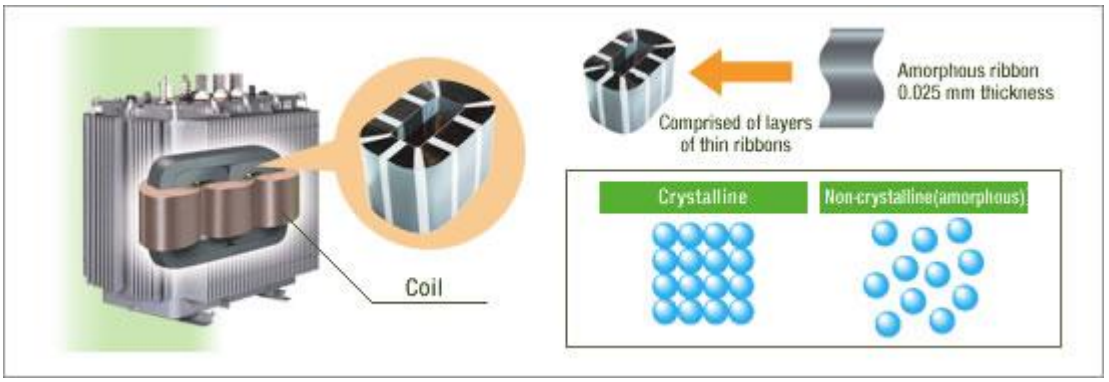
Additional information for the proposed methodology
"Installation of energy efficient transformers in a power distribution grid"

1. Overview of the technology applied

This proposed methodology focuses on energy efficient transformers in a power distribution grid which have amorphous metal core.

There are two sources of power loss in transformers: load losses and no-load losses.
Load losses are losses of electricity due to resistance in the electrical winding of the transformer. These losses include eddy current loss in the primary and secondary conductors of the transformer. These losses occur when the electricity flows through the transformer.
No-load losses are losses of electricity due to transformer core magnetizing or energizing. These losses occur whenever a transformer is energized and remain constant regardless of the amount of electricity flowing through it.

Amorphous metal core reduces the no-load losses and improves energy efficiency of transformers with its crystal architecture. Compared with the conventional steel type (i.e. silicon steel) with a regularly arrayed structure, amorphous metal has a random arrangement of crystals.
When amorphous metal is used for transformer core, it reduces hysteresis loss and eddy current loss and realises energy efficiency improvement.



2. Market share of transformers in Vietnam

Although there is no official market data of transformers installed in Vietnam, based on the interview with one of the world largest producers and suppliers of amorphous metal, the market of transformers has been dominated by the transformers with silicon steel

core. It was just four or five years ago when the transformers with amorphous metal core started to be sold in Vietnam. Also, the transformers with amorphous metal core occupies only 1-2 % of total market share of new installation and renewal of transformers in Vietnam for the last four or five years.

3. Standards for load losses and no-load losses set by the power companies

The power companies in Vietnam have their own standards for load losses and no-load losses for transformer procurement. There are also national standards (TCVN1984-1994, TCVN6306-1) for load losses and no-load losses of transformers. The standards set by power companies are stricter than the national standards, therefore the suppliers of transformers are required to meet the standards set by the power companies. In addition, there are cases in which power companies set specification values for load losses and no-load losses for the individual procurement of transformers. These specification values are often stricter than the standards set by power companies. It is expected that these standards or specification values for load losses and no-load losses are in decreasing trend (i.e. efficiency of the transformers are improving).

The standard values or specification values are set for different capacities and numbers of phase of the transformer. Followings are the examples for standard set by EVN SPC, one of the five power companies in Vietnam.

3.1 No-load loss rate for the transformers

[Single-phase]

k	Capacity [kVA]	$NLL_{RE,i,k}$ [W] (silicon steel core)	$NLL_{PJ,i,k}$ [W] (amorphous metal core)
1	15	52	17
2	25	67	22
3	37.5	92	31
4	50	108	36
5	75	148	49
6	100	192	64

[Three-phase]

k	Capacity [kVA]	$NLL_{RE,i,k}$ [W] (silicon steel core)	$NLL_{PJ,i,k}$ [W] (amorphous metal core)
7	100	205	70
8	160	280	95
9	180	315	108
10	250	340	125
11	320	390	145
12	400	433	165

13	560	580	220
14	630	787	270
15	750	855	290
16	800	880	310
17	1,000	980	350
18	1,250	1,020	420
19	1,500	1,223	470

3.2 Load loss rate for the transformers

Values for transformers with silicon steel core and transformers with amorphous metal core are same.

[Single-phase]

k	Capacity [kVA]	Load loss rate [W]	
		silicon steel core	amorphous metal core
1	15	213	213
2	25	333	333
3	37.5	420	420
4	50	570	570
5	75	933	933
6	100	1,305	1,305

[Three-phase]

k	Capacity [kVA]	Load loss rate [W]	
		silicon steel core	amorphous metal core
7	100	1,258	1,258
8	160	1,940	1,940
9	180	2,185	2,185
10	250	2,600	2,600
11	320	3,330	3,330
12	400	3,818	3,818
13	560	4,810	4,810
14	630	5,570	5,570
15	750	6,725	6,725
16	800	6,920	6,920
17	1,000	8,550	8,550
18	1,250	10,690	10,690
19	1,500	12,825	12,825

4. Blackout rate in Vietnam

The System Average Interruption Duration Index (SAIDI)[1] of five power companies have been collected for the past three years (2012, 2013 and 2014). The blackout rate on

[1] SAIDI is the average outage duration (minutes) for each customer served, which is calculated as the sum of all customer interruption durations divided by the total number of customers served.

yearly basis can be calculated as SAIDI divided by the total minutes of the year. It is, however, difficult to calculate the blackout rate on monthly or daily basis, considering that the transformers are often introduced in the midstream of the year.

As shown in the table below, the average blackout rate is improving year by year from 2012 to 2014, and it is expected that the average blackout rate will continue to improve year by year in the future. Therefore, selecting the worst (the highest) blackout rate during the last three years amongst all power company data, which is 1.87%, would ensure the conservativeness, and reduce the burden to identify the blackout rate for individual transformers, considering that transformers are generally introduced in large numbers and in different regions.

No	Unit name	2012		2013		2014	
		SAIDI (min)	%	SAIDI (min)	%	SAIDI (min)	%
1	EVN NPC	9,005.0	1.71%	4,588.0	0.87%	4,130.0	0.79%
2	EVN CPC	7,540.0	1.43%	4,149.0	0.79%	3,182.0	0.61%
3	EVN SPC	7,047.0	1.34%	4,100.0	0.78%	2,576.0	0.49%
4	EVN HANOI	9,816.0	1.87%	3,995.0	0.76%	2,043.0	0.39%
5	EVN HCMC	2,988.0	0.57%	1,974.0	0.38%	1,286.0	0.24%
		Average	1.38%	Average	0.72%	Average	0.50%