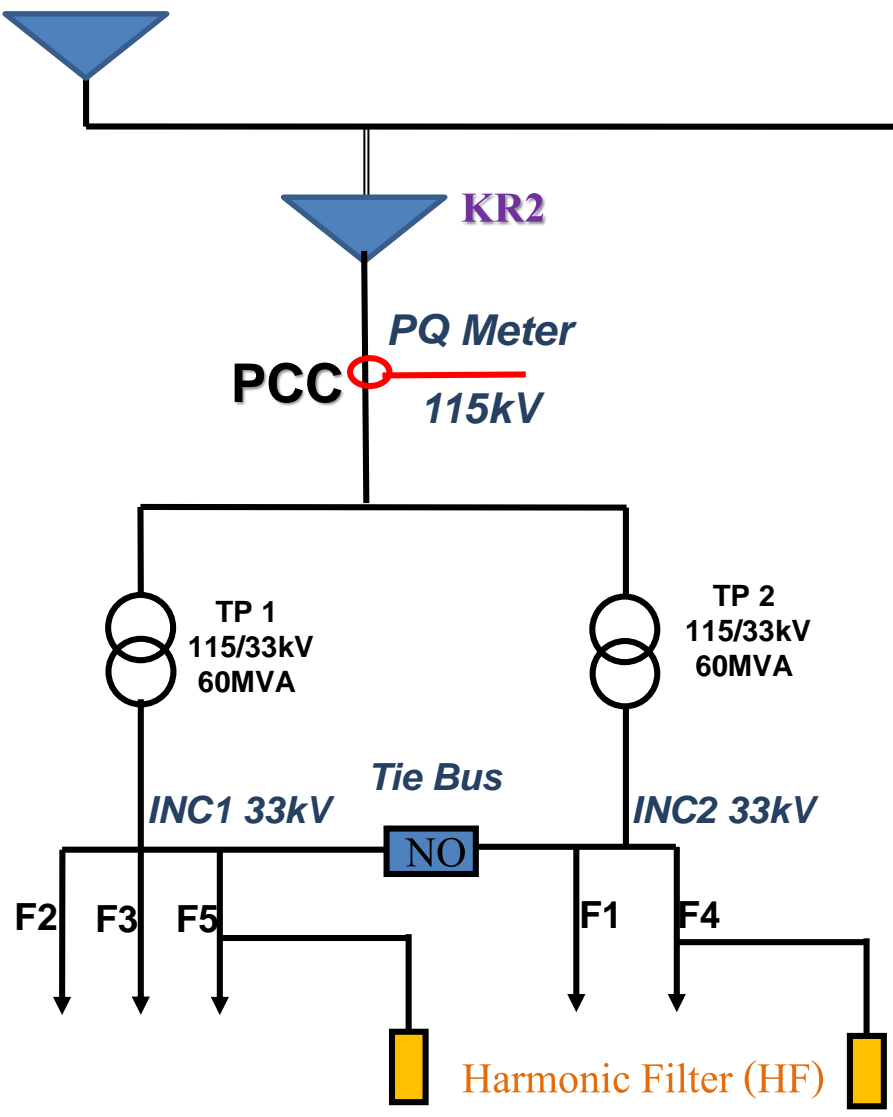
Frequency scan



Harmonic current at PCC

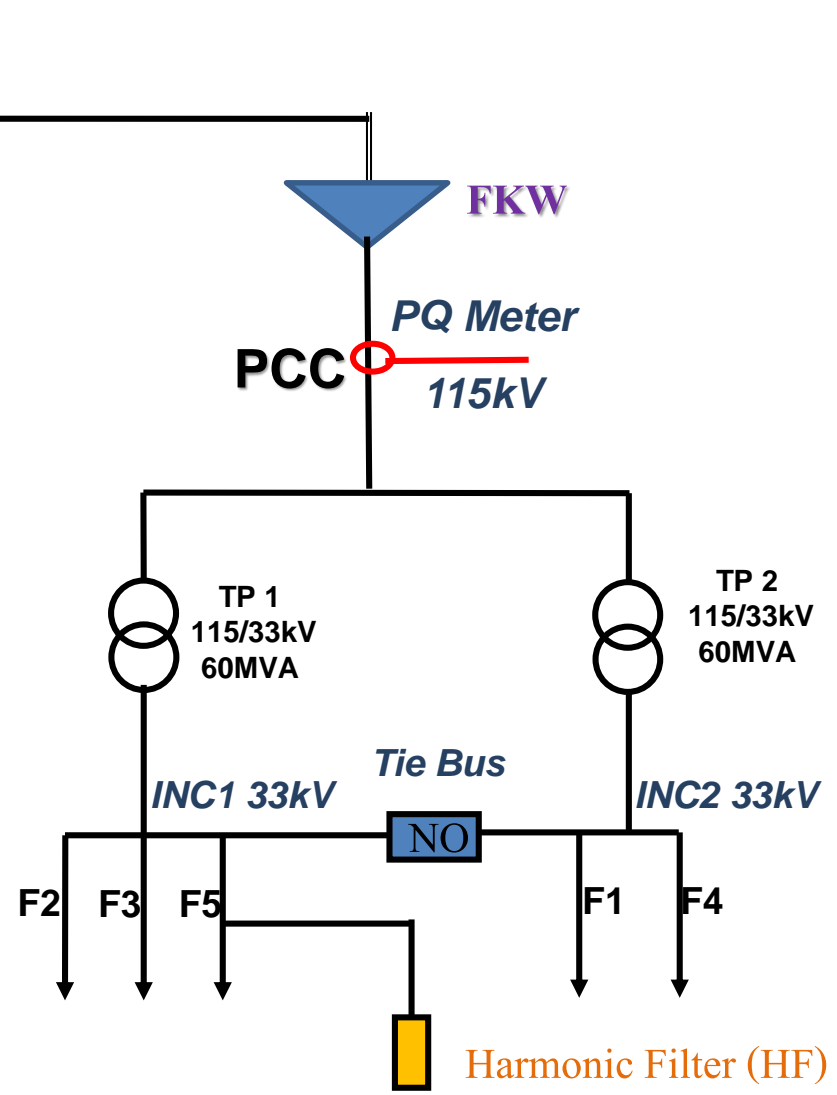
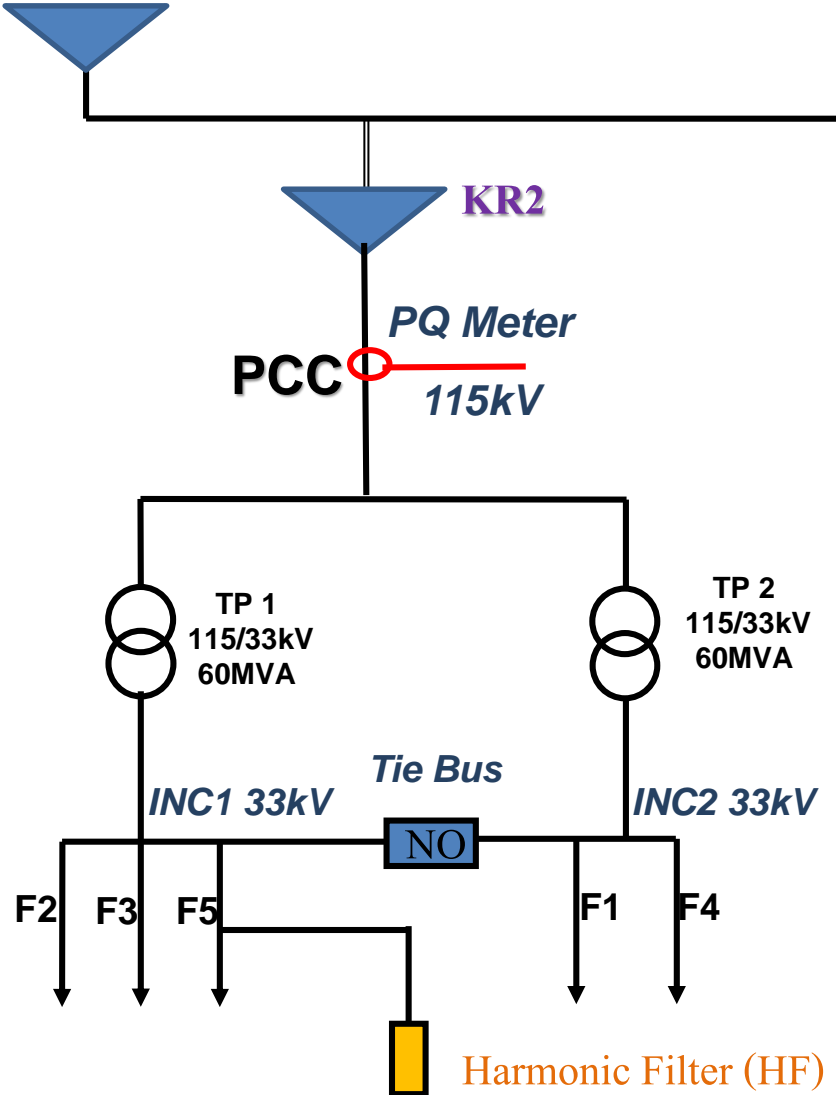
EGAT/PEA Substation

Proposed



EGAT/PEA Substation

Implemented



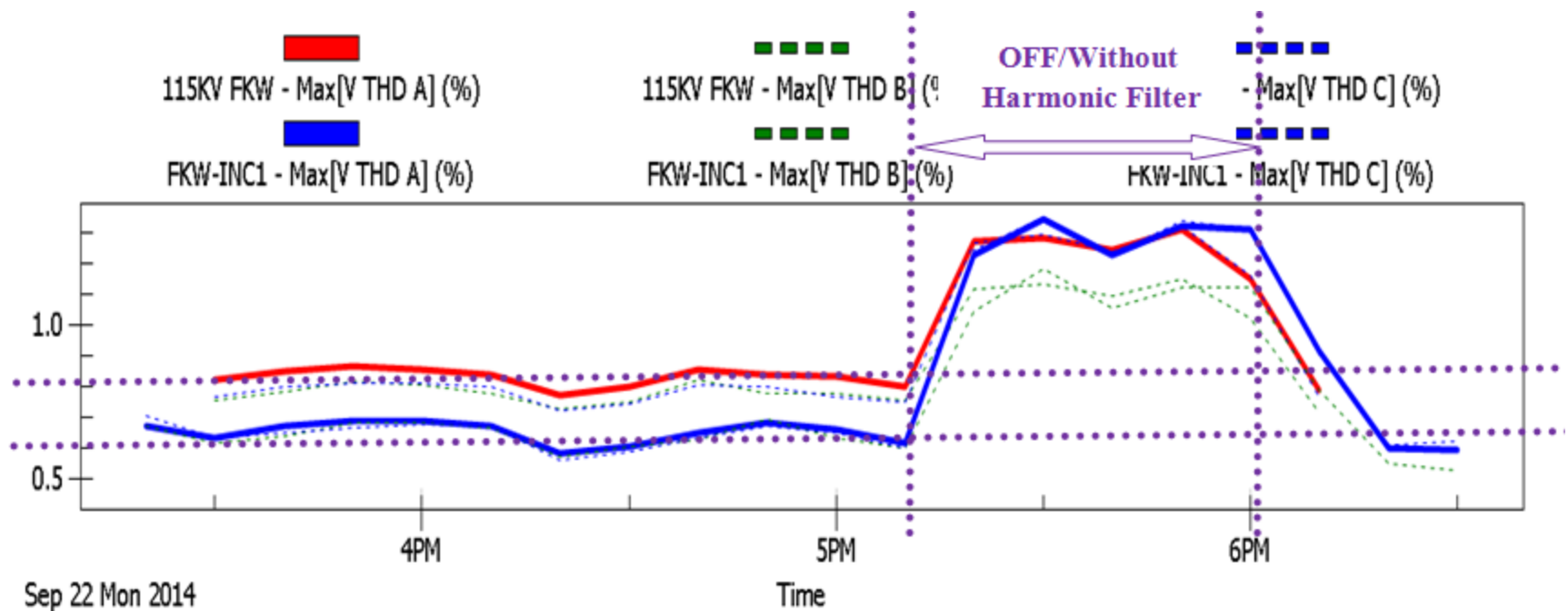
Harmonic Filter Installation



Harmonic Filter Installation

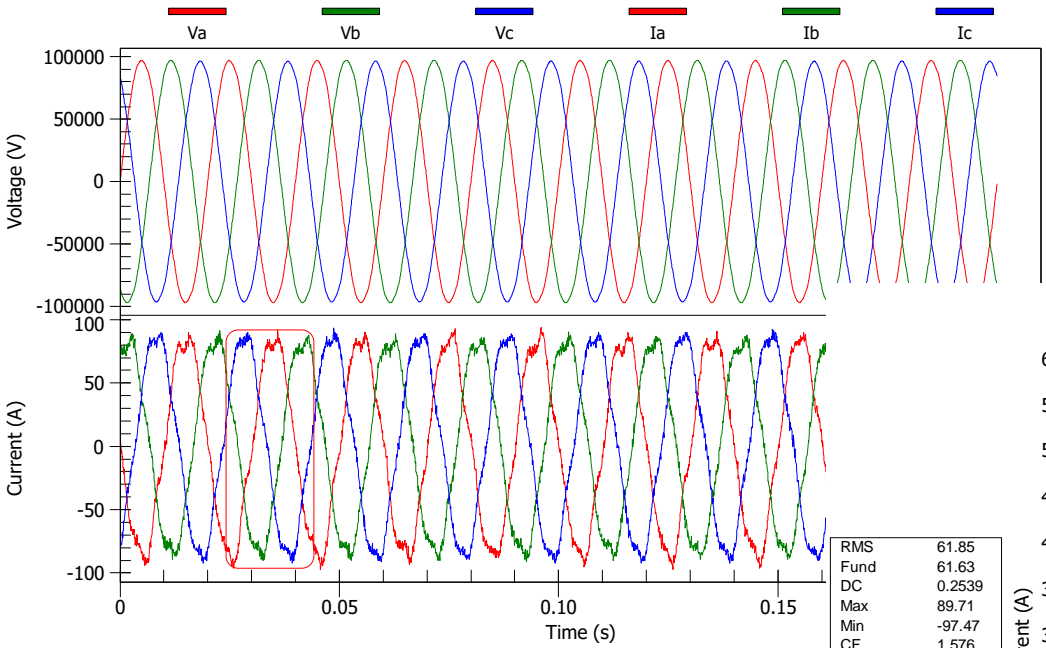


Implementation Result



Implementation Result: w/ HF

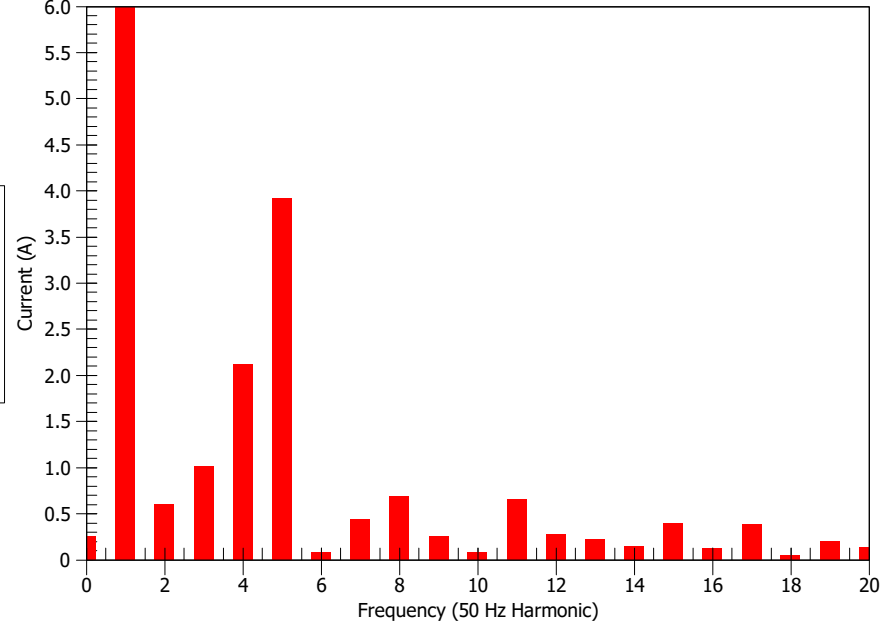
115KV FKW - 9/22/2014 16:29:59.8100



RMS	61.85
Fund	61.63
DC	0.2539
Max	89.71
Min	-97.47
CF	1.576
FF	1.124
THD Fund	8.42%
THD RMS	8.39%
HRMS	5.192
Phase Jump	0.3151°

115KV FKW - 9/22/2014 16:29:59.8100

1-Cycle FFT Ia From 0.03602 to 0.05594 s

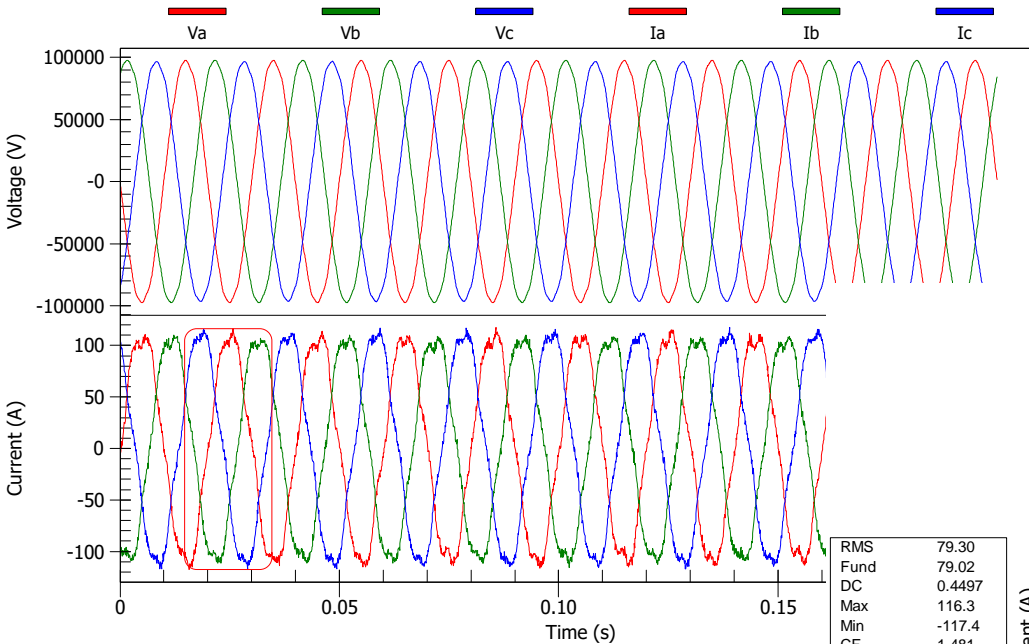


PQ

PQView (R)

Implementation Result: w/o HF

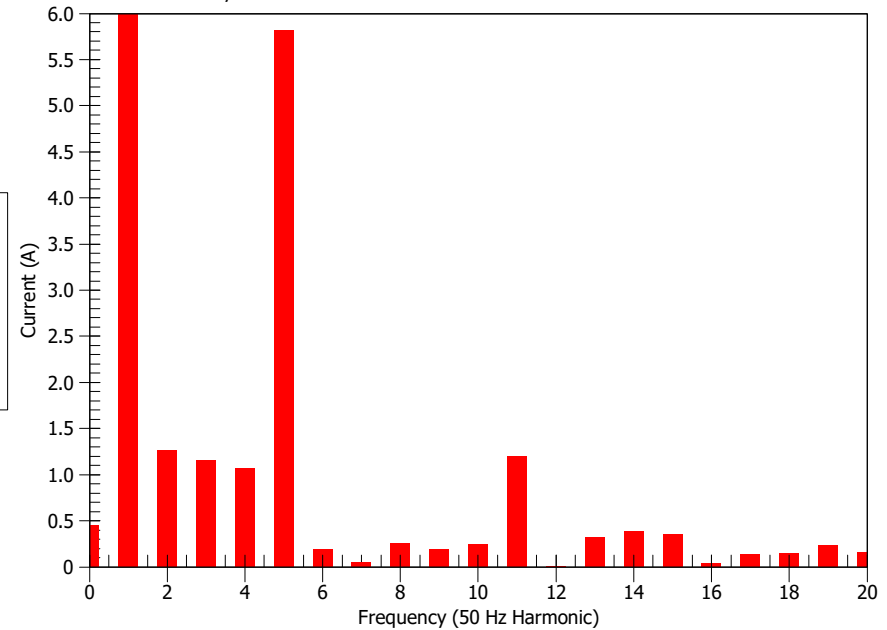
115KV FKW - 9/22/2014 17:39:59.8101



RMS	79.30
Fund	79.02
DC	0.4497
Max	116.3
Min	-117.4
CF	1.481
FF	1.132
THD Fund	8.41%
THD RMS	8.38%
HRMS	6.648
Phase Jump	-0.1217°

115KV FKW - 9/22/2014 17:39:59.8101

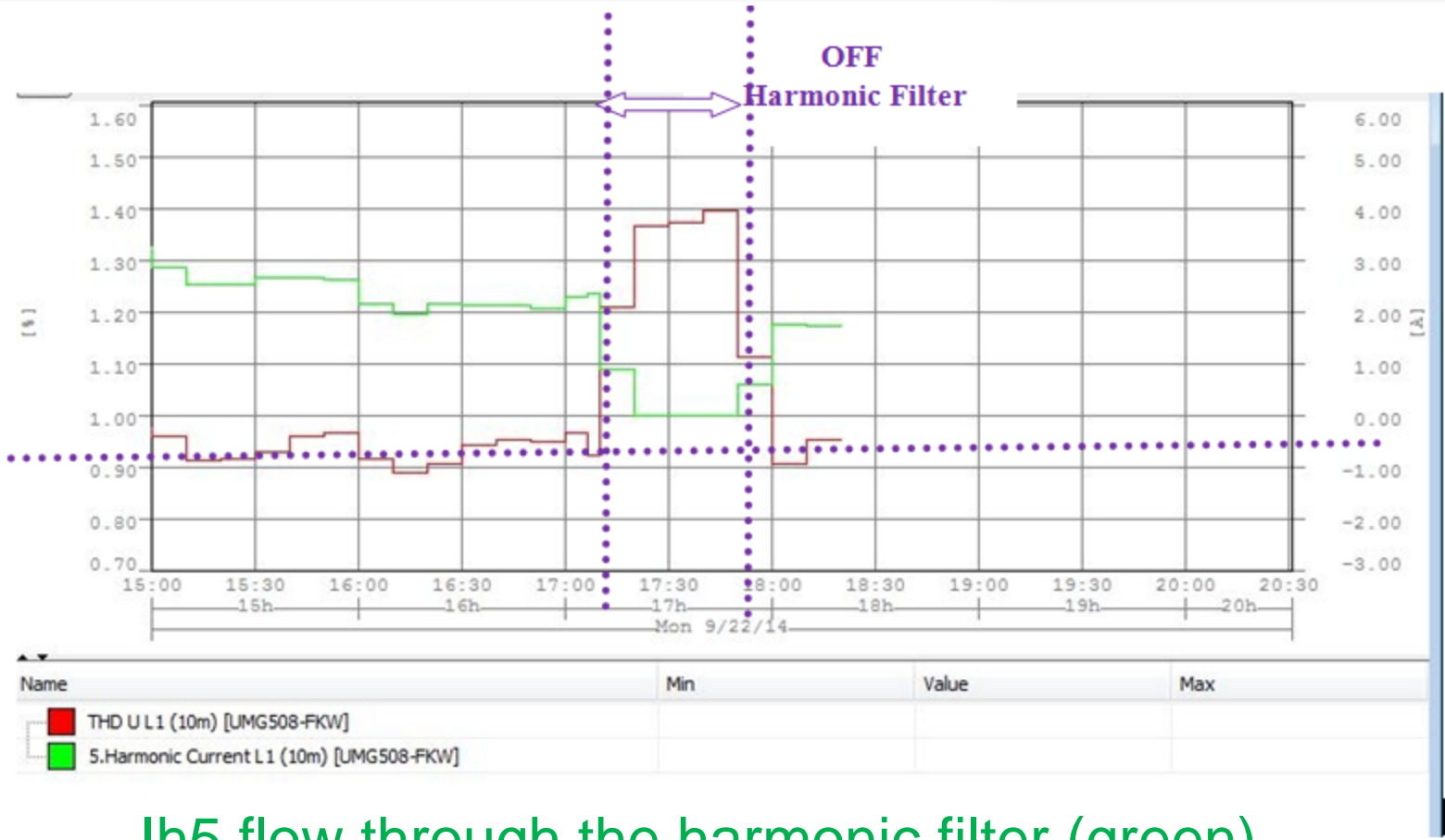
1-Cycle FFT Ia From 0.01476 to 0.03468 s



PQ

PQView (R)

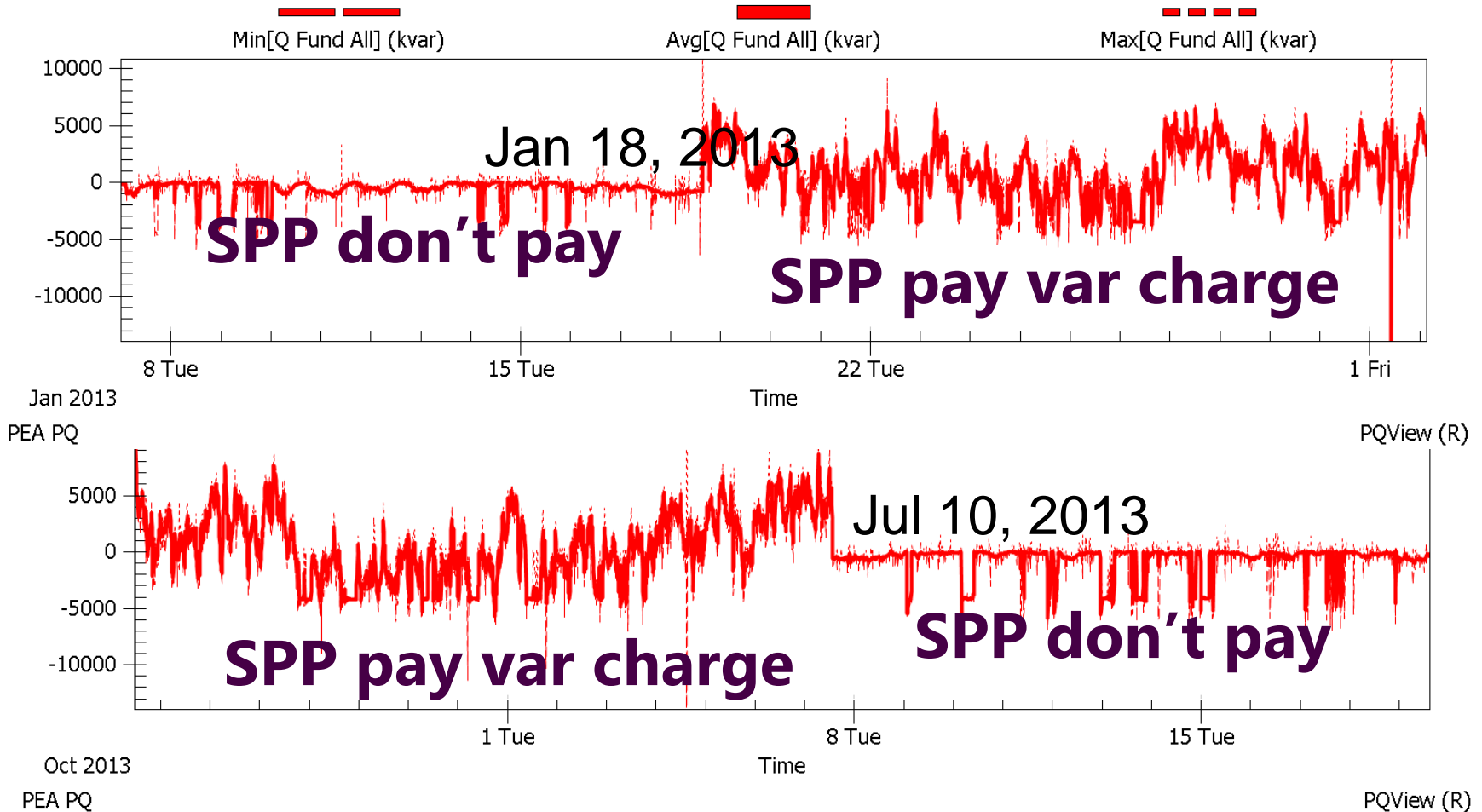
Implementation Result



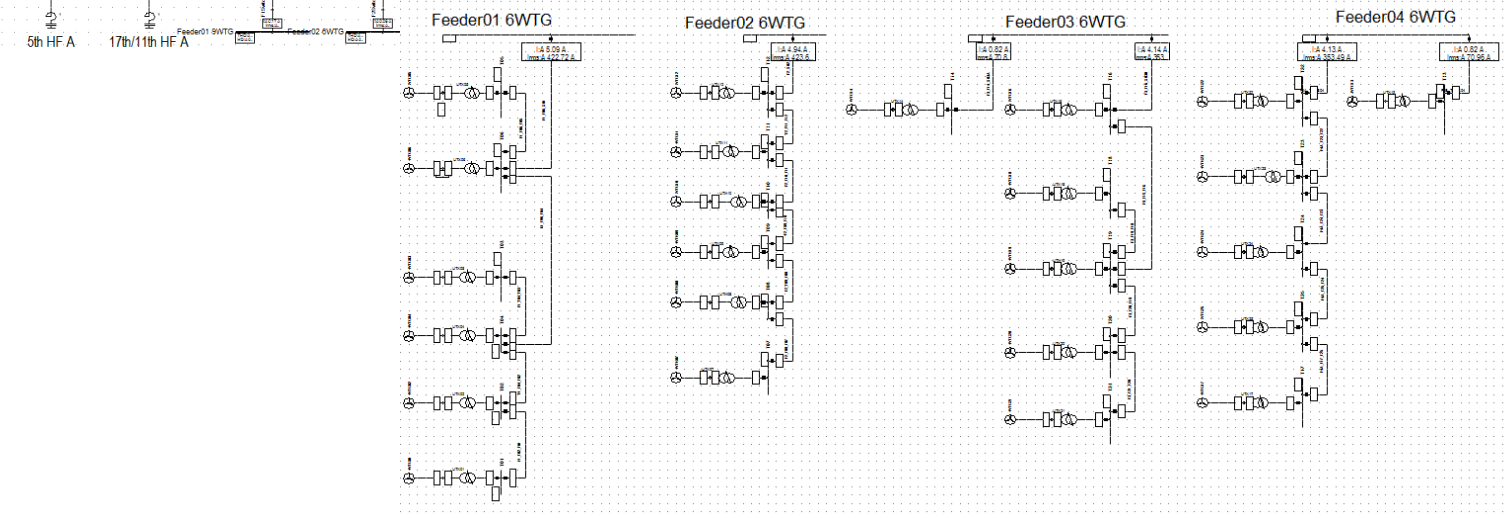
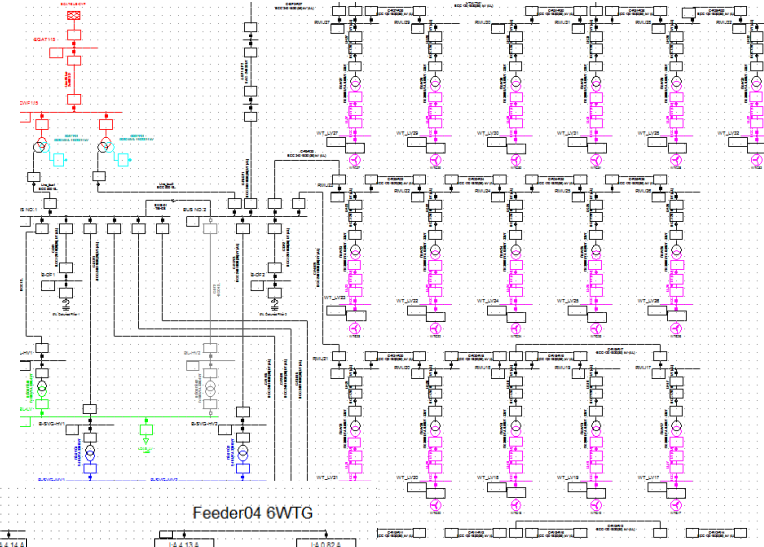
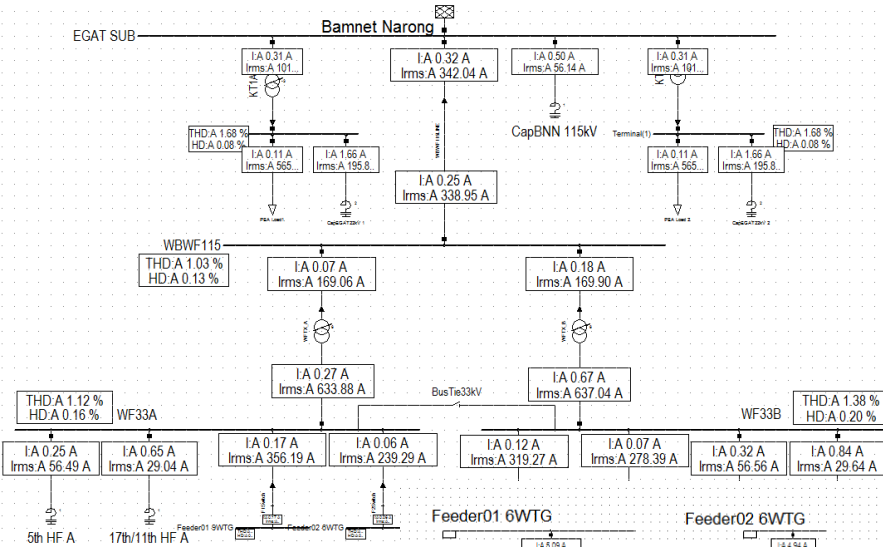
Ih5 flow through the harmonic filter (green)
THDv at harmonic filter (purple)

var Charge

115KV FKW - Q Fund All
From 10/26/2012 2:10:00 AM to 5/18/2014



Ongoing projects to design the Harmonic Filter

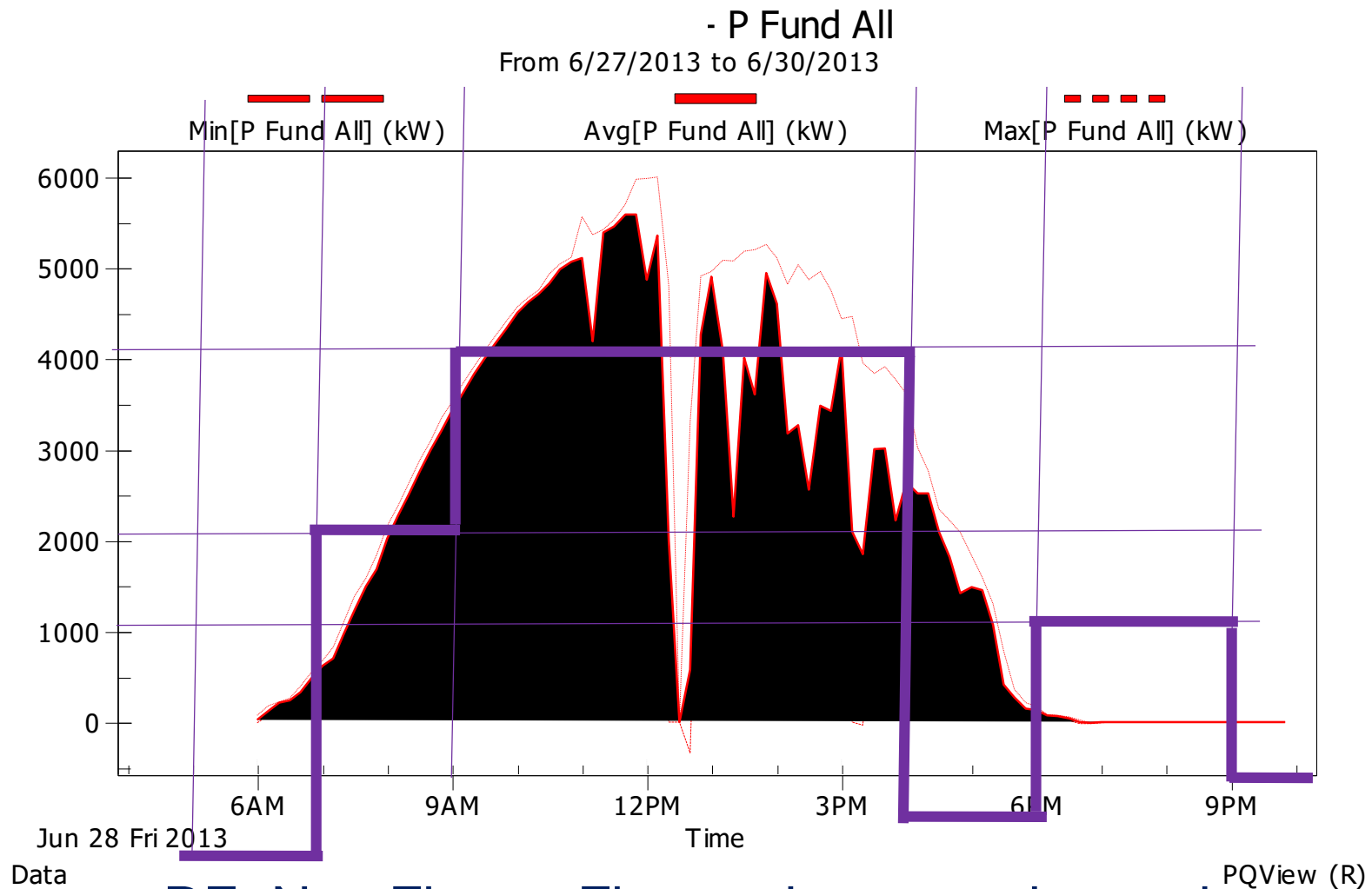


1. Upcoming SPP/VSP (RE) shall be **Firm** (RE Firm definition is needed)
2. Ancillary Services Business Model by using Energy Storage should be set up.



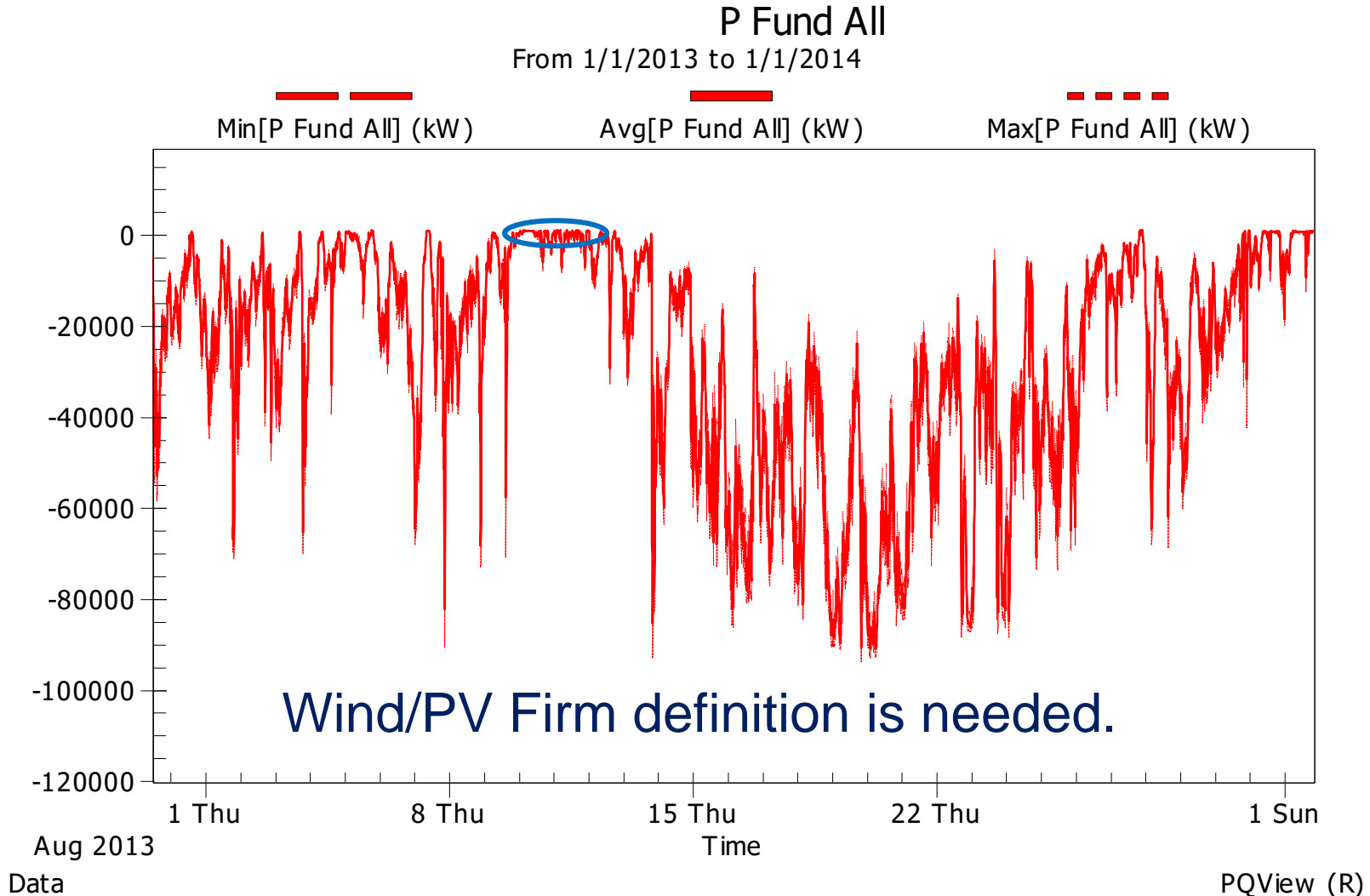
<https://www.facebook.com/EppoKnowledge/posts/381529442040574>

Homework RE Firm: e.g. PV farm [6 MW]



RE: Non Firm to Firm and support the peak

Output power of wind farm [90 MW]



56 PEA

PEA
การไฟฟ้าส่วนภูมิภาค

**Smart
GRID**

โครงข่ายไฟฟ้าอัจฉริยะเพื่ออนาคต



ทั่วถึงทุกโครงข่าย ผู้ใช้ไฟเชื่อมั่น ก้าวทันทุกเทคโนโลยี

PEA ได้พัฒนาโครงข่ายไฟฟ้าอัจฉริยะ (PEA Smart Grid) ให้มีศักยภาพและทันสมัยรองรับการใช้พลังงานทางเลือกได้อย่างเต็มประสิทธิภาพพื้นที่ทั่วประเทศในความรับผิดชอบ

