The Economics of the 900 MHz Rebanding Proposal

A Cost-Benefit Analysis

PREPARED FOR

Florida Power and Light Company

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THE Brattle GROUP

This report was prepared for NextEra Energy. To prepare this report, Florida Power & Light agreed to share certain technical and financial information. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group or its clients.

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I. Summary and Conclusions

1. Enterprise Wireless Alliance and PDVWireless, Inc. ("EWA/PDV") have proposed to reconfigure the 896-901/935-940 MHz band—commonly referred to as the "900 MHz band" currently used for narrowband operations by Business, Industrial, and Land Transportation and Specialized Mobile Radio licensees—to create a new broadband segment and move remaining narrowband incumbent users into a band that is less than half the size of the current band. Dr. Harold Furchtgott-Roth has reviewed this proposal and performed a Cost-Benefit Analysis which fails to account for the vast majority of the costs that would be incurred by EWA/PDV, by incumbent users, and by American citizens. This report performs a Cost-Benefit Analysis that properly accounts for all parties who would incur costs under the proposed spectrum reallocation, using the area of Florida in which the Florida Power and Light Company operates as a "case study" of the effects of the proposal. Within this region, I estimate that the proposal will result in total benefits to society of at most $83 million if the broadband pricing for significantly larger (and therefore more valuable) spectrum blocks holds, but possibly much less—as little as $4 million based on the experience of an earlier auction of spectrum blocks more similar to the 3/3 MHz block proposed by EWA/PDV. In addition, I estimate that the proposal will result in one time "transition costs" of $62 million, "ongoing costs" with a present value of $35 million, and could result in potential "externality costs" of up to $1 billion in Florida Power and Light Company's areas of operation. As such, the costs to implement the proposal would exceed the benefits. Specifically, I estimate that the proposal would have net private costs in excess of benefits in these regions of Florida alone of at least $15 million (assuming the higher total benefits of $83 million) and perhaps net costs in excess of benefits of $93 million.[1] When the results of my Cost-Benefit Analysis are scaled-up to the national level, I predict the total net cost over benefits of the proposed spectrum reallocation to be significant.

[1] Calculations not exact due to rounding.

II. Introduction and Overview

2. NextEra Energy is a large electric utility and energy company, with subsidiaries NextEra Energy Resources, LLC; Florida Power and Light Company ("FPL"); NextEra Energy Partners, LP; NextEra Energy Services; and NextEra Energy Transmission.[2] NextEra and its subsidiaries hold various Business, Industrial, and Land Transportation ("B/ILT") narrowband wireless licenses on the 896-901/935-940 MHz band—commonly referred to as the "900 MHz band"—which they use to carry out their business operations. Enterprise Wireless Alliance and PDVWireless, Inc. (collectively, "EWA/PDV") have proposed to reconfigure the paired 5/5 MHz band currently allocated for narrowband uses to a 3/3 MHz broadband segment and a 2/2 MHz narrowband segment. Under this proposal, some of the current narrowband communications conducted over the existing 5/5 MHz band would be integrated into the new 3/3 MHz broadband segment and the remaining narrowband communications would be transitioned to the new 2/2 MHz narrowband segment. EWA/PDV has submitted two proposals within the last year to the FCC. The first was submitted on October 2, 2017, and subsequent comments were submitted on May 1, 2018 that revised the initial proposal. For the purposes of the analysis presented below, these proposals are similar enough that they may be addressed simultaneously rather than one at a time. Although policymakers may consider many different factors in their evaluation of a proposal (namely, broader public interest considerations), NextEra has asked me to review the EWA/PDV proposal from an economic perspective and evaluate whether or not it is likely to produce benefits in excess of its costs.

3. From a policy perspective, it is important that spectrum be put to its highest valued uses.[3] The Principle of Spectrum Reallocation says that when the value created by spectrum in a new use exceeds the value of the spectrum in an existing use, plus the cost of transitioning

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[2] "Our Company," NextEra Energy, 2017, accessed December 11, 2017, available http://www.nexteraenergy.com/company.html. See also "Our Subsidiaries," NextEra Energy, 2017, accessed December 11, 2017, available http://www.nexteraenergy.com/company/subsidiaries.html.

[3] Coleman Bazelon and Giulia McHenry, "Spectrum Value," Telecommunications Policy, Volume 37, Issue 9, October 2013.

from the old use to the new use, the band of spectrum at issue should be reallocated.[4] This principle should be applied to proposals to change how the 900 MHz B/ILT band is configured. When properly applied, this Principle of Spectrum Reallocation effectively amounts to a Cost-Benefit Analysis ("CBA") of the EWA/PDV proposal.

4. EWA/PDV asked Dr. Harold Furchtgott-Roth to evaluate their proposal.[5] In that analysis, Dr. Furchtgott-Roth notes that Federal Communications Commission ("FCC") Chairman Ajit Pai has called for more economic analysis in FCC rulemaking.[6] Despite Dr. Furchtgott-Roth's statements in support of economic analyses, he does not provide a structured or complete CBA. Existing guidelines provided by the Office of Management and Budget ("OMB"), however, explain how to apply a proper CBA. This report implements the OMB guidance for the EWA/PDV proposal.

5. Following the OMB guidelines for Cost Benefit Analysis, I find that the direct costs of reallocating the 900 MHz band in parts of Florida alone are $98 million, with additional external costs between $506 million and $1 billion if FPL could not replicate the disaster recovery efficiencies of its existing 900 MHz network after the proposed reconfiguration. Using the results of the 600 MHz spectrum auction as a means of valuing the 900 MHz band in question, I find that the benefits of the EWA/PDV proposal in this same region are only $83 million. Using the results of the 1.4 GHz spectrum auction as a means of valuing the 900 MHz band in question, I find that the benefits of the EWA/PDV proposal in this same region are even lower, only $4 million. Expanding my analysis of the EWA/PDV

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4 "Testimony of Coleman Bazelon before the U.S. House of Representatives, Committee on Energy and Commerce, Subcommittee on Communications and Technology," November 16, 2017.

5 Notice of *Ex Parte* Presentation, "A Cost Benefit Analysis of Proposals to Restructure the 900 MHz Band," Harold Furchtgott-Roth, *In the Matter of Review of the Commission's Rules Governing the 896-901/935-940 MHz Band,* WT Docket No. 17-200, FCC, October 2017. ("Furchtgott-Roth Cost Benefit Analysis.")

6 Furchtgott-Roth Cost Benefit Analysis, at p. 2. Notably, the FCC is developing an Office of Economics and Data which will combine economists and data professionals to provide economic analysis, manage the FCC's data resources and conduct long-term research. See Ajit Pai, "The Importance of Economic Analysis at the FCC," Remarks of FCC Chairman Ajit Pai at the Hudson Institute, Washington, D.C., April 5, 2017, accessed December 11, 2017, available https://apps.fcc.gov/edocs_public/attachmatch/DOC-344248A1.pdf.

proposal in Florida to a national level suggests that the net effect of this policy would result in losses of as much as $418 million to U.S. firms and citizens in total.

III. The 900 MHz Band in the United States

A. Band and Industry Background

6. The 900 MHz band is a 10 megahertz ("MHz") block of spectrum divided between the 896-901 MHz and 935-940 MHz bands.[7] This paired band is specifically designated for industrial and business uses.[8] B/ILT licensees include utility companies, manufacturers, energy companies, emergency responders, and more.[9] Additionally, an operator can use this spectrum to provide Specialized Mobile Radio ("SMR") service for the use of individuals, federal government agencies and for public safety and B/ILT.[10] SMR licensees sell mobile radio services to businesses.[11] There currently are 3,184 active

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7 Report and Order, *In the Matter of Amendment of Parts 2 and 22 of the Commission's Rules Relative to Cellular Communications Systems; Amendment of Parts 2. 15, and 90 of Commission's Rules and Regulations to Allocate Frequencies in the 900 MHz Reserve Band for Private Land Mobile Use; Amendment of Parts 2. 22, and 25 of the Commission's Rules to Allocate Spectrum for, and to Establish Other Rules and Policies Pertaining to the Use of Radio Frequencies in a Land Mobile Satellite Service for the Provision of Various Common Carrier Services,* GEN Docket No. 84-1231 RM-4812; GEN Docket No. 84-1233 RM-4829; GEN Docket No. 84-1234 RM-4247, Release No. FCC 86-333, FCC, September 19, 1986.

8 47 C.F.R. §90.603.

9 Notice of Inquiry, *In the Matter of the Review of the Commission's Rules Governing the 8896-901/935-940 MHz Band; Realignment of the 896-901/935-940 MHz Band to Create a Private Enterprise Broadband Allocation; Amendment of the Commission's Rules to Allow for Specialized Mobile Radio Services Over 900 MHz Business/Industrial Land Transportation Frequencies,* WT Docket No. 17-200 RM-11738 RM-11755, FCC, August 4, 2017, at p. 2. ("PEBB Notice of Inquiry"). A B/ILT licensee can apply for a modification of the license for authorization to use the spectrum for commercial operations or can apply to transfer or assign the license to an SMR user. See 47 C.F.R. §90.621(f).

10 47 C.F.R. §90.603(c).

11 PEBB Notice of Inquiry, at p. 2.

licenses in this 5/5 block: 2,193 site-based licenses and 991 licenses for designated Major Trading Areas ("MTAs").[12] See Table 1 below.

Table 1: Uses of 900 MHz

Purpose	Number of Licenses	Percentage of Total
Business	607	19.1%
Industry, Land, Transportation	841	26.4%
Pre-Auctioned SMR	745	23.4%
Auctioned SMR	991	31.1%
Total Licenses	3,184	100.0%

Sources: FCC Universal Licensing System, available http://wireless.fcc.gov/uls/index.htm?job=transaction&page=weekly. See Databases Land Mobile-Private Land Mobile–Commercial, and Market Based Services downloaded June 19, 2018.

Note: Pre-Auctioned SMR licenses are site-based licenses, and auctioned SMR licenses are MTA-based licenses.

7. The B/ILT licensees are allocated licenses that are designated for Private Land Mobile Radio ("PLMR") services. The defining feature of PLMR services is that the spectrum-based services are an intermediate input of production rather than the primary output.[13] PLMR license holders are often companies that maintain critical infrastructure and typically have specific spectrum and geographic coverage requirements to maintain operations. For example, a natural gas pipeline company requires spectrum along the long narrow geographic area of the pipeline. Likewise, a factory owner might utilize spectrum intensively, but only in the small geographic area surrounding a factory.[14] Energy companies like FPL use spectrum to perform crucial communications which maintain and

[12] The FCC states: "The Major Trading Areas (MTAs) are based on the Rand McNally 1992 Commercial Atlas & Marketing Guide, 123rd Edition, at pages 38-39." See "FCC Areas," FCC, accessed June 19, 2018, available https://www.fcc.gov/oet/maps/areas.

[13] Coleman Bazelon, "Next generation frequency coordinator," Telecommunications Policy Volume 23, 2003, at p. 518.

[14] Id, at pp. 518 – 519.

support restoration of their energy infrastructure.[15] The common feature of these uses is that the spectrum requirements are unique for each use and typically are not well served by large pre-defined area licenses.

8. In contrast, SMR license holders provide radio service on a for-profit basis. In other spectrum bands, this typically takes the form of cellular service.[16] In the 900 MHz band, rather than providing cellular service as the end-product for consumers, SMR license holders utilize narrowband spectrum licenses to provide communication services as an intermediary good for other businesses.[17] The FCC has offered site-based SMR licenses and has auctioned MTA-level SMR licenses.[18]

9. The majority of the 900 MHz licenses are site-based licenses, which are allocated via a process that begins with the licensee submitting an application for a defined geographic area and specific frequencies.[19] Site-based licenses are assigned "solely on the basis of fixed distance separation criteria" that typically requires a minimum distance of 70 miles between co-channel systems.[20] Table 2 below summarizes the top ten entities by the number of non-auctioned site-based licenses owned.

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15 Reply Comments of NextEra Energy, Inc., *In the Matter of Review of the Commission's Rules Governing the 896-901/935-940 MHz Band,* WT Docket No. 17-200, FCC, November 1, 2017, at p. 3. ("Reply Comments of NextEra Energy, Inc.").

16 "Specialized Mobile Radio Service, About," FCC, available https://www.fcc.gov/wireless/bureau-divisions/broadband-division/specialized-mobile-radio-service-smr, accessed June 20, 2018.

17 47 C.F.R. §90.603(b).

18 "Specialized Mobile Radio Service, Licensing," FCC, accessed June 20, 2018, available https://www.fcc.gov/wireless/bureau-divisions/broadband-division/specialized-mobile-radio-service-smr.

19 47 C.F.R. §90.621(a)

20 47 C.F.R. §90.621(b).

Table 2: Top Ten Entities by Site-based License Ownership

Company	Number of B/ILT Licenses	Number of Pre-Auctioned SMR Licenses	Number of Auctioned SMR Licenses	Number of Licenses
PDV Wireless	44	542	898	1,484
Industrial Wireless Technologies	13	97	21	131
Oncor License Holding Company	67	0	0	67
Westar Energy	51	0	0	51
Duke Energy Business Services	48	0	0	48
General Motors Research Corporation	47	0	0	47
Florida Power and Light Company	43	0	0	43
Southern California Gas Company	41	0	0	41
Southern California Edison Company	21	0	5	26
PSEG Services Corporation	12	0	10	22

Source: FCC Universal Licensing System, available http://wireless.fcc.gov/uls/index.htm?job=transaction&page=weekly. See Databases Land Mobile-Private Land Mobile–Commercial, and Market Based Services, downloaded June 19, 2018.

10. The 900 MHz band also includes MTA-level licenses for SMR-designated spectrum blocks.[21] The 1,020 licenses authorized in the twenty spectrum blocks for the 51 MTAs were allocated through competitive bidding.[22] The FCC auctioned area licenses in the SMR 900 MHz band in the 1996 Auction 7, and then subsequently held a re-auction of returned licenses in the 2004 Auction 55.[23] While there are not any additional 900 MHz SMR auctions planned, this spectrum can be obtained through an assignment of authorization (a sale of a license), a transfer of control (purchase of a licensee), a partition (sale or lease of a portion of a license based on geographic area) and/or disaggregation (sale

21 "Specialized Mobile Radio Service, Licensing," FCC, available https://www.fcc.gov/wireless/bureau-divisions/broadband-division/specialized-mobile-radio-service-smr, accessed June 20, 2018.

22 "FCC Auctions: Factsheet: Auction 7," FCC Auctions, FCC, available, accessed June 20, 2018, http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=7. ("FCC Auction 7 Factsheet").

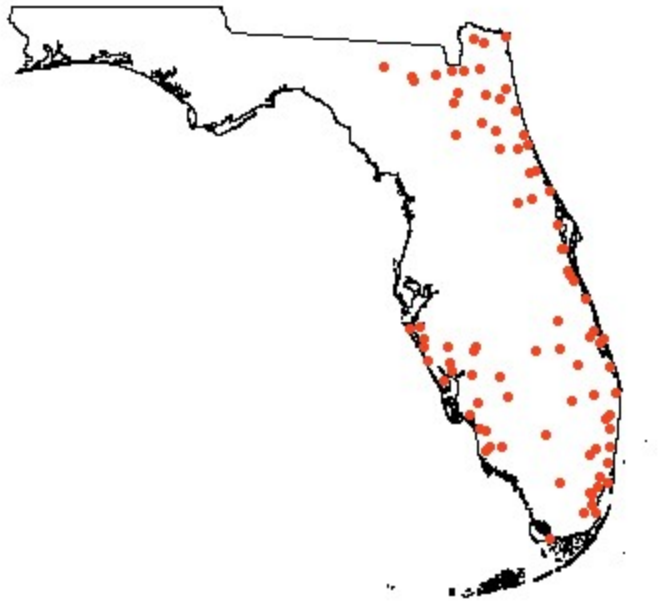
23 Public Notice, *FCC Announces Winning Bidders in the Auction of 1,020 licenses to provide 900 MHz SMR in Major Trading Areas*, DA 96-586, FCC, April 15, 1996, available http://wireless.fcc.gov/auctions/default.htm?job=release&id=49&y=1996, accessed June 20, 2018. See also Public Notice, *900 MHz Specialized Mobile Radio Service Spectrum Auction Closes, Winning Bidders Announced,* DA 04-578, FCC, March 2, 2004, available http://wireless.fcc.gov/auctions/default.htm?job=release&id=16&y=2004, accessed December 10, 2017.

or lease of a portion of a license's spectrum), or spectrum leasing.[24] The incumbent SMR licenses—those site-based licenses allocated before the auctions—are entitled to co-channel protections by the MTA-licensee and adjacent channel interference protections.[25] However, the incumbent SMR licensees are restricted in their ability to expand beyond their defined service areas.[26] The MTA-licensees must typically locate their facilities at least 70 miles from incumbent SMR licensees' facilities.[27]

B. FPL AND THE 900 MHZ BAND

11. FPL holds approximately 43 active B/ILT licenses in the 900 MHz band serving 68 sites with over 100 locations.[28] Figure 1 maps the location of these sites.

Figure 1: FPL 900 MHz Holdings



[24] "Specialized Mobile Radio Service, Licensing," FCC, accessed June 20, 2018, available https://www.fcc.gov/wireless/bureau-divisions/broadband-division/specialized-mobile-radio-service-smr.

[25] FCC Auction 7 Factsheet.

[26] FCC Auction 7 Factsheet.

[27] FCC Auction 7 Factsheet.

[28] FCC Universal Licensing System. See Database Land Mobile-Private for Florida Power and Light Holdings, downloaded June 19, 2018. Information provided by FPL.

Source: FCC Universal Licensing System. See Databases Land Mobile-Private for Florida Power and Light Holdings, downloaded June 19, 2018

Notes: FCC ULS lists 43 licenses owned by FPL. For these 43 licenses, the FCC records 121 locations and has geographic coordinates for 104 of these locations. These 104 locations observations with geographic coordinates are plotted above.

12. FPL is the third-largest electric utility company in the United States, serving nearly five million customer accounts or an estimated 10 million plus people across nearly half the state of Florida.[29] It provides over 70 percent of its electricity from natural gas, and has begun operating seven commercial-scale solar energy facilities.[30] In addition, FPL operates two nuclear plants in Florida, the St. Lucie Power Plant and the Turkey Point Power Plant.[31] FPL uses its B/ILT licenses to operate an internal radio system to provide dispatch communications for electrical service restoration and maintenance.[32] These communications are essential, as they incorporate emergency notifications and disaster recovery communications, as seen during Hurricane Irma.[33]

C. PDVWireless and The 900 MHz Band

13. PDVWireless owns over a thousand licenses, more than 90 percent of which are for SMR purposes. See Table 3 for a breakdown of PDVWireless' spectrum holdings.

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29 "FPL Company Profile," Florida Power and Light, 2018, accessed June 20, 2018, available https://www.fpl.com/about/company-profile.html.

30 "Power Plant Projects," Florida Power and Light, 2018, available https://www.fpl.com/clean-energy/plant-projects.html, accessed June 20, 2018. See also "Florida Power & Light opens four new solar power plants and closes another coal plant," FPL Newsroom, FPL, accessed June 20, 2018, available http://newsroom.fpl.com/2018-01-08-Florida-Power-Light-opens-four-new-solar-power-plants-and-closes-another-coal-plant.

31 "FPL Nuclear Power Plants," Florida Power and Light, 2018, accessed June 20, 2018, available https://www.fpl.com/clean-energy/nuclear/power-plants.html.

32 Reply Comments of NextEra Energy, Inc., at p. 2.

33 Reply Comments of NextEra Energy, Inc., at p. 2.

Table 3: PDVWireless 900 MHz Use

Purpose	Number of Licenses	Percentage of Total
Business	9	0.6%
Industry, Land, Transportation	35	2.4%
Pre-Auctioned SMR	542	36.5%
Auctioned SMR	898	60.5%
Total Licenses	1,484	100.0%

Source: FCC Universal Licensing System. See Databases Land Mobile-Private, Land-Mobile Commercial, and Market-Based Services, downloaded June 19, 2018. For PDV Spectrum Holding Company, FCI 900, Inc., ACI 900 Inc. Machine License Holding, Nextel WIP License Corporation, Nextel of California, and Nextel License Holding 1.

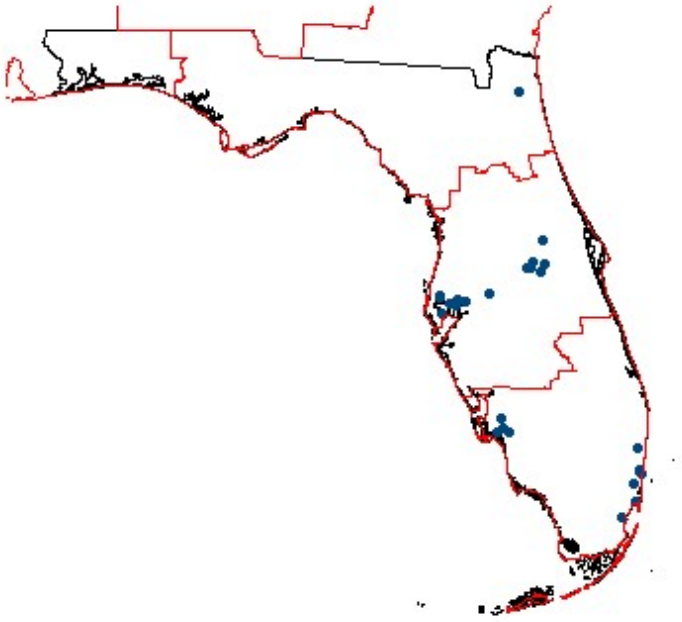
Note: Pre-Auctioned SMR licenses are site-based licenses, and auctioned SMR licenses are MTA-based licenses.

14. PDVWireless acquired most of its spectrum through an Asset Purchase Agreement with Sprint in 2014.[34] This agreement transferred to PDVWireless the licenses owned by the Sprint subsidiaries FCI 900, Inc., ACI 900, Inc., Machine License Holding, Nextel WIP License Corporation, Nextel of California, and Nextel License Holding 1.[35] PDVWireless also holds MTA-based licenses. With these licenses, PDVWireless spectrum coverage includes the entire continental United States, Alaska, Hawaii, and Puerto Rico. The only MTAs PDVWireless does not cover are Guam and American Samoa. The following figures show PDVWireless' holdings in Florida and the continental United States.

34 Pacific Datavision, Inc., Post Effective Amendment No. 1 to Form S-1 Registration Statement, SEC, filed June 10, 2015, accessed January 3, 2018, at p. ii.

35 Ibid.

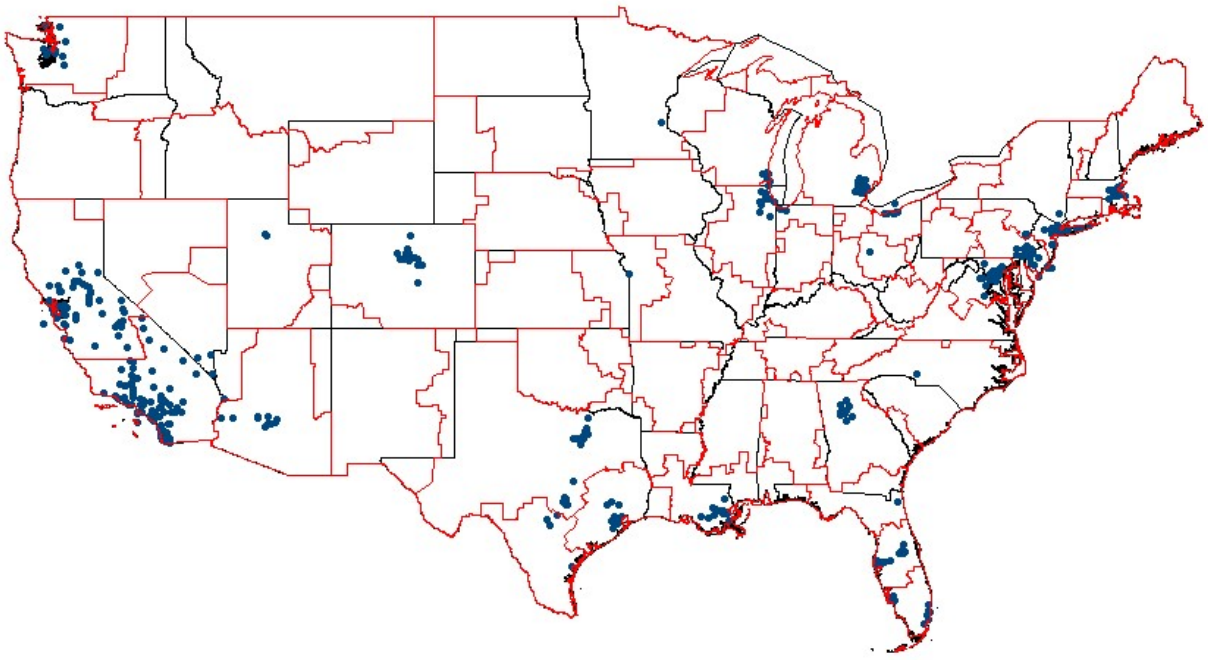
Figure 2: PDVWireless 900 MHz Holdings in Florida



Sources: FCC Universal Licensing System. See Databases Land Mobile-Private, Land-Mobile Commercial, and Market Based Services, downloaded June 19, 2018. For PDV Spectrum Holding Company, FCI 900, Inc., ACI 900 Inc. Machine License Holding, Nextel WIP License Corporation, Nextel of California, and Nextel License Holding 1. The Major Trading Areas (MTAs) are based on the Rand McNally 1992 Commercial Atlas & Marketing Guide, 123rd Edition, at pp. 38-39.

Note: MTA-licenses outlined in red, site-licenses in blue, and Florida outlined in black.

Figure 2: PDVWireless 900 MHz Holdings



Sources: FCC Universal Licensing System. See Databases Land Mobile-Private, Land-Mobile Commercial, and Market Based Services, downloaded June 19, 2018. For PDV Spectrum Holding Company, FCI 900, Inc., ACI 900 Inc. Machine License Holding, Nextel WIP License Corporation, Nextel of California, and Nextel License Holding 1. The Major Trading Areas (MTAs) are based on the Rand McNally 1992 Commercial Atlas & Marketing Guide, 123rd Edition, at pp. 38-39.

Notes: Licenses in Alaska, Hawaii, and Puerto Rico are not shown.

PDVWireless has 2,077 site based licenses and 898 MTA-licenses. Of the site based licenses, the FCC has geographic coordinates for 1,094 which are plotted above. PDVWireless owns at least one SMR area license in each MTA, except Alaska, Hawaii, and Puerto Rico.

MTA-licenses outlined in red, site-licenses in blue, and states are outlined in black.

15. PDVWireless provides communications for businesses with its private push-to-talk, two-way radio network in the United States based on its 900 MHz licenses.[36] PDVWireless offers three lines of products: TeamConnect, Private LTE Networks, and DIGA-Talk Plus.[37] TeamConnect and DIGA-Talk Plus provide workforce communication using two-

[36] "About," PDVWireless, 2018, accessed June 20, 2018, available https://www.pdvwireless.com/about/.

[37] "Team Connect," PDVWireless, 2018, accessed June 20, 2018, available https://www.pdvwireless.com/teamconnect/. "Private LTE Networks," PDVWireless, 2018 "Products," PDVWireless, 2018, accessed June 20, 2018, available

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way radio service, GPS location and geofencing, and automated job status updates.[38] Although PDVWireless has licenses for its 900 MHz spectrum to provide these communication services, much of PDV's spectrum in Florida is undeveloped and unused.[39]

IV. Summary of EWP/PDV's Proposal

16. EWA/PDV has proposed to reconfigure the 900 MHz band in order to create a wireless private carrier, a Private Enterprise Broadband ("PEBB") carrier, which would provide broadband capabilities to private enterprises ("PEs") and critical infrastructure industries ("CIIs").[40] EWA/PDV has proposed a split of the current 5/5 MHz band into one contiguous 3/3 MHz broadband portion and a non-contiguous 2/2 MHz narrowband portion, the latter of which would be available to B/ILT users, including FPL.[41] The PEBB would then endeavor to work with PE/CII entities to build broadband systems to their specifications, which PDVWireless argues are needed systems for PE/CII entities.[42]

Continued from previous page

https://www.pdvwireless.com/private-lte/. "Nationwide Push-to-Talk Radios," DIGA-Talk, 2018, accessed June 20, 2018, available https://www.pdvwireless.com/diga-talk/.

38 "Team Connect," PDVWireless, 2018, accessed June 20, 2018, available https://www.pdvwireless.com/teamconnect/. "Nationwide Push-to-Talk Radios," DIGA-Talk, 2018, accessed June 20, 2018, available https://www.pdvwireless.com/diga-talk/.

39 Information provided by FPL.

40 Further Comments of Enterprise Wireless Alliance and PDVWireless, Inc., *In the Matter of Review of the Commission's Rules Governing the 896-901/935-940 MHz Band,* WT Docket 17-200, FCC, May 1, 2018, ("Further Comments of EWA/PDV"), at p. iii.

41 The EWA/PDV Proposal (see footnote 42) proposed to split the current 5/5 MHz band into a 3/3 MHz broadband portion and a 2/2 MHz narrowband portion. Further Comments of EWA/PDV propose a rebanding in which the narrowband portion is slightly less than 2/2 MHz—148 channels in total (Further Comments of EWA/PDV, at p. iv). In the remainder of my analysis, I assume that the proposed narrowband portion is 2/2 MHz, and refer to it as such.

42 Comments of Enterprise Wireless Alliance and PDVWireless, Inc., *In the Matter of Review of the Commission's Rules Governing the 896-901/935-940 MHz Band,* WT Docket 17-200, FCC, October 2, 2017, ("EWA/PDV Proposal"), at p. iii.

17. Under the initial EWA/PDV proposal, the FCC would allocate the 3/3 MHz block at 898 MHz to 901MHz, paired with the block at 937 MHz to 940 MHz, for broadband use.[43] In further comments filed May 1, 2018, EWA/PDV proposed shifting the broadband allocation down by 400 kHz to 897.600 – 900.600 MHz and 936.600 – 939.600 MHz. In the initial proposal, the PEBB licenses would be designated by MTA and awarded to holders of at least 15 (out of a total of 20) geographic SMR authorizations within the MTA, which were originally purchased at auction.[44] In the further comments filed May 1, 2018, PEBB licenses would be based on Metropolitan Statistical Areas ("MSAs") in the top 306 Cellular Market Areas ("CMAs") and on individual counties in the remaining 428 CMAs. The remaining B/ILT and other, non-PEBB SMR licensees would relocate to the remaining noncontiguous 2/2 MHz block, or participate in the PEBB operation.[45]

18. The initial EWA/PDV proposal does not recommend auctioning the PEBB licenses. They do, however, suggest constructing an overlay auction mechanism for currently unused channels in the lower 2/2 block for non-PEBB authorizations.[46] EWA/PDV recommends that the FCC use an initial voluntary relocation process and then implement a mandatory relocation process, similar to the processes used for the 800 MHz reconfiguration.[47] The further comments filed May 1, 2018 recommend that in the first year after adopting new PEBB licensing rules, PE/CII applicants should be granted the exclusive opportunity to secure PEBB licenses through the traditional frequency coordination process.[48] Thereafter, in markets where no PE/CII entity has secured the PEBB license, overlay auctions should be conducted, with the PEBB license awarded to the highest bidder, whether commercial or PE/CII.[49]

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43 EWA/PDV Proposal, at p. 17.

44 EWA/PDV Proposal, at p. 22.

45 EWA/PDV Proposal, at p. 22.

46 EWA/PDV Proposal, at pp. 23-24.

47 EWA/PDV Proposal, at p. 28.

48 Further Comments of EWA/PDV, at p. iv.

49 Further Comments of EWA/PDV, at pp. iv-v.

V. Cost-Benefit Analysis

19. A CBA is a standard framework used to aid policymakers in evaluating whether a particular public project or government policy on balance creates economic benefits. This framework weighs the economic costs and economic benefits of a proposal, and it is intended to be flexible enough that it can be applied to a wide variety of potential policies. Executive Order 13563, issued in 2011, requires federal executive agencies to perform CBAs in all of their major rulemakings.[50]

20. It is worth noting that a CBA need not be the only information considered in formulating policy; rather, it is a summary of the quantifiable economic information related to a potential policy. Some concerns, such as citizens' happiness, may be difficult to quantify in a CBA. Legal and technological issues can also be a challenge to address. In such cases, the economic costs of a proposed policy may be just one of several legitimate considerations of policymakers. Similarly, a CBA often does not explicitly address distributional issues—who wins and who loses if a proposed policy is adopted—which also can be a legitimate concern of policymakers.

21. The Office of Management and Budget ("OMB") Circular A-4 provides general guidelines that federal executive agencies are required to follow in conducting CBAs.[51] These guidelines are based on accepted economic principles, and provide a common framework on which economists at those agencies can rely. The guidelines provided by OMB Circular A-4 are focused on applying a CBA in regulations. As a consequence, they are more broadly applicable than just for federal executive agencies. For example, the FCC has

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50 The order states that "each [executive] agency must…select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity)", Executive Order 13563 of January 18, 2011, §1, Federal Register Vol. 76, No. 14, January 21, 2011 ("Executive Order 13563").

51 OMB, Circular A-4, "Regulatory Analysis," September 17, 2003 ("OMB Circular A-4").

suggested applying a CBA to analyze the Open Internet Order, and it has suggested using the guidelines set forth in the OMB Circular A-4 in this undertaking.[52]

22. Dr. Furchtgott-Roth's analysis spends considerable time opining on factors that should or should not be included in a CBA, but his report acts to confuse rather than clarify. While Dr. Furchtgott-Roth is correct that the economic welfare framework that ultimately underlies CBA is based on Consumer Theory—the formal name for this theory of individual choice and private cost benefit considerations[53]—his discussion does not provide meaningful insight into applying a CBA to the matter at hand. OMB Circular A-4 has already established an economically sound and well accepted set of guidelines that should be applied here.

23. OMB Circular A-4 lays out four requirements that are applicable here:

    1. That any CBA establish a baseline defining the world absent a proposed action against which proposals can be evaluated,
    2. That all costs and benefits of a proposal are identified and accounted for,
    3. That costs and benefits are expressed in common monetary units and discounted to their present value, and
    4. That uncertainty may be accounted for in both the baseline and any proposed rule changes.[54]

A. ESTABLISHING A BASELINE

24. In performing a CBA, it is essential to select an appropriate baseline. In accordance with the economic principles of a CBA, the OMB regulatory guidelines require that "[t]his baseline should be the best assessment of the way the world would look absent the proposed action."[55] Importantly, the appropriate baseline against which to compare a

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52 Notice of Proposed Rulemaking, *In the Matter of Restoring Internet Freedom,* WC Docket 17-108, FCC, released May 23, 2017, at pp. 34-35.

53 Furchtgott-Roth Cost Benefit Analysis, at pp. 6-7.

54 OMB Circular A-4, at pp. 15-42.

55 OMB Circular A-4, at p. 15.

potential rulemaking is not simply the world as it exists in the present. Instead, as the OMB states, the baseline "should reflect the future effect of current government programs and policies."[56] For example, evaluations of proposals to reform many programs, such as Social Security, recognize that the program is likely to grow absent any intervention.

B. Costs and Benefits are Accounted For

25. A CBA should consider all of the relevant costs and benefits that accrue to society as the result of a proposed regulatory action. Some costs can be directly observed, such as the costs of retooling equipment or the costs of additional capital expenditures resulting from a regulatory action. Some costs can be inferred based on an agent's willingness to pay to avoid a negative outcome. For example, if it is observed that a firm is willing to pay $50,000 to avoid a negative outcome, then it can be inferred that the firm must incur costs of at least $50,000 as a result of this outcome. From an economist's perspective, all costs or other net economic impacts should be included in the analysis, whether they are borne by the parties directly affected by the rulemaking or by third-parties.

C. Costs and Benefits are Expressed in Common Monetary Units and Properly Discounted

26. The value of a dollar today is greater than the value of a dollar tomorrow; this economic fact is typically referred to as the "time value of money." To compare costs and benefits accruing to different parties and in different time periods, they must be translated to a common money metric and discounted to their "present value." The common money metric is not just a common currency; it should be a measure of expected benefits. That is, the riskiness of future outcomes should be addressed separately (by taking expected values) from the discounting that translates future values to their present values. Uncertainty about future outcomes is addressed further in the following section.

27. To properly express the benefit of a project to society, the discounting procedure must reflect the opportunity cost of capital and the social rate of time preference; these are the

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[56] OMB Circular A-4, at p. 15.

rates at which society is willing to exchange a dollar today for a dollar in the future. The OMB states that, "The analytically preferred method of handling temporal differences between benefits and costs is to adjust all the benefits and costs to reflect their value in equivalent units of consumption and to discount them at the rate consumers and savers would normally use in discounting future consumption benefits."[57] The OMB requires real discount rates of three and seven percent to be used as a base-case for regulatory analysis. Seven percent is "an estimate of the average before-tax rate of return to private capital in the U.S. economy," while three percent approximates the social rate of time preference for consumption.[58]

28. Rulemakings often affect the health and safety of individuals. CBA requires that costs or benefits due to changes in public safety are measured in monetary units in accord with the public's willingness to pay for improvements in health or safety. The OMB requires regulators to provide "a benefit-cost analysis of major health and safety rulemakings," stating that "[i]n monetizing health benefits, a [willingness to pay] measure is the conceptually appropriate measure as compared to other alternatives…Using the [willingness to pay] measure for health and safety allows you to directly compare your results to the other benefits and costs in your analysis."[59]

D. Uncertainty is Properly Accounted For

29. The exact costs and benefits from a rulemaking cannot be known with certainty, and this should be reflected in a CBA. When probability distributions over possible outcomes can be developed, they should be incorporated into the calculation of the proper expected values of future outcomes or into sensitivity analyses. It is important to include sensitivity analyses in a CBA when costs or benefits are sensitive to various assumptions; the OMB

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57 OMB Circular A-4, at p. 33.

58 OMB Circular A-4, at p. 33.

59 OMB Circular A-4, at p. 28.

states that "[m]ajor assumptions should be varied and net present value and other outcomes recomputed to determine how sensitive outcomes are to changes in the assumptions."[60]

VI. Establishing a Baseline

30. This report describes a CBA of EWA/PDV's proposal for the regions of Florida in which FPL operates. Because FPL has shared detailed cost information with me, I am able to more fully analyze the effects of EWA/PDV's proposal in FPL's operating region than in the United States in general. I also use this region as a "case study" to examine what the potential effects of EWA/PDV's proposal might be when extrapolated to a national scale.

31. When conducting a CBA, the proper baseline against which to compare a proposed policy change is not simply the world as it exists today. The proper baseline is the world as it is expected to exist in the future, absent any policy change. For example, NextEra Energy has noted that demand for spectrum in the critical infrastructure industry is both growing and already constrained.[61] Thus, the costs associated with restricting FPL's access to spectrum today are, in fact, an underestimate of what these costs will be in the future. This point is developed further in Section VII below.

32. Similarly, when considering costs and benefits on a per-capita basis, it is important to acknowledge forecasted changes in population. For example, if a state is expected to face

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60 OMB, Circular A-94, "Subject: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 29, 1992, at p. 11.

61 Reply Comments of NextEra Energy, Inc., at p. 3. See also Comments of Duke Energy Corporation, October 2, 2017, at p. 6: "it is doubtful that Duke Energy would be able to secure the required number of unencumbered and non-interfering channels to provide the same coverage and capacity currently enjoyed following any reallocation of channels and frequencies that would reduce the B/ILT channels to any number less than the 199 currently available." See also Comments of the Utilities Technology Council, October 2, 2017, at p. 8: "utilities need access to licensed broadband spectrum to meet their increasing capacity requirements. Utilities must increase capacity to support smart grid deployment and new cybersecurity requirements. They also need access to spectrum because carriers are discontinuing wireline leased line circuits that utilities use for substation monitoring and protective relaying applications, as well as other utility applications that protect the safety, reliability and security of utility operations." See also Comments of Lower Colorado River Authority, October 2, 2017, at p. 3-5: "[900 MHz spectrum] is needed for future use by B/ILT entities for site-based, narrowband operations."

some cost per-capita in 10 years, the cost should not be multiplied through by the state's current population. Rather, the per-capita cost should be scaled-up by the state's projected population in 10 years. Similarly, where relevant, projected economic growth should be incorporated into any future projections. This point is particularly relevant to the current analysis, as Florida is one of the regions of the United States that is most prone to hurricanes and other natural disasters, and it is also one of the fastest growing regions of the United States.[62] Thus, the costs to society from natural disasters in Florida will grow significantly in the future. This point is addressed in Section VII.A.4 below.

VII. Costs and Benefits are Accounted For

A. Costs of Reallocation

33. Dr. Furchtgott-Roth's analysis repeatedly asserts that "[n]o social costs or new negative externalities associated with the EWA/pdvWireless proposal have been identified in the record."[63] The notion that there are no social costs or negative externalities created by the proposal is simply incorrect. For example, EWA/PDV's proposal may not provide enough bandwidth for current B/ILT users and their projected future needs, and it would certainly limit future development of the 900 MHz band by new B/ILT needs of future users. [64] As these potential B/ILT users are not among the parties addressed by the proposal, the costs they would face as a result of a rulemaking are regarded as "social costs" or "negative externalities" of the proposal.

34. Dr. Furchtgott-Roth further states that the proposal adequately compensates NextEra and other parties that will incur costs as a result of the proposed rulemaking, concluding that "if the PEBB licensee makes other parties whole, they are no worse off."[65] However, this

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62 Mike Schneider, "Florida Cities Among the Biggest Population Gainers," U.S. News & World Report, March 23, 2017, accessed December 11, 2017, available https://www.usnews.com/news/best-states/florida/articles/2017-03-23/florida-were-among-the-biggest-population-gainers-last-year.

63 Furchtgott-Roth Cost Benefit Analysis, at p. 14.

64 Reply Comments of NextEra Energy, Inc., at p. 10.

65 Furchtgott-Roth Cost Benefit Analysis, at p. 15.

tautological statement is of little comfort to those 'other parties.' Many of the affected parties, including NextEra, are not confident that they will be made whole because EWA/PDV's proposal will not provide enough bandwidth in the proposed 2/2 MHz band for current B/ILT users and their projected future needs, and it would limit future development of the 900 MHz band by potential new B/ILT licensees. Additionally, the EWA/PDV proposal does not account for the increased operating costs that NextEra and other B/ILT licensees will incur year after year to accommodate the reconfiguration.

35. Dr. Furchtgott-Roth also asserts that the "complaints against the EWA/pdvWireless proposal appear to be…equity issues…outside of the realm of direct government consideration."[66] Dr. Furchtgott-Roth is alluding to a principle of CBA in which pure wealth transfers need not be accounted for.[67] For example, if a proposed policy takes an asset worth $1 from Party A and gives it to Party B, there is both a cost of $1 (to Party A) and a benefit of $1 (to Party B), but these costs and benefits wash or net out. Thus, an economic analysis that only measures total net impacts on society will measure zero net cost in such a situation and effectively ignores such "equity issues". Even if such a transfer washed out (as noted below, however, the transfer does not wash out in this matter) but created equity issues that are not directly part of a CBA, that does not mean they are not legitimate considerations for policymakers.

36. Furthermore, beyond the legitimacy of considering equity issues, Dr. Furchtgott-Roth's implication that a transfer of the 3/3 MHz band from B/ILT users like NextEra to EWA/PDV constitutes a pure wealth transfer is simply false. First, as discussed below in Section VIII.A, the transaction itself is far from costless. For example, NextEra would face significant retooling costs from transitioning from the current 5/5 MHz band to the newly truncated 2/2 MHz band. Furthermore, the value created by NextEra or EWA/PDV as a result of operating on the 3/3 MHz band in question is different for each party, since the parties use the band for fundamentally different operations. Transferring an asset from one

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66 Furchtgott-Roth Cost Benefit Analysis, at pp. 14-15.

67 OMB Circular A-4, at pp. 14, 38.

party to another only washes out in a CBA if the asset's value does not change based on the party that owns it, and the asset's value is the same to both parties. Clearly, in the case of the analysis at hand, the value generated by the 3/3 MHz band depends a great deal on the party that owns it, rendering Dr. Furchtgott-Roth's statement about "equity issues" severely misleading and irrelevant to this matter. This point is further explored in Sections VII.A.2 through VII.A.4 below.

37. Even transfers that do strictly cancel out in a CBA can still be of interest to policymakers, since identifying winners and losers is a legitimate area of concern for them. For example, transfers from lower income to higher income individuals may be ignored in a CBA, but may nonetheless be an undesirable outcome. In this case, the proposed spectrum reallocation is likely to act as a wealth transfer from 900 MHz licensees (who would bear the costs of the proposed policy) to EWA/PDV (who would benefit from it). This fact is masked by the CBA, which only measures the net cost (or benefit) of the proposal, though it is still likely to result in a wealth transfer.

38. The potential costs of the proposed rulemaking to entities holding B/ILT and SMR licenses, and to society at large, are numerous. Broadly, these costs fall under one of four categories. First, there are one-time costs associated with transitioning the existing 5/5 MHz band segment into a 3/3 MHz broadband segment and 2/2 MHz narrowband segment, which EWA/PDV claims it will cover. Second, there are ongoing costs that FPL and other B/ILT firms would continually face if their operations were restricted to a 2/2 MHz band, which EWA/PDV would cover only partially; these costs would be incurred year after year as a result of EWA/PDV's proposed rebanding. Third, there are non-monetary costs related to performance and safety issues. Though the costs due to safety issues do not immediately impact any firm's bottom line, they are significant and should be acknowledged in a CBA. Finally, external costs are costs that would not be incurred by FPL, EWA/PDV, or other users of the 900 MHz band, but which would instead be borne more broadly by society. EWA/PDV proposes to cover only the first and second categories of costs, and incompletely, even in those cases. In any event, all of these costs should be explicitly included in a CBA. If the sum of these costs is greater than the benefit created by the proposed rulemaking, on net, society would be made worse-off as a result of

EWA/PDV's proposal. Of course, this empirical question is what a proper CBA is intended to answer.

1. Transition Costs of Reallocation

39. There are several large, one-time transition costs associated with the proposed spectrum reallocation. First, FPL has a large number of receivers and transmitters that would need to be retuned in order to function on a new 2/2 MHz band. FPL estimates that 75 percent of its spectrum in the 900 MHz band is licensed in the proposed 3/3 MHz band, which is the portion that would be forfeited under the EWA/PDV proposal.[68] Not only would all devices using these frequencies require, at a minimum, retuning, but reassigning devices to a 2/2 MHz band would require retuning many of the devices that currently operate on the 2/2 MHz band that FPL would retain in order to make room for the additional devices on the band. In addition, FPL would require changes to receivers and scanners and the construction of additional base stations to accommodate the proposed frequency reallocation.[69] In total, a considerable number of FPL's 68 sites and hundreds of transmitters would need to be manually retuned.[70] Furthermore, it is unclear whether or not FPL would even be able to identify a suitable alternative channel for all the devices it currently uses.[71] All told, because of the technical consequences associated with the proposed reallocation, FPL finds that the number of channels in use by FPL devices in the new 2/2 MHz band would increase by more than 150 percent.[72]

40. FPL estimates the capital expenditures from reconfiguring its devices at $70 - $90 million.[73] In addressing costs of EWA/PDV's proposal to other firms operating in the 900 MHz band, NextEra cites comments estimating the costs of relocating railroad operations at

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68 Reply Comments of NextEra Energy, Inc., at p. 10.

69 Reply Comments of NextEra Energy, Inc., at p. 13.

70 Reply Comments of NextEra Energy, Inc., at p. 10.

71 Reply Comments of NextEra Energy, Inc., at p. 10.

72 Reply Comments of NextEra Energy, Inc., at p. 10.

73 Reply Comments of NextEra Energy, Inc., at pp. 10, 12.

$100 million[74]. Presumably, these costs would be covered by "the PEBB licensee [that] makes other parties whole."[75]

41. In addition to costs borne by firms that currently operate in the 900 MHz band, there would also be significant costs to EWA/PDV and other firms that would need to develop capital to take advantage of a potential 3/3 MHz band. Though EWA/PDV have stated a willingness to bear some of these costs, these costs still must be considered in a CBA, a point which Dr. Furchtgott-Roth's analysis completely ignores.[76] As noted below, ultimately it is only the *net* benefits that are the final result of a CBA. Consequently, the costs of creating those benefits (the broadband deployments in the 3/3 MHz band) must be counted. Intuitively, a scenario in which $1 million in benefits requires $100,000 in expenditures is quite different from one that requires $900,000 in expenditures.

2. Ongoing Costs of Reallocation

42. Under the proposed reconfiguration, the remaining 2/2 MHz narrowband portion of the 900 MHz band would likely become more crowded as the remaining narrowband operations must coexist in the smaller allocation. As discussed above in Section VII.A.1, the initial build-out of infrastructure needed to accommodate the transition must be considered as a cost for the purposes of the CBA. However, in addition to the initial costs associated with adding this infrastructure, there will also be the ongoing costs of maintaining the new infrastructure that must be considered in the CBA as well. FPL anticipates two types of ongoing cost increases. First, EWA/PDV's proposal would require FPL to invest in additional base stations, and those base stations would generate additional ongoing operating costs. Second, existing base stations would have to be retrofitted with additional capital in order to accommodate the closer channel spacing and higher noise floor in the newly created 2/2 MHz band.[77] This additional capital would require ongoing expenditures

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74 Reply Comments of NextEra Energy, Inc., at p. 13.

75 Furchtgott-Roth Cost Benefit Analysis, at p. 15.

76 Furchtgott-Roth Cost Benefit Analysis. See also EWA/PDV Proposal, at p. iv.

77 Information provided by FPL.

to operate and maintain. As these costs will be ongoing, a net present value calculation must be performed on this stream of costs, using the real discount rate of seven percent required by the OMB, where, as noted above, seven percent is the discount rate for private capital in the U.S. economy.[78]

3. Non-monetary Costs of Reallocation[79]

43. In addition to the monetary costs associated with the proposed reallocation, FPL, other B/ILT and SMR entities affected by the proposed rulemaking, and the general public would have to incur significant non-monetary costs. These costs are varied, reflecting the diversity of operations that are carried-out on the 900 MHz band.

44. FPL and other firms use the 900 MHz band for such mission-critical purposes as voice communications for nuclear power plant security operations, nuclear siren system operations, smart grid energy efficiency monitoring and electric distribution control, and dispatch and emergency communications after natural disasters.[80] These uses illustrate several unique aspects of the operations on the 900 MHz band.

45. First, it is critical that transmissions on this band occur without interruption and with as little noise as possible. In economic terms, the cost to society of a noisy or interrupted transmission can be orders of magnitude larger than the costs of a faulty transmission in other applications. In the extreme, the costs of losing communications can be catastrophic. Second, peak demand for transmissions on the 900 MHz band must address incident and disaster response, where communications are crucial to public safety and service restoration. For example, FPL's 900 MHz band voice dispatch system was used to send 4.5 million transmissions in the first few critical days as it coordinated restoration

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78 OMB Circular A-4, at p. 33.

79 While Sections VII.A.1, VII.A.2, and VII.A.4 correspond with sections below in which these costs are estimated, these costs are, by nature, unable to be quantified below. Note that this does not indicate that these costs should not be of concern to policymakers.

80 Reply Comments of NextEra Energy, Inc., at p. 3.

operations in the aftermath of Hurricane Irma, a rate significantly higher than normal.[81] The combination of high marginal costs from faulty transmissions and huge peak demand for spectrum create an environment in which severe costs can arise in the absence of sufficient access to spectrum in B/ILT operations.

4. External Costs of Reallocation

46. External costs of reallocation are those that are borne by economic actors other than those directly affected by the proposal under consideration. Although they do not enter the internal calculus of 900 MHz licensees, they should be included in a proper CBA. One of the major external costs of EWA/PDV's proposal stems from the increased time that FPL could require to restore power to Floridians following a hurricane or other natural disaster. As NextEra points out, "use of [FPL's] 900 MHz PLMRS radios for dispatch and emergency communications saves the company 1 to 2 days in total restoration time [after major natural disasters], compared to [the] estimated restoration [time] without the use of 900 MHz communications."[82] Though FPL would retain some transmission rights on the

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81 Reply Comments of NextEra Energy, Inc., at p. 2. Information provided by FPL.

82 Reply Comments of NextEra Energy, Inc., at p. 12.

FPL's voice radio system is designed to be robust and survivable. There are four key aspects of the voice radio system's design. First, there is significant coverage overlap which provides tolerance to site failure. Second, each radio site has a wired and wireless circuit connecting the site to the system, a generator and fuel to operate the site for three days minimum, and batteries that will operate the site for more than 24 hours if commercial power and the generator are not available. Third, critical users have both a handheld radio and a high powered truck radio, the latter of which allows field users to access multiple radio sites so that one failure does not disrupt communications. Finally, FPL has direct control over the maintenance of the radio system and it has dedicated technicians to address system issues and to facilitate the restoration of communications following a storm. This robust design helps expedite recovery of electrical service following a hurricane or other natural disaster.

The 900 MHz voice radio system enables FPL to effectively communicate following a storm, which saves an estimated one to two days of restoration time. The system allows FPL to immediately assess and communicate storm damage in order to plan recovery efforts, and it allows FPL to set up recovery centers within 24 hours of a storm clearing the affected service area. FPL can handle a high volume of recovery communications without delays, which allows for undisrupted coordination with FPL's field resources. Following a storm, FPL directly maintains its radio system with FPL technicians in order to optimize the overall electrical system recovery effort.

Information provided by FPL.

900 MHz band under the EWA/PDV proposal, a 2/2 band may not be sufficient to restore electrical service to customers at the same rate as FPL's 5/5 MHz band or the transition to the reduced set of channels may face complications. Restoring electrical service following a major natural disaster requires a very high number of transmissions on a well working system, which may be jeopardized on the proposed 2/2 band.[83] The external costs associated with power outages are enormous by all accounts, and include the foregone production of goods and services.

47. Though there are limited applicable data available on the costs associated with natural disasters in the regions FPL serves, national-level data shows that these costs are significant. For example, a White House report on electric grid resiliency from 2013 summarized several previous studies. This report found that the annual cost of power outages nationally is in the range of $28 billion to $209 billion,[84] and the annual costs of weather-related power outages are between $25 billion and $70 billion.[85] In 2016, the Lawrence Berkeley National Laboratory estimated annual costs of power outages to be $110 billion.[86] As Florida is among the fastest growing regions of the United States, the power outage costs borne by residents of Florida will grow in the future, both in absolute

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83 Reply Comments of NextEra Energy, Inc., at p. 2.

84 "Economic Benefits of Increasing Electric Grid Resiliency to Weather Outages," White House, August 2013, at p. 17.

85 "Economic Benefits of Increasing Electric Grid Resiliency to Weather Outages," White House, August 2013, at p. 17.

86 Joseph H. Eto, "The National Cost of Power Interruptions to Electricity Customers – An Early Peek at LBNL's 2016 Updated Estimate," Ernest Orlando Lawrence Berkeley National Laboratory, June 19, 2016, at slide 11. This report updates a more detailed report from 2006. In this earlier report, researchers at LBNL concluded that power outages cost between $22 and $135 billion annually, with a baseline estimate of $79 billion. The South Atlantic region—which includes Florida—bears the largest burden of outage costs at nearly 19 percent ($14.7 billion). See Kristina Hamachi LaCommare and Joseph H. Eto, "Cost of Power Interruptions to Electricity Consumers in the United States," Ernest Orlando Lawrence Berkeley National Laboratory, February 2006, at pp. 15, 18.

terms, and as a percentage of the total costs from delays in restoration following power outages in the United States.[87]

48. Aside from external costs due to power outages, there are likely to be other external costs resulting from EWA/PDV's proposal that are more difficult to quantify. For example, a rulemaking in accord with EWA/PDV's proposal may disincentivize capital investment in the future by sending a signal to current spectrum rights holders that their capital investments are not safe from government interference.

49. Dr. Furchtgott-Roth's analysis includes a lengthy discussion of the benefits of "preserving the rule of law and property rights."[88] Despite this discussion, Dr. Furchtgott-Roth completely ignores the disruption that interventionist policies like EWA/PDV's proposal typically cause. Firms that operate on the 900 MHz band like FPL are capital intensive, and such capital intensive firms are wary of investing in capital when there is a chance that their capital will be rendered worthless by government intervention in the future. The result of this wariness is that firms will under-invest in capital when there is a possibility that government intervention is likely to disrupt firm operations. This fact is well documented in the economics and policy literature—for example, the 2007 Economic Report of the President explains that "[b]ecause a larger capital stock makes labor more productive, investment is a primary driver of greater economic growth and higher standards of living. If governments pursue policies that involve the least amount of government interference necessary for a well-functioning capital investment market, this will encourage an efficient amount of investment."[89]

50. The FCC's adoption of a Notice of Proposed Rulemaking on EWA/PDV's proposal would send a signal to other firms to be wary of investing in radio spectrum capital if incumbent

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87 Mike Schneider, "Florida Cities Among the Biggest Population Gainers," U.S. News & World Report, March 23, 2017, accessed June 20, 2018, available https://www.usnews.com/news/best-states/florida/articles/2017-03-23/florida-were-among-the-biggest-population-gainers-last-year.

88 Furchtgott-Roth Cost Benefit Analysis, at p. 7.

89 "Economic report of the president," *Council of Economic Advisors,* Washington, DC, White House, February 2007, at p. 63.

firms are not protected. One advantage of voluntary reallocation programs, such as the recently concluded 600 MHz Incentive Auction, is that they protect against this disincentive by assuring that investment expectations are not diminished by a revised policy. Unless the FCC takes steps to protect incumbent spectrum users like FPL—and these steps are visible to other spectrum users—adopting proposals like EWA/PDV's would establish a precedent that may make future spectrum users consider risks of reallocation before investing in capital. If adopting this proposal would, in fact, result in under-investment in radio spectrum capital, the inefficiencies created would represent additional external costs of the proposal that are not accounted for in this analysis.

B. Benefits of Reallocation

51. The benefits of reallocation are limited by the value created. Given that other spectrum already allocated for broadband could be used to provide the services proffered by EWA/PDV, the value of reallocating the 900 MHz band frequencies to broadband is similarly limited to the value of other broadband frequencies. This opportunity cost approach provides the basis for estimating an upper bound on the economic value of the licenses created by the EWA/PDV proposal. In order to quantify this opportunity cost, I use a "comparables approach," which values the amount paid at auction for a similar spectrum band on a dollars per MHz, per person, basis.

VIII. Costs and Benefits are Expressed in Common Monetary Units and are Properly Discounted

A. Costs of Reallocation

1. Transition Costs

52. As discussed in Section VII.A.1, the "transition costs" of EWA/PDV's proposal would occur once, and they would be incurred as a result of incumbent firms transitioning from

the existing 5/5 MHz band to the proposed 2/2 MHz band. Thus, these monetary costs enter into the CBA once, and are undiscounted.[90]

53. FPL has identified a number of transition costs that would be associated with the EWA/PDV proposal. It estimated these costs and provided them to me. I reproduce the information provided by FPL in Appendix A. Consistent with the focus of CBA on measuring impacts of policy proposals as measured against a baseline, I consider only transition costs that FPL identified as necessary under the EWA/PDV proposal, but that would not be incurred by FPL otherwise.

54. According to the analysis provided, maintaining existing FPL operations after adopting the EWA/PDV proposal would require the addition of at least 45 transmission sites.[91] These 45 additional sites would include 22 sites which FPL owns and 23 sites that FPL would lease.[92] Each existing (and additional) site's effective transmitting range would be reduced under the proposal due to the closer frequency spacing and higher noise floor that implementing the proposal would generate.[93] This reduction in transmission range would create gaps in the coverage area from the existing sites, necessitating the construction of new sites.

55. The analysis provided estimates that in order to implement the EWA/PDV proposal the addition of adding 22 new owned-sites to FPL's network and the Radio System for the new sites will cost $38 million.[94] It also estimates that updating FPL's 68 existing sites would

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90 If the transition was to take a meaningful amount of time, then some amount of discounting would be appropriate.

91 FPL's analysis indicates that the number of additional sites could range from 45 to 48. To be conservative in calculating costs, the lower number will be used in this report. Leased sites are discussed further below.

92 Information provided by FPL.

93 Information provided by FPL.

94 Calculation: $38 million = $8 million + $5 million + $25 million. See Table 4.

cost $24 million.[95] The total one-time transition costs are estimated to be **$62 million**. Table 4 below summarizes these costs.

Table 4: Transition Costs

	Type of Cost	Quantity	Unit Cost	Total Cost
New Sites	New Sites with 300' Towers	15	$500,000	$7,500,000
	New Sites with 400' Towers	7	$662,802	$4,639,614
	Radio System	45	$547,537	$24,639,165
Existing Sites	Minor Tower Support Upgrade	20	$20,000	$400,000
	Building Replacement	9	$75,440	$678,960
	300' Tower Replacement	5	$189,085	$945,425
	400' Tower Replacement	5	$355,810	$1,779,050
	Radio System Upgrade	68	$300,000	$20,400,000
	FCC Licensing	68	$2,000	$136,000
Nuclear Siren System	Transmitting Site Update	4	$75,000	$300,000
	Endpoint Update	139	$6,000	$834,000
Total				$62,252,214

Source: Table A1.

Note: Table A1 includes some costs that are not one-time transition costs. These are excluded from Table 4, and they appear in Table 5 instead.

2. Ongoing Costs

56. "Ongoing costs" of EWA/PDV's proposal are recurring; thus these costs are treated differently in a CBA from the one-time transition costs. A net present value ("NPV") calculation is used to discount this stream of costs to adjust for the timing of the costs and the time value of money. The analysis provided identifies a number of ongoing costs that would be associated with EWA/PDV's proposal. Regardless of the rate at which these costs are actually incurred, they are reported here as annualized rates. These costs are associated with the leased sites. The new leased sites are expected to cost $1 million per year.[96] The additional improvements to the existing leased sites are expected to cost

[95] Calculation: $24 million = $0.4 million + $0.7 million + $1 million + $2 million + $20 million + $0.1 million. Calculations not exact due to rounding. See Table 4.

[96] Calculation: $1 million = $690,000 + $540,000. Calculations not exact due to rounding. See Table 5.

$12,000 per year. FPL would also need to increase staffing with at least one engineer at a cost of $180,000 per year and seven radio technicians at a cost of $150,000 per year each, for a total of $1.2 million per year.[97] As these are ongoing capital and operating costs, the OMB prescribes using an annual discount rate of seven percent, the cost of private capital in the United States. At this discount rate, the NPV of these ongoing costs are approximately **$35 million**.[98] See Table 5.

Table 5: Ongoing Costs of Transition

	Type of Costs	Quantity	Annual Per Unit Cost	Annual Total Cost
New Leased Sites	New Leased Sites	23	$30,000	$690,000
	Lease of Backhaul Service to New Sites	45	$12,000	$540,000
Existing Leased Sites	Site Lease Increase	20	$600	$12,000
Other Costs	Increase Staff		N/A	$1,230,000
Total				$2,472,000
Present Value				$35,314,286

Source: New Leased Sites and Existing Leased Sites data from Table A1. Increased Staffing costs from Table A2.

Note: Present Value Calculation: $35.3 million = $2.472 million/ 0.07, where seven percent is the discount rate for private capital in the U.S. Calculations not exact due to rounding.

3. External Costs

57. There are also costs resulting from the proposal that would fall on parties who are not directly involved in the proposed rulemaking: American firms and citizens. These costs, frequently referred to as "externalities" in the economics literature, must also be accounted for in a CBA. The external costs associated with this proposal are ongoing, and thus a NPV calculation must again be used to derive a present value for the stream of external

[97] Calculation: $1 million = (7 radio technicians × $150,000 salary) + (1 engineer × $180,000 salary). Calculations not exact due to rounding. Information provided by FPL.

[98] Calculation: $35 million = $2 million / 0.07. Calculations not exact due to rounding.

costs. As mandated by the OMB, costs that affect the American consumers are discounted at a rate of three percent, the estimated social rate of time preference for consumption, while costs that affect American businesses are discounted at the higher rate of seven percent, the OMB-estimated return to private capital in the U.S.

58. One significant source of potential externality from the EWA/PDV proposal is the cost associated with power outages that Floridians and other Americans are expected to endure following natural disasters. In the past two years alone, Florida has experienced two major hurricanes. In 2016, Hurricane Matthew caused 46 deaths and $10 billion in wind and water damage in the United States.[99] In 2017, Hurricane Irma caused 92 deaths and $50 billion in wind and water damage.[100] Both storms resulted in over one million FPL customers losing power.[101] In the last fourteen years, there have been six hurricanes that have resulted in over one million FPL customers losing power, in addition to causing large-scale property damage and loss of life;[102] if major hurricanes continue to occur at this rate, there is a 43 percent probability that a major hurricane will affect Florida in any given year.[103] For the purposes of my analysis below, I consider a major hurricane to be one in which at least one million FPL customers lose power, and I assume that the probability of

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99 Stacy R. Stewart, "Hurricane Matthew (AL142016) 28 September – 9 October 2016," Tropical Cyclone Report, National Hurricane Center, April 7, 2017, at pp. 12, 15.

100 John P. Cangialosi, Andrew S. Latto, and Robbie Berg, "Hurricane Irma (AL112017) 30 August – 12 September 2017," Tropical Cyclone Report, National Hurricane Center, June 30, 2018, a pp. 13, 15.

101 Hurricane Matthew resulted in 1.2 million FPL customers experiencing an outage. Hurricane Irma resulted in over 4.4 million FPL customers experiencing an outage. A "customer" is frequently a household containing multiple residents. See Direct Testimony of Manuel B. Miranda, FPL, "Petition by Florida Power & Light for the Approval of Final/Actual Storm Restoration Costs, Associated True-Up Process Related to Hurricane Matthew, and the related testimony and exhibits of Manuel Miranda, Kim Ousdahl, Eduardo Devarona, and Tiffany Cohen which support the petition," *Florida Public Service Commission*, Docket No. 20160251-EI, February 20, 2018, at p. 20. See also Direct Testimony of Manuel B. Miranda, FPL, "Petition by Florida Power & Light Company for Evaluation of Storm Restoration Costs Related to Hurricane Irma," *Florida Public Service Commission*, Docket No. 20180049-EI, August 31, 2018, at p. 24.

102 Information provided by FPL. See Id. See also, Direct Testimony & Exhibits of Geisha J. William, "In Re: Florida Power & Light Company's Petition for Issuance of a Storm Recovery Financing Order," *Florida Public Service Commission,* January 13, 2006, at p. 46.

103 Calculation: 43 percent probability = 6 major hurricanes / 14 years.

such a storm occurring in any given year is 43 percent. As discussed in Section VII.A.4 above, FPL is estimated to restore electrical service one to two days faster due to its hardened 900 MHz voice dispatch system—relative to the expected restoration time without this system—following these catastrophic events.[104]

59. It is difficult to assess how potentially limited current and/or future access to spectrum will affect FPL's restoration efforts following a major natural disaster. The impact of the EWA/PDV proposal on FPL's restoration efforts would depend on many variables, including the regions of Florida affected and the severity of the natural disaster. It would also depend on the success of the transition from the 5/5 MHz band to the 2/2 MHz band. Should the transition not work as planned and, despite the expenditures on mitigation described above, FPL's network would not perform as it has in a future natural disaster then additional costs would be incurred. I find it infeasible to estimate the economic damages associated with partially restricting FPL's access to 900 MHz spectrum. Consequently, below, I estimate the total economic losses that would result in completely restricting FPL's access to the 900 MHz band—or, put differently, I estimate the total economic benefits of FPL's 900 MHz dispatch system. To be clear, my estimate acts as an upper bound on the potential economic losses due to EWA/PDV's proposal. Even as an upper bound, these economic losses are cause for concern, as the estimated external benefits generated by FPL's 900 MHz dispatch system are massive.

60. As discussed above, I consider the probability that a major hurricane (here assumed to be a hurricane that causes more than 1 million Floridians to lose power) affecting Florida in any given year to be 43 percent. Moreover, I estimate that FPL's 900 MHz dispatch system would result in 551,000 – 1,102,000 additional person-days of electrical service following a

[104] NextEra states that, "[f]ollowing a disaster roughly the magnitude of a category 4 hurricane, FPL estimates that use of its 900 MHz PLMRS radios for dispatch and emergency communications saves the company 1 to 2 days in total restoration time, compared to estimated restoration without the use of 900 MHz communications." NextEra Reply Comments, at pp. 11-12.

major hurricane.[105] Annualizing this rate, FPL's 900 MHz network is estimated to generate approximately 236,000 – 472,000 person-days of additional electrical service per year, in expectation.[106]

61. The annual per capita GDP of the United States in 2016 (the most recent year available) is $57,638, a daily per capita GDP of $157.91.[107] That is, the average value created per person by the American economy is $157.91 per day. Virtually all modern American workplaces require electricity to operate, so this potential production is likely to be completely foregone in the event of a prolonged power outage. Aside from the costs of lost productivity, going without power for an extended period of time can result in other costs that include traveling to hotels or shelters, hotel room rental fees, and the psychological costs of being without power as well as other health effects. Given the costs of foregone productivity, in addition to the consumption costs experienced when faced with prolonged power outages, I conservatively estimate the cost to society of an American going without power for a day to be $150.[108] At this rate, 236,000 – 472,000 person-days of electrical service are worth $35 – $71 million.[109] Thus, I estimate FPL's 900 MHz network to generate these narrow benefits to society of $35 – $71 million to Floridians annually, a benefit to society that may be jeopardized to some degree under EWA/PDV's proposal. As this is an annual rate, the net present value of this stream of forgone benefits, discounted at

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105 Calculation: 551,000 to 1,102,000 person-days = 1 to 2 days × 1 million Florida residents affected × 55.1 percent. As of 2016, the counties that FPL holds 900 MHz licenses in contain 55.1 percent of the population of Florida. Thus, if 1 million Florida residents are affected per catastrophic hurricane event, I assume 55.1 percent of those residents, on average, benefit from FPL's fast restoration times resulting from their hardened 900 MHz network.

106 Calculation: 236,000 to 472,000 person-days per year = 551,000 to 1,102,000 person-days per disaster × 43 percent probability of a major hurricane per year. Of course, restoration of outages occurs over time, with fewer homes remaining as the restoration efforts are made. I interpret the 1 to 2 days improvement as affecting the entire distribution of outages.

107 "GDP per capita (Current US$)," The World Bank, accessed June 20, 2018, available https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=US.

108 The measurement of this lost value associated with a power outage can vary widely and depends on the purpose for which the estimate is used. I recognize these caveats.

109 Calculation: $35 to $71 million = 236,000 to 472,000 person-days per year × $150 GDP per capita per day.

the OMB-specified rate of seven percent, is **$506 million – $1 billion**.[110] This is the estimated total present value of the external benefits to society that are generated by FPL's 900 MHz dispatch system.

62. While the electrical outages caused by hurricanes are significantly more common in Florida than in the United States on the whole, the cost of power interruptions is fairly consistent across the major US regions.[111] Hurricanes are not the only natural disaster that can result in power outages; storms, earthquakes, flooding, tornadoes and fires can all cause widespread power outages. Florida—and the South Atlantic region as a whole—bears the largest burden of costs due to power outages and it is the most populous region of the United States as well.[112] Thus, FPL's experience in restoring power in the aftermath of Hurricane Irma is likely to be similar to the experience of other critical infrastructure industry firms across the country. For example, the Lower Colorado River Authority ("LCRA") operates a 900 MHz trunked radio communications system with 67 radio tower sites and "[m]ore than 8,800 mobile radio users [who] rely on the LCRA system for their daily communications."[113] The LCRA operates in an area of the country that is notorious

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110 Calculation: $506 million to $1 billion = $35 to $71 million / 0.07. Note that, in reality, some of these externality costs will accrue to firms and some will accrue to individuals. Per the OMB's recommendations, any costs that accrue to individuals should be discounted at a lower rate of three percent per year. Thus, the decision to discount all costs at seven percent is a conservative assumption in the sense that this calculated range is a lower bound for the true externality costs.

111 Kristina Hamachi LaCommare and Joseph H. Eto, "Cost of Power Interruptions to Electricity Consumers in the United States," Ernest Orlando Lawrence Berkeley National Laboratory, February 2006, at p. 26. See also Joseph H. Eto, "The National Cost of Power Interruptions to Electricity Customers – A *Revised* Update," Distribution Reliability Working Group, 2017 IEEE PES Joint Technical Committee Meeting, January 10, 2017.

112 Costs due to power outages scale closely with population, suggesting that Florida residents are not significantly more prone to power outages due to hurricanes than other regions are prone to power outages due to other natural disasters. See Kristina Hamachi LaCommare and Joseph H. Eto, "Cost of Power Interruptions to Electricity Consumers in the United States," Ernest Orlando Lawrence Berkeley National Laboratory, February 2006, at p. 15. See also Joseph H. Eto, "The National Cost of Power Interruptions to Electricity Customers – A *Revised* Update," Distribution Reliability Working Group, 2017 IEEE PES Joint Technical Committee Meeting, January 10, 2017.

113 "Telecommunications services to Texas communities," Lower Colorado River Authority, accessed July 5, 2018, available https://www.lcra.org/community-services/Pages/telecom.aspx.

for flash flooding, and it employs "crews…on around-the-clock alert whenever floods threaten."[114] The environment in which the LCRA operates is similar to that of FPL in that fast, extremely reliable communication is vital to both public safety concerns and minimizing the economic costs of natural disasters.

63. Though not externality costs, FPL also incurs tremendous private costs as a result of hurricanes and other natural disasters. Following a natural disaster, FPL employs thousands of workers for more than 12 hours per day while restoration efforts are ongoing, in addition to the large capital and equipment costs that are typically incurred following a natural disaster.[115] Thus, any increase in this restoration time that results from EWA/PDV's proposal would represent significant private costs to FPL and its customers. I do not attempt to quantify these costs in my CBA, but they should still be of concern to policymakers. By excluding such costs, my analysis is conservative in the sense that it underestimates the true costs of EWA/PDV's proposal.

B. BENEFITS OF REALLOCATION

64. In order to estimate the stream of benefits generated by EWA/PDV's proposal, I consider the dollars per MHz, per person, ("$/MHz-pop") paid in a recent 600 MHz incentive auction, FCC Auction 1000.[116] Significantly, similar to the 3/3 band that would be created by the EWA/PDV proposal, this spectrum was under 1 GHz and designated for broadband services and was auctioned only about a year ago. The "comparables approach" I employ is a standard means of valuing spectrum.[117]

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[114] "Managing floods in Flash Flood Alley," Lower Colorado River Authority, accessed July 5, 2018, available https://www.lcra.org/water/floods/Pages/default.aspx.

[115] Information provided by FPL.

[116] Incentive Auction 1000 was conducted in 2016. It included Reverse Auction 1001 and Forward Auction 1002, and it generated $12.901 billion in net proceeds. "Incentive Auction Dashboard," FCC, accessed June 20, 2018, available https://auctiondata.fcc.gov/public/projects/1000.

[117] Coleman Bazelon and Giulia McHenry, "Spectrum Value," Telecommunications Policy, Volume 37, Issue 9, October 2013.

65. In order to compare commensurate costs and benefits, I consider only the $/MHz-pop for the counties in which FPL has B/ILT licenses. I calculate a weighted average of the $/MHz-pop paid per county, weighing the $/MHz-pop across counties by both the number of MHz auctioned, and the size of the county in 2016, as recorded by the U.S. Census Bureau.[118] For example, my calculation would place twice as much weight on the $/MHz-pop in a county with 1,000,000 citizens as it would place on a county with 500,000 citizens.

66. In total, the weighted average $/MHz-pop paid for 600 MHz spectrum in the counties in which FPL has licenses is $1.22/MHz-pop. As the 600 MHz auction sold larger 10 MHz bands of spectrum, the $/MHz-pop value I calculate is likely to overestimate the value of the 3/3 MHz band that would result from EWA/PDV's proposal, since larger bands of spectrum are considered to be more valuable.[119] (That is, a 3/3 MHz band is worth less than 30 percent of a 10/10 MHz band or 60 percent of a 5/5 MHz band.) In 2016, the total population of the counties in which FPL holds B/ILT licenses is 11 million residents. Thus, under a standard comparables approach, the total benefit created by EWA/PDV's proposal is **$83 million** for areas in which FPL operates.[120]

IX. Uncertainty is Properly Accounted For

67. I consider the costs and benefits discussed above as the most likely cases under EWA/PDV's proposal. However, these values are forecasts, and, as with all forecasts, they are subject to a degree of uncertainty. It is crucial to note that this uncertainty or the errors it produces is not symmetric. The costs and benefits estimated above assume that EWA/PDV's proposal would be implemented in a timely and—more importantly—safe manner. The potential "upside errors," in which net benefits are actually higher than my

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[118] "Florida QuickFacts," United States Census Bureau, accessed February 7, 2018, available https://www.census.gov/quickfacts/fact/table/FL/PST045216.

[119] Thomas W. Hazlett and Robert E. Muñoz, "A welfare analysis of spectrum allocation policies," RAND Journal of Economics, Vol. 40, No. 3, Autumn 2009, at pp. 432-433.

[120] Calculation: $83 million = 1.22 $/MHz-pop × 11 million residents × 6 MHz. Calculations not exact due to rounding.

estimates, are relatively small. For example, if the 900 MHz band under consideration were slightly more valuable than the 600 MHz bands I consider in Section VIII.B, the benefits I estimate may be slightly greater than my forecasts above indicate. However, the potential "downside errors," in which net benefits are actually lower than my estimates, could be tremendous. A sustained, large-scale power outage following a natural disaster in Florida could cost society billions of dollars. The costs associated with creating a new frequency band when the proposed 2/2 MHz band reaches its capacity could be hundreds of millions of dollars, if not more.

68. I formally consider two sensitivity analyses in which I modify key inputs to my above calculations. I have chosen these inputs as the subjects of my sensitivity analyses because these are among the inputs to which my analysis is most sensitive. These analyses provide a larger range of net benefits from EWA/PDV's proposal than I calculate in my primary specification above.

69. For the first sensitivity analysis, I consider calculating the benefits of EWA/PDV's proposal under an alternative $/MHz-pop value. Specifically, I perform a comparables calculation similar to the one described in Section VIII.B, however, instead of basing my calculations on the results of the recent 600 MHz auction, I use the results of the 2007 1.4 GHz FCC Auction 69.[121] The 1.4 GHz band is a small, paired band with which "[l]icensees may provide both fixed and mobile services including wireless internet, high speed data as well as advanced two-way mobile and paging services."[122] As this band is similar in both size and function to the 3/3 band that EWA/PDV's proposal would create, the 1.4 GHz band serves as a reasonable, if somewhat older, comparable.

70. As in Section VIII.B, I calculate the weighted average $/MHz-pop paid in the 1.4 GHz auction in the same regions in which FPL operates. In FCC Auction 69, the 1.4 GHz band

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[121] Auction 69 was conducted in 2007 and generated $124 million in net proceeds. "Auction 69 Factsheet," FCC, accessed June 20, 2018, available http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=69.

[122] "Auction 69 Factsheet Permissible Operations," FCC, accessed June 20, 2018, http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=69#Permissible Operations.

sold for an average price of $0.055 per MHz-pop. Using this $/MHz-pop measure, the net benefits of EWA/PDV's proposal would be only **$4 million** versus $83 million as calculated in my primary specification above.[123]

71. For the second sensitivity analysis, I revisit the discount rate used to calculate the NPV of the external costs of EWA/PDV's proposal. As discussed above, the OMB recommends using a higher, seven percent discount rate to discount costs that firms face, which reflects the private cost of capital in the United States. However, the OMB recommends a lower, three percent discount rate when discounting consumption to reflect the time preferences of private individuals.[124] In calculating the externality costs of power outages due to hurricanes, I discounted costs using a discount rate of seven percent in my primary specification, which essentially assumes that all costs due to natural disasters are borne by firms. Though this assumption reflects a conservative approach (in the sense that it generates the smallest estimate of the present value of costs), it is not realistic. An alternative assumption is that firms and consumers each incur 50 percent of the costs associated with natural disasters. In this case, society would discount costs from natural disasters half at the rate of seven percent and half at the lower rate of three percent. Redoing my analysis using this assumption, the potential external costs of EWA/PDV's proposal would be **$843 million** – **$1.69 billion**, compared to a range of costs estimated in my primary analysis above of $506 million – $1 billion.[125]

72. In the study of uncertain future events, economists often make a distinction between "risk"—a term used to describe events that are not certain to occur, but have known or measurable probabilities of occurring—and "uncertainty"—a term characterizing future events that are inherently unknowable, to which a probability of occurring cannot be

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123 Calculation: $4 million = 0.055 $/MHz-pop × 11 million residents × 6 MHz. Calculations not exact due to rounding.

124 OMB Circular A-4, §E, Discount Rates.

125 Calculation: $843 million to $1.69 billion = 0.5 × ($35 to $71 million / 0.07) + 0.5 × ($35 to $71 million / 0.03). Calculations not exact due to rounding.

assigned.[126] Though one cannot predict a hurricane making landfall in Florida a year in advance, the probability of such an event can be estimated. However, events like the Deepwater Horizon disaster of 2010 are so rare and idiosyncratic that assigning them a probability of occurring is less feasible. Risk, on the one hand, should be accounted for in CBA, and such analyses are, in fact, mandated by the OMB.[127] Uncertainty, on the other hand, is necessarily too speculative to incorporate into a CBA. This does not mean, however, that the uncertainty associated with the EWA/PDV proposal cannot be discussed.

73. This point is of particular concern in estimating the externality costs associated with EWA/PDV's proposal. As discussed previously, FPL's 900 MHz dispatch system creates significant economic value in that FPL is able to leverage its infrastructure to rapidly restore power following major natural disasters. The frequency and intensity with which natural disasters will continue to affect Florida is a question of risk—these events will continue to occur in the future. Thus, I am able to estimate with reasonable confidence the value that FPL's 900 MHz dispatch system creates.

74. However, the effects of EWA/PDV's proposal on FPL's dispatch system—and the speed with which FPL would be able to restore power following a major disaster if the proposal is adapted—are unknowable until such an event occurs. Thus, I find that there is significant uncertainty associated with the potential externality costs of EWA/PDV's proposal. My estimation of the total value of FPL's 900 MHz dispatch system in Section VIII.A provides an illustration of the magnitude of these uncertain costs, but not a prediction or calculation of their expected levels.

75. In broad terms, EWA/PDV's proposal is disruptive to a network that is currently well-functioning. My analysis of the transition and ongoing costs associated with EWA/PDV's proposal assumes that this network would continue to be well-functioning under the proposed changes, which may be an optimistic assumption. When modifying a wireless network as important and as complicated as the 900 MHz band, there is some probability

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[126] Knight, Frank H. *Risk, Uncertainty and Profit*, (New York: Hart, Schaffner and Marx, 1921).

[127] OMB Circular A-4.

that an unforeseen issue will arise. Although my CBA only addresses some sources of quantifiable risk, EWA/PDV's proposal introduces downside uncertainties that are unquantifiable, and may be large. The exclusion of these uncertainties from my CBA should not be taken as an indication that they are negligible, but rather as a sign that they are difficult to estimate with sufficient precision.

X. Net Benefits of Reallocation

76. The previous sections report the inputs to my CBA of EWA/PDV's proposal: Section VIII.A details the transition costs, ongoing costs, and potential external costs of the proposal, quantifying these costs where possible, and Section VIII.B uses a comparables approach to value the benefits that would be created by the proposal. Finally, Section IX reports the results of sensitivity analyses of inputs to which my calculations are most sensitive. As the relevant costs and benefits have been tallied, the CBA can be performed. The basic CBA equation is:

$$\text{Net Benefits} = \text{Total Benefits} - \text{Total Costs}$$

77. Section VIII.A calculates two types of private costs—transition costs and ongoing costs—that would result from EWA/PDV's proposal, as well as an upper bound on externality costs associated with the proposal. Accordingly, considering only the private costs associated with the proposal, the above equation can be expanded as follows:

$$\text{Net Benefits} = \text{Total Benefits} - (\text{Transition Costs} + \text{Ongoing Costs})$$

78. Finally, aggregating the costs and benefits reported in Section VIII.A above provides an estimate of the net benefits of EWA/PDV's proposal, assuming the higher end of benefits, as calculated in Paragraph 66:

$$\text{Net Benefits} = \$83 \text{ million}^{128} - (\$62 \text{ million}^{129} + \$35 \text{ million}^{130})$$

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128 See Section VIII.B.

129 See Section VIII.A.

130 See Table 5.

Net Benefits = Negative $15 million[131]

79. Using the range of costs considered under the sensitivity analyses instead yields the alternative CBA equation, assuming the alternative valuations from Paragraphs 69-70:

Net Benefits = $4 million [132] – ($62 million[133] + $35 million[134])

Net Benefits = Negative $93 million[135]

80. Under my primary specifications, the CBA equation concludes that EWA/PDV's proposal would result in a net loss to society (that is, a negative net benefit) of at least $15 million for the regions of Florida in which FPL operates. Under the assumptions considered in the sensitivity analyses, the proposal results in a potential net loss to society of $93 million.

81. It is crucial to note that, due to the manner in which my CBA is structured, my estimates are likely to be generous, in the sense that the benefits I have calculated are all-inclusive, but the direct costs I have calculated are very likely to be a lower bound on the total costs that society would face from EWA/PDV's proposal. Under the comparables approach, rational bidders should pay an amount at auction that reflects all the (private) benefits[136] that can be generated from the band of spectrum being auctioned, so it is unlikely that my approach has systematically excluded any considerable economic benefits. However, because of the difficulty in quantifying some of the economic costs of EWA/PDV's proposal (such as the externality costs discussed in Section VIII.A or the costs to society of disincentivizing future capital investment), it is likely that the true costs to society of EWA/PDV's proposal are higher than my estimates.

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131 Calculations not exact due to rounding.

132 See Section IX.

133 See Table 4.

134 See Table 5.

135 Calculations not exact due to rounding.

136 That is, the bidder should be willing to pay up to an amount equal to the total benefits that accrue to the bidder.

82. Given both the generous nature of my analysis, and the fact that the benefits of EWA/PDV's proposal fall so short of its costs, the conclusions of my CBA are stark: the proposal likely costs the citizens of Florida millions of dollars on net. Although my benefits calculation considered only areas in which FPL operates, the pattern found in Florida—that the proposal's benefits are greatly outweighed by its costs—is likely to generalize to the entire United States. In more rural states, the costs of EWA/PDV's proposal are likely to be lower, but the benefits would also accrue to fewer people. Moreover, it is well established that spectrum is less valuable in rural areas, even after accounting for population differences, because there is significantly more spectrum supply.[137]

83. As discussed previously, scaling-up the results of my analysis of Florida to the national level requires that the area under study is not systematically different from the United States as a whole. I believe that my analysis generalizes to the national level for three reasons: First, costs and benefits, when accruing to society, were measured on a per-capita basis. Though Florida is more populous than most states, this difference is accounted for by performing calculations on a per-capita basis. Second, critical infrastructure industries are ubiquitous throughout the United States. There are many utilities, telecommunications companies, public health and emergency service providers, and transportation providers in all regions of the United States that are likely to face costs like those that FPL would face under EWA/PDV's proposal. In this respect, I do not believe the region in which FPL operates to be unique. Finally—while Florida is more prone to hurricanes than other regions of the United States—I believe that the calculated external costs associated with EWA/PDV's proposal are similar to those that would be faced by residents of the United States on the whole. As discussed in Section VIII.A, various regions of the United States each face their own natural disasters, and critical infrastructure industry firms like FPL are likely to face unique recovery efforts in the wake of these disasters. Moreover, research into the costs associated with power interruptions suggests that Florida bears costs from

[137] Coleman Bazelon and Giulia McHenry, "Spectrum Value," Telecommunications Policy, Volume 37, Issue 9, October 2013.

power interruptions that are in-line with similar costs in other regions of the United States (after accounting for differences in population).

84. Given the above discussion, I scale-up the costs of EWA/PDV's proposal to estimate the potential costs of the proposal to the entire United States. This exercise is intended as an illustration of the severity of the costs that may result from the EWA/PDV proposal on a national level, rather than a formal analysis. The population covered by the analysis of FPL is 11 million, or 3.52 percent of the United States as of the 2016 census estimate.[138] Simply scaling-up my analysis to the entire United States population suggests net benefits of negative $418 million.[139] In order for this estimate to serve as an accurate reflection of the total costs to society of EWA/PDV's proposal on a national level, other 900 MHz operators would have to utilize the 900 MHz band with similar intensity, using equipment similar to that of FPL. I have not performed a formal analysis of the types of equipment employed on the 900 MHz spectrum outside of Florida nor have I analyzed the intensity with which the 900 MHz band is utilized on a national level. However, it is my understanding that FPL represents a reasonable example of a firm that employs the 900 MHz band to carry out its operations. To the degree that FPL does represent a reasonable example of such a firm, my analysis will generalize to the United States as a whole.

XI. Summary and Conclusions

85. Enterprise Wireless Alliance and PDVWireless, Inc. have proposed to divide the 900 MHz B/ILT and SMR band into two segments, moving remaining narrowband incumbent users into a band that is less than half the size of the current band. Dr. Harold Furchtgott-Roth has reviewed this proposal and performed a Cost-Benefit Analysis which fails to account for the vast majority of the costs that would be incurred by Enterprise Wireless Alliance and PDVWireless, Inc., by incumbent users, and by American citizens. This report

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138 As of January 1, 2017 the U.S. Census Bureau was 322,311,308. Calculation: 3.52 percent = 11,356,619 / 322,311,308. See "U.S. and World Population Clock," United States Census Bureau, U.S. Department of Commerce, accessed June 21, 2018, available https://www.census.gov/popclock/?intcmp=w_200x402.

139 Calculation: -$418 million = (-$15 million) / 0.03.

performs a Cost-Benefit Analysis that properly accounts for all parties who would incur costs under the proposed spectrum reallocation, using the area of Florida in which the Florida Power and Light Company operates as a "case study" of the effects of the proposal. Within this region, I estimate that the proposal will result in total benefits to society of at most $83 million but possibly much less—as little as $4 million if recent broadband pricing does not hold for this specific allocation. In addition, I estimate that the proposal will result in one time "transition costs" of $62 million, "ongoing costs" with a present value of $35 million, and could result in potential "externality costs" of up to $1 billion in Florida Power and Light Company's areas of operation if FPL could not replicate the disaster recovery efficiencies of its existing 900 MHz network after the proposed reconfiguration. On net, I estimate that the proposal would have private costs in these regions of Florida alone of at least $15 million and more likely more in net costs in excess of benefits. When the results of my Cost-Benefit Analysis are scaled-up to the national level, I predict the total net cost over benefits of the proposed spectrum reallocation to be even higher.

XII. Appendix A: Costs of Reallocation

Table A1: Costs of Reallocation Estimates

	Description	Number of Sites	Unit Cost	Cost for Total Units
	[A]	[B]	[C]	[D]
New Sites				
[1]	Develop New Sites (300' Towers)	15	$500,000	$7,500,000
[2]	Develop New Sites (400' Towers)	7	$662,802	$4,639,614
[3]	Lease Sites	23	$30,000	$690,000
[4]	Lease of Backhaul Service to New Sites	45	$12,000	$540,000
[5]	E, F, & I Five (5) Channel Trunked Radio System	45	$547,537	$24,639,165
[6]	**Subtotal for New Sites**			$38,008,779
Updates to Existing Sites				
[7]	Leased Sites Fee Increase due Additional Antennas & Floor Space			$0
[8]	Site Lease Increase @ $300/Tx/Yr	20	$600	$12,000
[9]	Minor Tower Support Upgrade	20	$20,000	$400,000
[10]	Building Replacement	9	$75,440	$678,960
[11]	300' Guyed Tower Replacement	5	$189,085	$945,425
[12]	300' Self Supporting Tower Replacement	5	$355,810	$1,779,050
[13]	Upgrade of Radio System	68	$300,000	$20,400,000
[14]	FCC Licensing	68	$20,000	$1,360,000
[15]	**Subtotal For Existing Sites**			$25,575,435
[16]	**Total**			$63,584,214

Source: Information provided by FPL.

Notes:

[D] = [B] × [C]

[6] = Sum([1] - [5])

[13]: Includes Engineering, Licensing, and Equipment

[15] = Sum([7] - [14])

[16] = [6] + [15]

[3], [4], [7], and [8]: Ongoing Costs. Only first year costs are displayed. See Report for Net Present Value Calculation.

Table A2: Labor Costs of Reallocation Estimates

Description	Quantity	Salary	Total
Radio Technicians	7	$150,000	$1,050,000
Engineer	1	$180,000	$180,000
Total Labor Costs			$1,230,000

Source: Information Provided by FPL.

Note: Costs are ongoing and listed per year.

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