NEW GENERATION OF SMART METER DEPLOYMENT PLANNING, WITH PRIME V1.4

Fernando Guisasola Montes
Master in Smart Grids
Universidad Pontificia de Comillas
Madrid, Spain
201604074@alu.comillas.edu

Abstract—**This document analyses the details of PRIME functionality and the situation of Iberdrola's AMI to offer different planning strategies for the deployment of new AMI in Iberdrola's Spanish LV Distribution Grid. Different simulations are performed in Matlab to determine the optimal technically viable solution. A final planning is developed incurring in a mere 1.3% investment cost increase by accelerating the deployment of PRIME v1.4 with the use of devices with Dual-Stack capabilities.**

Keywords—AMI, Dual-Stack, NB-PLC, PRIME v1.4, Smart Grids, Smart Metering

I. INTRODUCTION

The development of Smart Grids is intrinsically bound to the information collected and transmitted through the grid own telecommunications infrastructure. Utilities like Iberdrola are constantly leaning on their telecommunications capabilities to deploy new applications and develop already existing ones to improve customer service as well as their general operation and maintenance efficiency.

Iberdrola's current system is based on PRIME v1.3.6 and is looking to advance gradually into a PRIME v1.4 based network. For the coexistence of both versions careful analysis and planning is needed to ensure that the costumer experiences no drawbacks as a result of the transition. This planning is both for maintaining the QoS provided to Iberdrola's costumers as the economic and technical viability of a country level deployment of SMs coexisting with previous versions of PRIME.

In 2007, RD 1110/2007 was issued, this decree stated that all mechanical meters had to be substituted by new smart meters equipped with telecommunication modules[1]. The deployment started in 2010 and did not end until all meters where finally replaced in 2018. The delays were caused by many reasons such as incapability to access the location of the meters for example. Later regulations stated that these meters could not have a service life longer than 15 years[2], forcing utilities to start renewing their metering infrastructure by 2025 in the case of Iberdrola. This is the primordial motivation to plan and start the deployment of meters just as their service life ends to avoid discarding assets service life.

PRIME v1.4 with its increased use of bandwidth (CENELEC-A, FCC and ARIB) over the currently used PRIME v1.3.6 (CENELEC-A), the inclusion of new robust transmission modes and backward compatibility mechanisms presents itself as a reliable, cost-effective upgrade for utilities inside of the Prime Alliance. Its backward compatibility allows for gradual deployment and coexistence with previous versions of PRIME, whilst its use of a higher frequency allows not only for a higher throughput of data, but also access to channels less affected by noise.

II. PROJECT DEFINITION

The goal of this document is to develop a planning strategy for the following fifteen years for Iberdrola to deploy new PRIME v1.4 SMs along with the necessary infrastructure to relay that information to a centralized database and support the necessary applications built upon their telecommunications network.

This document is divided into four main sections.

A. Introduction and State of the Art

Serves as an introduction and state of the art review allowing the reader to familiarize him/herself with the different solutions and technologies available at the time of planning this deployment.

B. Deployment Decisions and Variables

Covers the decisions and variables related to the deployment of SMs, it is further divided into three separated chapters each facing the deployment from the point of view of Smart Meters, Network Connectivity and Secondary Substations respectively.

1) Smart Meters

Focuses on prioritization of variables regarding SMs that are relevant for the deployment. Some of the variables chosen are Installation date, SSs average service life, security state, manufacturer and type of service point.

2) Network Connectivity

This section covers decisions from the Network connectivity side, automatic channel selection will be explored versus the possibility of assigning a fixed channel. Different solutions proposed by manufacturers and the PRIME MAC Task Force will be analyzed. As well as the necessary tests to ensure the channel chosen is the optimal one and how to change it if necessary.

3) Secondary Substations

The third section involves the changes that happen at a secondary substation level and will cover the problematics related to multiple transformer positions, the need of replacing DC for a newer physical version or a virtualized one, installation of Base Nodes and GTPs as well as the integration of this planning with the on-going DC replacement plan. Currently available solutions will be analyzed as well as solutions that are still in development but could be available by 2025.

C. Techo-Economic Analysis

This section focuses on the iterative simulations performed to determine the optimal strategy for the deployment of PRIME v1.4 in Iberdrola's AMI.

The deployment is set to begin in 2025, therefore there are numerous unknown variables than could affect it as well as technological advancements that are already in progress. Due to these reasons, it was necessary to perform three different simulations with a variety of scenarios and conditions to optimize the deployment in an economic sense without disregarding the technical viability of the scenarios proposed. The simulations proposed can be summarised in the following table:

	Simulation 1	Simulation 2	Simulation 3
SS Level Analysis	✓	✓	✓
Fuse Box Level Analysis	✓	-	✓
Dual Stack	-	✓	✓
Early Replacements	✓	-	✓
Number of Scenarios	41	2	1
Use	Sensitivity Analysis	Extended Deployment	Detailed Realism

Table 1. Simulation Parameters Summarised

D. Deployment Planning

The final deliverable of this document, an extract of the aggregated planned deployment is included in an appendix including the aggregated results on a national level as well as aggregated in each of the administrative regions Iberdrola uses (North, East, West and Central). The planning file is in excel format and contains the following sections:

- Current Status: Sheet where all of Iberdrola's AMI is described, all the information is grouped by SSs and the information can be categorized in the following categories differentiated by colour in the corresponding spreadsheet:
  - SS Description: Where their ID, Location and Telecom Solution is displayed.
  - SS Size: Where the total amount of SMs are shown as well as the amount of Non-Securable SMs.
  - SS Age: Where the average SS age as well as the first and last installed SM in that SS is shown.
  - SS Supply Points: Where all the SS's SMs are classified according to their supply type according to [1].
  - SS Manufacturer: Where all the SS's SMs are classified according to their manufacturer.
  - SS Yearly Breakdown: Where all the SS's SMs are classified according to their year of installation.
- Deployment: Sheet where all of Iberdrola's SSs are indexed along with their full replacement date resulting from the analysis of Simulation 3. This sheet also contains the planned SMs substitution year by year from 2025 to 2040.
- Summary: Sheet where the full deployment is aggregated on a national level and administrative region level from 2025 to 2037.

III. State of the Art

PLC is a type of wired telecommunication where signals are introduced typically in a 50/60 Hz power network to enable point to point communications without the use of additional dedicated physical channels. Different types of modulations are introduced to increase the throughput and avoid errors caused by interferences.

PLC's performance and availability are intrinsically determined by the state of their own electrically grid, meaning that it is reliable for everyday operation but maybe not one's first choice under emergency operation conditions.[3]

It is a telecommunication solution usually adopted by electrical utilities because of its low deployment cost since they usually already own the electrical infrastructure that serves as a physical medium for telecommunications. However, there are multiple examples of domestic use of PLC as an alternative to wireless or fibre-based solutions[4].

Consequentially, PLC is usually affected negatively by the following factors[5]:

- Channel/Ambient noise.
- Interference from electronic devices connected to the power supply that do not use PLC communications.
- Attenuation (Varies depending on the frequency of interest).
- Channel variability in both frequency and time.

A. NB-PLC

Narrow Band PLC gained new attention from 2005 onwards based on the need to deploy smart metering. This raised the requirements for this technology to allow for remote management of SMs as well as other functionalities[4].

NB-PLC occupies frequencies between 3 and 500 kHz corresponding to VLF/LF/MF. Different associations define what part of the spectrum can be utilized for each region. The following table shows the designated organization that regulates the frequency bands available by region.

Region	Organization	Frequency Band (kHz)
Europe	CENELEC	3-95
		95-125
		125-140
		140-148.5
Japan	ARIB	10-450
China	EPRI	3-90
		3-500
USA	FCC	10-490

Table 2. Available NB-PLC Frequencies[5]

B. PRIME v1.3.6

PRIME was defined and maintained by the Prime Alliance[6] as a standard for AMR using NB-PLC. It has been deployed in over 15 countries worldwide in more than 20 million meters. It also has been adopted into ITU-T (G.9904) and IEEE (1901.2).

1) *Network Architecture*

PRIME builds subnetworks around base nodes usually located at secondary substations. The different components form a tree like structure with a central BN as its base. These subnetworks are composed of base nodes and service nodes[7].

- Base Nodes: Acts as a master node that provides connectivity to the subnetwork. There is only one per network and it manages all the resources and connections. Originally the subnetwork is the base node itself and other nodes expand it by registering in the base node.
- Service Nodes: All the other nodes of the subnetwork that do not act as base node are service nodes. The nodes start in a disconnected state and follow the appropriate procedures to register into the base node's network. The service nodes act as a transmitter for their own data towards the base node and as a repeater for other service nodes that are unable to connect directly to the base node.

The functioning states of service nodes are the following:

- Disconnected: Service nodes start in this state while they search for a base node or a service node with connection to a base node.
- Terminal: In this state the service node is registered in the base node and can communicate its traffic by establishing connections.
- Switch: The service node has the same functions as a terminal node, but it is also able to forward data to and from other nodes in the grid. It functions as a repeater.

The process of changing functioning states is illustrated by the following figure:

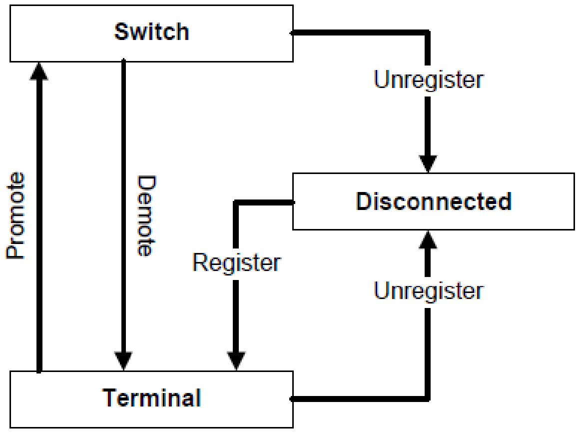

Figure 1. PRIME Service Nodes State Switching Diagram[7]

Since SNs in Switch mode act as repeaters for other SVs that are unable to connect to the BN, a multilevel architecture is usually constructed. These networks are self-forming and usually require a few hours to stabilize, resulting in architectures such as the real PRIME v1.3.6 network from Iberdrola's grid shown below. This subnetwork is of special interest because it shows four different levels as well as a SN that cannot connect due to poor noise conditions.

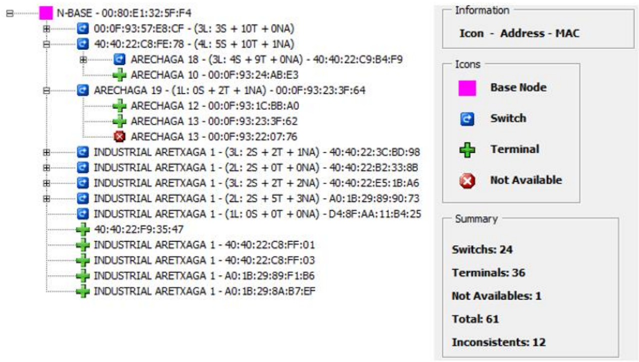

Figure 2. Example of Iberdrola's PRIME Network

2) *Transmission Modes*

PRIME uses OFDM technology to modulate different signals orthogonally, the main reasons for choosing this modulation technique are[7]:

- Its inherent adaptability in the presence of frequency selective channels (which are common but unpredictable, due to narrowband interference or unintentional jamming).
- Its robustness to impulsive noise, resulting from the extended symbol duration and use of FEC.
- Its capacity for achieving high spectral efficiencies with simple transceiver implementations.

The PHY layer of PRIME operates inside of the CENELEC-A Band, however, it only uses the frequencies between 41.992 kHz and 88.867 kHz.

This is achieved by using OFDM modulation utilizing 97 (96 data and one pilot) equally spaced subcarriers, transmitted in symbols with a duration of 2240 microseconds, of which 192 microseconds are comprised of a short cyclic prefix[7].

PRIME uses Differential Modulation, this implies that the phase of the upcoming symbol is interpreted based on the phase difference with the previous symbol, not the absolute phase of the received symbol, this greatly improves the BER and eliminates the need for receiver synchronization. The modulation used can be one of the three following constellations, choosing a bigger constellation whenever the channel conditions allow it to increase the transmission rate without increasing transmission errors.

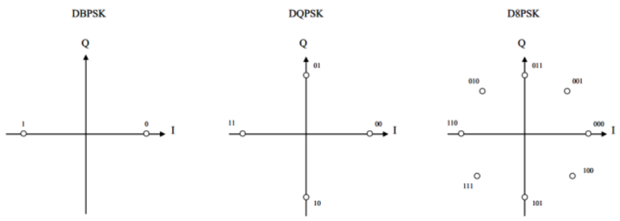

Figure 3. PRIME OFDM Constellations[8]

3) *PHY Layer*

The physical layer is designed to transmit and receive information over powerlines which are known to be a rather poor telecommunication medium given the wide variety of conductor types utilized in the same network as well as all the noise introduced by devices like electric appliances.

PRIME uses a combination of approaches to achieve robust, high-speed, low-cost telecommunications. This scheme is based on adaptative OFDM to allow for the highest transmission speed with a guaranteed robustness, along with FEC and Data Interleaving.

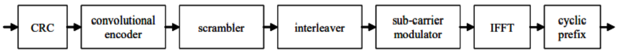

Figure 4. Block Diagram of a PRIME PHY Transmitter

C. PRIME v1.4

PRIME v1.4 is the newest available version of PRIME still based on OFDM, it improves the up to 130 kbps of raw data [7] transfer rate of the previous PRIME v1.3.6. The major improvements/changes from the previous version v1.3.6 related to the data transmission are now presented.

1) MAC Layer Improvements

PRIME v1.4 features two different types of physical frames, Type A (v1.3.6) and a new Type B frame. In the following figures, the difference and duration of both types of frames will be clarified.

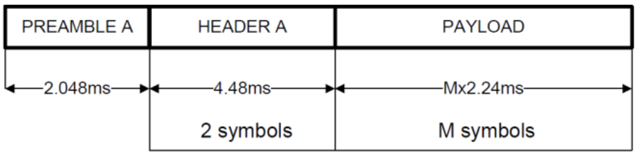

Figure 5. Type A PRIME PHY Frame[8]

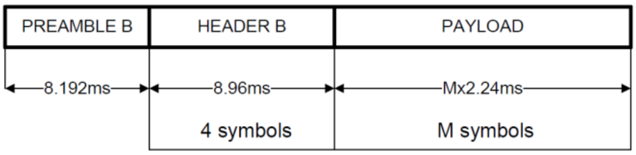

Figure 6. Type B PRIME PHY Frame[8]

Both frames start with a preamble followed by a header and a payload composed of OFDM symbols each lasting 2.24 ms. In Type A, the header is formed by two OFDM symbols and the payload is made of M symbols, M being lower or equal to 63, whereas Type B has a 4 OFDM symbols long header and an M symbols long payload with a maximum of 252 symbols.

PHY Header Type B presents the following advantages [8]:

- It can signal 4 times more symbols.
- It provides up to 8 times bigger padding than type A frames.
- The CRC is 12 bits long instead of 8 bits, so it reduces the possibility of false positives in the PHY layer by 2^4.
- The MAC layer information is smaller so that in can be encoded in 1 symbol, resulting in 4 after repetition while type A uses 2 symbols without the repetition mechanism.

As part of the flexible coding scheme, PRIME v1.4 allows for the use of both type of frames, Type B for its greater robustness and Type A for its higher transmission efficiency.

2) Robust Transmission Modes

In order to provide a higher reliability in harsh environmental conditions, two new robust transmission modes were added to v1.4. These modes improve system robustness against both impulsive noise and interfering noises. In particular, all the portions of the frame Type B have been enhanced using a repetition factor of 4.

The FEC mechanism for robust modes in PRIME v1.4 is composed of a convolutional encoder (Already present in v1.3.6) and a repetition encoder.

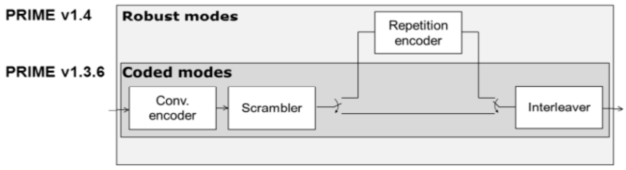

Figure 7. PRIME Robust Modes Block Diagram

3) FCC/ARIB Band Extension

The PHY layer in v1.3.6 specificized the use of OFDM in CENELEC-A (3 kHz to 95 kHz)[7]. PRIME v1.4 now extends the band up to 500 kHz, multiplying by 8 the bandwidth originally available now divided in 8 channels. The following figure shows the new channel allocation, the new version of PRIME now ranges from 41.922 kHz to 471.6796875 kHz.

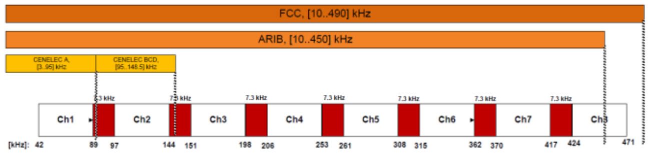

Figure 8. PRIME v1.4 Frequency Band Extension[8]

The different channels are separated by 15 subcarriers (7.3 kHz), each of them can be used as single independent channels or combined to allow for higher throughput although all combinations must always be between consecutive channels. The downside to using a multichannel is that the signal's power is evenly distributed between the channels used so the SNR is reduced which later results in more transmission errors.

The combination of all possible band plans and transmission modes result in transfer speed ranging from 5.4 kbps using one channel in the most robust mode (Robust DBPSK) to a maximum of 1028 kbps using all 8 channels in the less robust mode (D8PSK).

The raw data rate is shown in the following table as a function of N_{CH} regarding the number of channels currently used in the band plan.

Sub-Carrier Modulation Scheme	DBPSK			DQPSK			D8PSK	
Convolutional Code (1/2)	On	On	Off	On	On	Off	On	Off
Repetition Code	On	Off	Off	On	Off	Off	Off	Off
Raw Data Rate (kbps)	N_{CH}x5.4	N_{CH}x21.4	N_{CH}x42.6	N_{CH}x10.7	N_{CH}x42.9	N_{CH}x85.7	N_{CH}x64.3	N_{CH}x128.6

Figure 9. PRIME v1.4 Data Rates

D. PRIME v1.4 Pilot

In 2021 Iberdrola tendered an open offer to different manufacturers to set up tests regarding the latest version of PRIME. This project was also the Master's Thesis of Borja Villasante, a student of the Pontifical University of Comillas and the first stepping stone of this project.

In the end, a PRIME v1.4 pilot program was implemented in three different areas of Spain with 5k clients per area, with a variety of supply points (residential, industrial, urban, semi-urban).

The project has undergone some delays and is still in progress throughout 2022 with new equipment being tested on field as soon as it is being certified.

1) Deployment

The pilot was staged to happen in four progressive phases from testing the stability of PRIME v1.4 on the CENELEC A band using type A frames and no robust transmission modes to a fully operational PRIME v1.4 pure network.

2) Preeliminary Results

the pilot program has already bred some interesting results, right now there are PRIME v1.3.6 and PRIME v1.4 networks coexisting, associated with the same DC by means of an external PRIME v1.4 BN connected via ethernet cable. The connectivity and availability results are promising as far as shown in the following figure

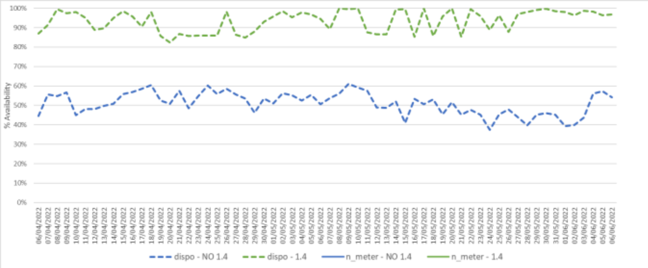

Figure 10. PRIME v1.3.6 Availability vs PRIME v1.4 Availability

It is very easy to realize the advantages of having PRIME v1.4 is in this SS where the SM availability has almost doubled continuously in a period of two months.

IV. Planning Decisions

This section will cover the three different aspects of the deployment mentioned in II.B.

A. *Smart Metering Perspective*

Iberdrola's currently deployed AMI incorporates 11.3 million meters in its distribution grid, aside from 15,000 meters have been scheduled to be part of the PRIME v1.4 pilot deployment program, all use PRIME v1.3.6 which was the latest version of PRIME v1.3. All SMs are deployed in 32 different provinces of Spain and have a service life of 15 years except the 4 million meters that were installed in years 2016 and 2017 which are allowed an extra 5 years of service life[2] to help utilities spread the replacement works over the years 2031 to2037.

1) First Iteration Variables

These variables correspond to the ones used in the simulations in order to assess the year of replacement of each Smart Meter.

- Date of Installation.
- Percentage of v1.4 SMs installed.

2) Second Iteration Variables

These variables are selected to prioritize certain Secondary Substations over others that are to be replaced on the same year.

- Manufacturer.
- Security Status.
- Connection Type.
- Supply Point Type.
- Average SS Age.
- Health Index of the BN and DC.

B. *Network Connectivity Perspective*

The new PRIME v1.4 offers 8 single channels to choose from, allowing however to combine consecutive single channels into broader channels with a lower SNR. For the time being, Iberdrola's deployment will only include single channel transmission. Once the stability of the new v1.4 network has been established will the option of multichannel transmission will be studied and developed in future works.

1) Fixed Channel Approach

One approach to optimal channel selection is to run localised tests in locations of the network which can be considered representative of larger areas with a wide variation of consumers and network topologies. Determine then what the optimal channel works for certain configurations and deploy the assets (BNs & SMs) fixed to a certain channel.

This approach carries a large investment cost as well as need for periodic revaluation.

2) Dynamic Channel Changing Algorithm

Channel changing algorithms are defined in PRIME v1.4 specification as a method for SNs to automatically connect to existing networks upon their start-up from a disconnected state. When first powered up, the SN will select one of the available channels from its band-plan and attempt to connect to a Subnetwork. While disconnected from the Subnetwork, SNs can only receive beacons from the BN and SWNs on the channel they are currently in and send PNPDUs on that same channel.

The current description of these algorithms in the specification is still vague with plenty of room for interpretation and manufacturers are presenting their own ideas to the PRIME Alliance.

3) Channel Selection Validation

Once the devices have connected and a grid has been formed it is necessary to establish a procedure to validate the performance of the network.

This kind of specific monitoring on the network must be manually activated. Typically, four kinds of measurements are done during the whole monitoring period:

- Availability.
- Topology & Network Stability[9].
- Short Cycles performance.
- Long Cycles performance.
- Long Term KPIs.

C. *Secondary Substations Perspective*

Current Iberdrola's SSs are equipped with one of three technologies for remote SM management purposes. With the transition to PRIME v1.4 the measures taken in each SS will depend on the functionalities of these technologies.

- GTP: Composed of a PRIME BN and a 3G Modem with double SIM Cards.
- TGC: Composed of a PRIME BN, a physical DC and LV supervision technologies.
- TGB: Composed of a PRIME BN, a physical DC, LV supervision technologies and a 3G Modem.

All of these devices have an associated Health Index that determines the date of substitution of said devices, however in order to transition to PRIME v1.4 faster, this can be overridden by the replacement of all SMs associated with it.

V. Techno-Economic Evaluation

To determine the optimal multiple simulations have been performed in order to determine the best strategy to follow once the deployment starts. The summarised simulations have been presented in Table 1.

A. *Simulation 1*

The first simulation serves as a first approach to the problem, it produces a sensitivity analysis by setting different percentage of substitution thresholds before transitioning to PRIME v1.4. This is done both at SS and Fuse Box level.

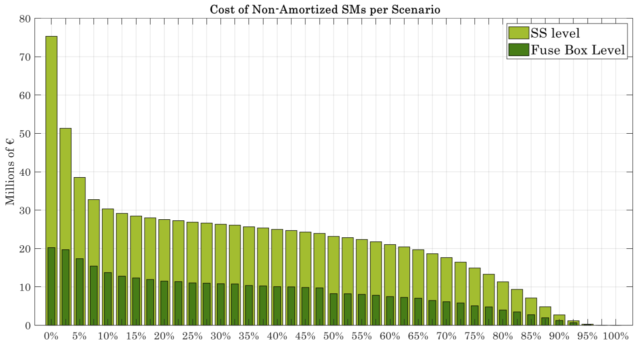

Figure 11. Simulation 1 Cost Sensitivity Analysis

Figure 11 represents the total cost incurred by not amortizing fully all the SMs currently installed. From a purely economic point of view, no SMs should be removed before their EOL. But as mentioned in III.B, PRIME networks base most of their performance on the number of elements available to form the network so it is sensible to establish a technical functionality threshold.

The first derivative of these curves is very interesting when trying to determine where to reduce the extra cost incurred by non-amortization of Smart Meters.

B. *Simulation 2*

This simulation assumes that Dual-Stack has been incorporated into the PRIME standard and all SMs incorporate both versions of PRIME into their memory and are by means of physical or digital mechanisms capable of changing their operating software. This eliminates the technical constraints of the PRIME architecture by maintaining the number of elements in the network constant.

This simulation has no cost of non-amortised meters, this simulation compares two different deployment strategies differentiated only on the time of replacement of those SMs that by regulation [2] have a possible extended service life.

The base case (Scenario 1) of this simulation is now presented and represents the deployment of SMs if every one is replaced with a service life of 15 years. And the comparison is made with Scenario 2 by using the extra five years of service life some SMs have to delay their replacement in order to facilitate logistics by reducing the maximum amount of SMs deployed per year.

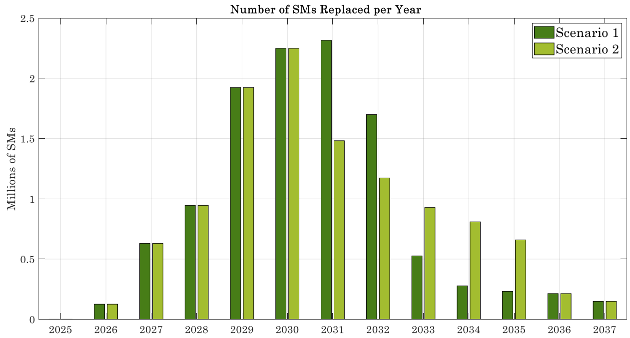

Figure 12. Simulation 2. SMs Deployment Curves Comparison

This difference in deployment years has no actual influence on the nominal cost of the deployment since all SMs are depreciated until EoS. There is a noticeable difference between the nominal value and the real value as the deployment suggested in Scenario 2 offers to delay part of the investment cost in some cases up to three years. This delayed not only improves logistics for Iberdrola, but it also has the effect of a real value discount given a non-deflation economy.

C. *Simulation 3*

This simulation is the culmination of the Techno-Economic analysis and is characterized by assuming Dual-Stack capabilities but also not amortising all of the devices. This simulation calculates the cost of technical performance improvement by advancing to PRIME v1.4 when a reasonable amount of SMs have been replaced.

1) *Constraints and Conditions*

- SMs are equipped with Dual-Stack.
- Fuse Boxes with 6 or less SMs will be fully replaced with PRIME v1.4 SMs once the first SMs in each Fuse Box reaches its EOL.
- Fuse Boxes with 7 or more SMs will be gradually replaced until their v1.4 SMs percentage over the total of SMs reaches 85% at which point all v1.3.6 SMs will be replaced at that Fuse Box.
- SSs where more than 85% of their fuse boxes have had their SMs replaced with v1.4 up until that year, are completely switched to PRIME v1.4 and all the remaining v1.3.6 SMs and BN are removed.

These constraints imply an iterative two-level simulation, where the first part of the simulation is performed at Fuse Box level and with those outputs, they are introduced as inputs for the second part of the simulation at SS level.

This has to be repeated until the cost of non-amortised meters reaches a compromise with the delay of full PRIME v1.4, the percentage presented before, represent the final percentages defined at the end of the iterative process.

The final output of the simulation is presented as cost of the whole renewal so to see the impact of non-amortised SMs over the full costs.

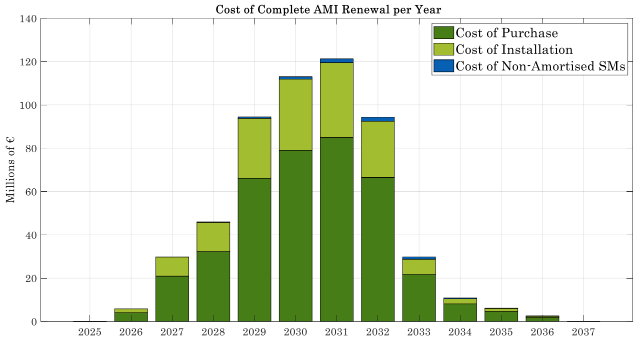

Figure 13. Simulation 3. Full Cost of AMI Renewal

The total cost of purchase, installation, and non-amortisation of SMs adds up to 553.99 M€ out of which, the cost of non-amortised assets only represents the 1.3%(7.25M€).

VI. Conclusions

This paper has presented the basic concepts of PRIME operability as well as the justification and the advantages for Iberdrola to transition their AMI to PRIME v1.4. There has been a thorough study of the possibilities for the deployment and after an iterative simulation-based process, a tradeoff solution between increased cost and technical performance increase has been reached. This solution accelerates the transition into PRIME v1.4 from fully transitioning at 100% to transitioning at 85%, while increasing the investment cost of new PRIME v1.4 Smart Meters just a 1.3%.

References

[1] Ministerio de Industria, Turismo y Comercio, Real Decreto 1110/2007, de 24 de agosto, por el que se aprueba el Reglamento unificado de puntos de medida del sistema eléctrico, vol. BOE-A-2007-16478. 2007, pp. 37860-37875. Accessed: May 19, 2022. [Online]. https://www.boe.es/eli/es/rd/2007/08/24/1110

[2] Ministerio de Industria, Comercio y Turismo, Orden ICT/155/2020, de 7 de febrero, por la que se regula el control metrológico del Estado de determinados instrumentos de medida, vol. BOE-A-2020-2573. 2020, pp. 16593-16735. Accessed: May 22, 2022 [Online]. https://www.boe.es/eli/es/o/2020/02/07/ict155

[3] A. Sendin, MA. Sanchez-Fornie, I. Berganza, J. Simon and I.Urrutia, *Telecommunication Networks for the Smart Grid*. London | Boston, Artech House, 2016

[4] «HomeGrid Forum Overview – HomeGrid Forum». https://homegridforum.org/homegrid-forum-overview/ (Accessed June 7, 2022).

[5] G. Bucci, F. D'Innocenzo, S. Dolce, E. Fiorucci, y F. Ciancetta, «POWER LINE COMMUNICATION, OVERVIEW OF STANDARDS AND APPLICATIONS», p. 6.

[6] PRIME Alliance. https://www.prime_alliance.org/alliance/specification/

[7] «Specification PRIME| PRIME Alliance», 21/07/2008. https://www.prime-alliance.org/alliance/specification/ Technology Whitepaper.

[8] «Specification PRIME v1.4 PRIME Alliance», 04/2020. https://www.prime-alliance.org/alliance/specification/ Technology Whitepaper.

[9] A. Sendin, B. Villasante and J.Matanza "Analysis and preparation of the deployment of PRIME 1.4 smart meters in an interoperable field environment for 15,000 meters" *Repositorio Comillas 2021.* http://hdl.handle.net/11531/55730

VII. Appendix I Planning Extracts

Total SSs	Total SMs	National Deployment by Year												
		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
102055	11289065	879	125951	633615	966520	1982233	2357137	2488831	1864726	512227	172047	104812	56751	23336

Table 3. National Deployment Yearly Breakdown

Total SSs	Total SMs	Deployment in the North Region by Year												
		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
17102	1980541	0	1333	73032	138942	416735	461025	397046	301989	106477	43003	22983	11689	6287

Table 4.North Region Deployment Yearly Breakdown

Total SSs	Total SMs	Deployment in the Central Region by Year												
		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
26630	2976310	0	12696	199502	291190	467501	609585	635474	510560	135653	53311	33990	19440	7408

Table 5. Central Region Deployment Yearly Breakdown

Total SSs	Total SMs	Deployment in the East Region by Year												
		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
35694	4419774	879	100808	224109	376749	703501	873426	1065930	753248	197016	59110	37406	20192	7400

Table 6. East Region Deployment Yearly Breakdown

Total SSs	Total SMs	Deployment in the West Region by Year												
		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
21921	1911330	0	11114	136971	159635	394474	413092	390250	298841	72420	16557	10392	5375	2209

Table 7. West Region Deployment Yearly Breakdown