ITU-T SG13 and ETSI NFV workshop
Green NFV

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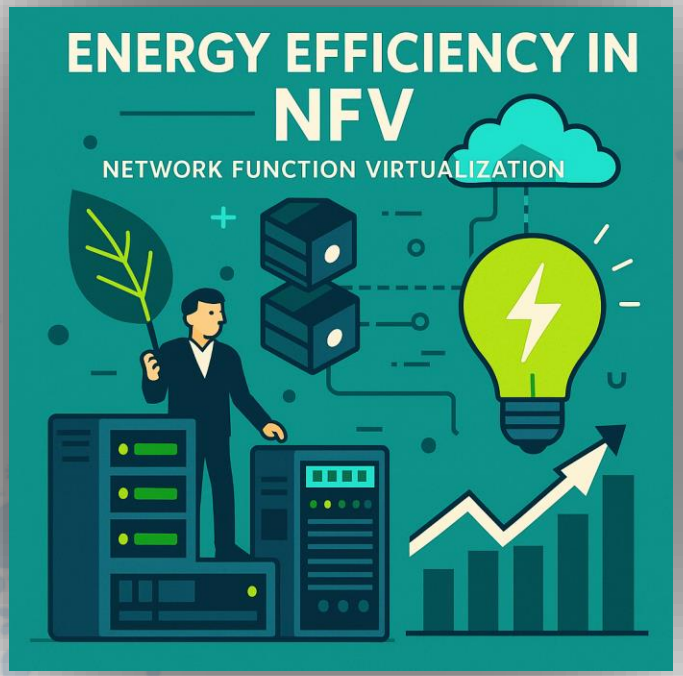
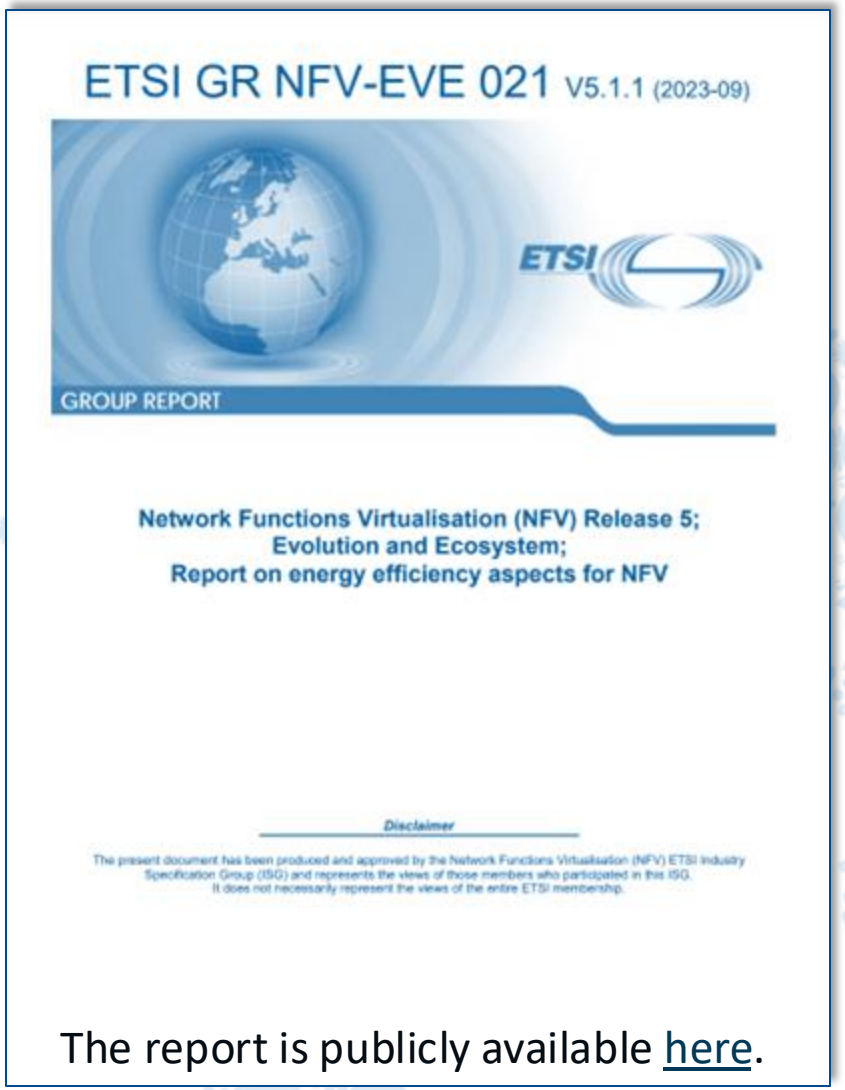
NFV Release 5 feature (FEAT29): “Green NFV”

- Motivation and background
  - Shift of the energy consumption in NFV: from physical appliances to softwarized network functions running on a common NFV infrastructure.
  - Move towards clean and green network deployments to address climate and environmental challenges.
  - For both the core and access networks, NFV, using cloud computing and virtualization as enablers, can offer a solid foundation for boosting resource usage efficiency, and become enablers for defining eco-friendly policies and reduce data-center carbon-footprint.
- Scope and objectives
  - Investigate which design and runtime aspects of NFV framework can influence energy consumption,
  - Enhance NFV-MANO information models and interfaces to efficiently consider power consumption and minimize environment impacts from running telecom networks: specify the information models and interfaces used to support various management and orchestration functions, in respect to fulfil network operator driven power consumption saving policies,
  - Analyse mechanisms that can enable power saving features in NFV by other AI/ML-based tools.



FEAT29 informative work: ETSI GR NFV-EVE 021

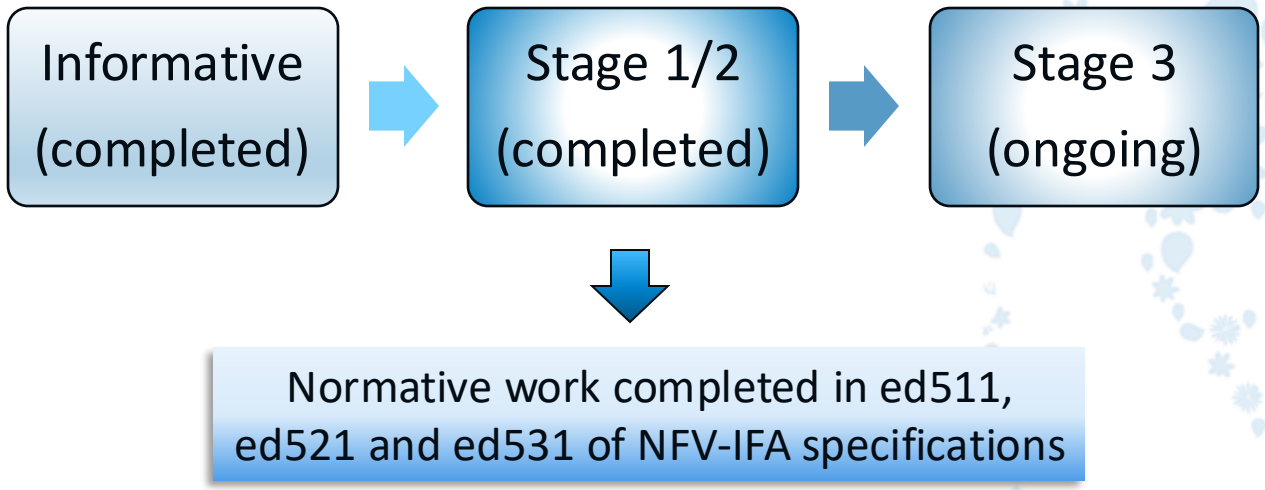
- ETSI ISG NFV published the ETSI GR NFV-EVE 021 “Report on energy efficiency aspects for NFV”, in September 2023 as part of the informative work on the “Green NFV” feature.
- Scope:
  - Investigates the aspects of NFV that have an impact on power consumption and energy efficiency
    - the design and runtime characteristics of the NFV framework, including VNF, NFVI, NFV-MANO,
    - the deployment configuration of NFV-MANO systems and their optimization in various scenarios, and
    - the mechanisms that enable the collection of energy related information, smart energy usage and decision making in NFV considering NFV capabilities such as orchestration and automation.
  - Documents potential solutions, and where applicable, it also provides recommendations for enhancements to the NFV architectural framework and its functionality aiming to provide further support to address energy efficiency objectives



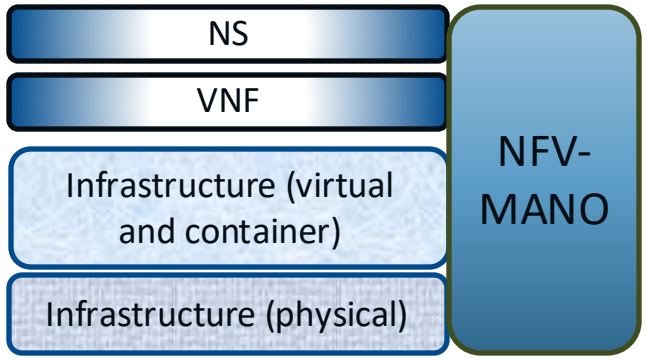
The report is publicly available here.

FEAT29 current specification status

- Informative work completed as part of ETSI GR NFV-EVE 021.
- Stage 2 normative work of FEAT29 started in 2H of 2023.
- The feature development and its normative phase is being tracked on the wiki pages:
  - NFV site: https://nfvprivatewiki.etsi.org/index.php?title=Feature_Tracking_Release_5#FEAT29:_Green_NFV
  - Public site: https://nfvwiki.etsi.org/index.php?title=Feature_Tracking_Release_5#FEAT29:_Green_NFV



FEAT29 current specification status



- FEAT29 covers green efficiency in NFV from multiple perspectives and areas.
- "Bottom-up" approach: :
  - First collect energy related metrics and perform power state management from infrastructure point of view.
  - Next steps, specify energy related metrics and power state management for higher layers, i.e., VNF and Network Service (NS) instances, and introduce the management enhancements in the remaining parts of NFV-MANO.

- Stage 2 FEAT29 main specification outcomes delivered in ETSI GS NFV-IFA specs v5.3.1 (including v5.1.1 and v5.2.1 updates) (1/5):
  - **ETSI GS NFV-IFA 010**: Functional requirements specification
  - **ETSI GS NFV-IFA 005**: Or-Vi reference point - Interface and Information Model Specification
  - **ETSI GS NFV-IFA 006**: Vi-Vnfm reference point - Interface and Information Model Specification
  - **ETSI GS NFV-IFA 031**: Requirements and interfaces specification for management of NFV-MANO
  - **ETSI GS NFV-IFA 036**: Requirements for service interfaces and object model for container cluster management and orchestration specification
  - **ETSI GS NFV-IFA 040**:Requirements for service interfaces and object model for OS container management and orchestration specification
  - **ETSI GS NFV-IFA 053**: Requirements and interface specification for Physical Infrastructure Management
  - **ETSI GS NFV-IFA 027**: Performance Measurements Specification
  - **ETSI GS NFV-IFA 011**: VNF Descriptor and Packaging Specification
  - **ETSI GS NFV-IFA 007**: Or-Vnfm reference point - Interface and Information Model Specification
  - **ETSI GS NFV-IFA 008**: Ve-Vnfm reference point - Interface and Information Model Specification
  - **ETSI GS NFV-IFA 013**: Os-Ma-nfvo reference point - Interface and Information Model Specification

FEAT29 current specification status (stage 3)

- Stage 3 is being currently finalized to cover all the stage 2 specified aspects, to be published as v5.3.1. It includes updates to:
  - Support description of power profiles of a VNF, and support the description of CPU power state related information and constraints on a per VDU basis.
  - Add support for power management of VNF instances in the NFV-MANO RESTful APIs (ETSI GS NFV-SOL 002/003/005)
  - Enable parameterization of power state related requirements associated to VDUs to be deployed in the NFV-MANO RESTful APIs (ETSI GS NFV-SOL 002/003).
  - Enhance virtualised resource descriptors to support providing power state requirements for virtualised resources to be allocated (ETSI GS NFV-SOL 014), and
  - Others.

Collaborations & Relationship with other SDOs

3GPP SA5

Providing standard energy consumption measurements for virtualized/cloudified deployments

- Virtualised resources and containerized workloads
- VNF/VNFCs
- NSs

3GPP Technical Specifications and Technical Reports include multiple references to ETSI GS NFV-IFA 027 specified measurements.

Joint workshops collaboration.

O-RAN Alliance

Similar scope of activity as “WG6 Orchestration and Cloudification”. O-RAN “Energy Savings” technical reports includes:

- References to ETSI GS NFV-IFA 027 measurements.
- References to cluster and OS container related energy consumption measurements provided by open-source tools (like Kepler). These measurements are a source for mapped measurements to NFV managed objects in ETSI GS NFV-IFA 027.

ETSI TC EE

Reuse of concepts, definitions and KPIs related to energy consumption and efficiency.

Liaison activities, joint workshops

ITU-T

Multifaceted Collaboration

Liaison activities

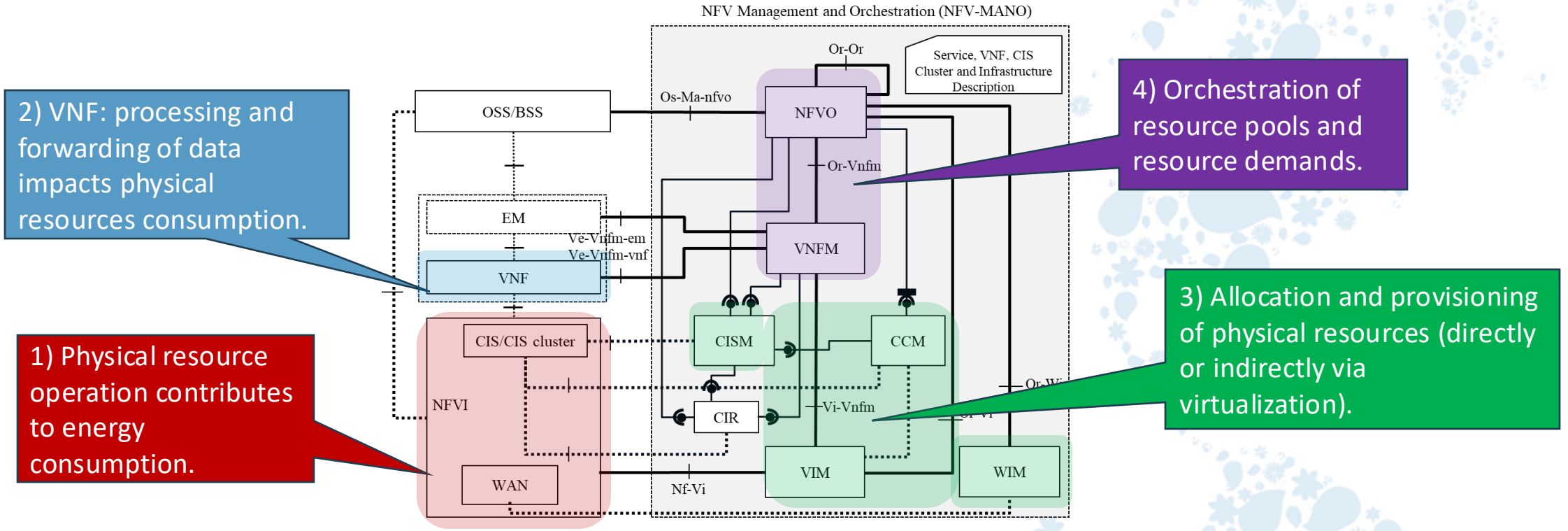
- ITU-T SG13
- ITU-T SG5

Energy efficiency framework

Technical framework for enabling energy efficiency in NFV

NFV for energy efficiency in telco networks

- All components in the NFV framework play a role in terms of energy consumption and efficiency.
- Actuation in all parts is essential for delivering higher energy efficiency.
  - Capacity aggregation by leveraging a common unified infrastructure.
  - Outbreaking processing capabilities with new infrastructure resources.
  - Remote operation, automation and orchestration.



Framework design

ETSI GR NFV-EVE 021 (Report on energy efficiency in NFV) studied use cases related to energy efficiency in NFV, identified key issues in enabling those use cases, and proposed solutions to address the issues.

Use cases related to

- Resources power saving management under different load conditions
- Acquiring infrastructure power consumption data
- Acquiring NFV power consumption data
- Processing power state driven VNF/NS deployment
- Dynamic power-state adjustment of compute resources for maintaining desired power budget
- …

Key Issues on

- energy consumption
- energy efficiency management
- energy efficient design
- energy related metrics and KPIs

Solutions for

- NFV descriptors
- Orchestration and LCM of NSs &VNFs
- Infrastructure management (virtual and physical)
- Acquisition of power consumption related data on all levels
- Defining energy efficiency KPIs for NFV managed objects
- …

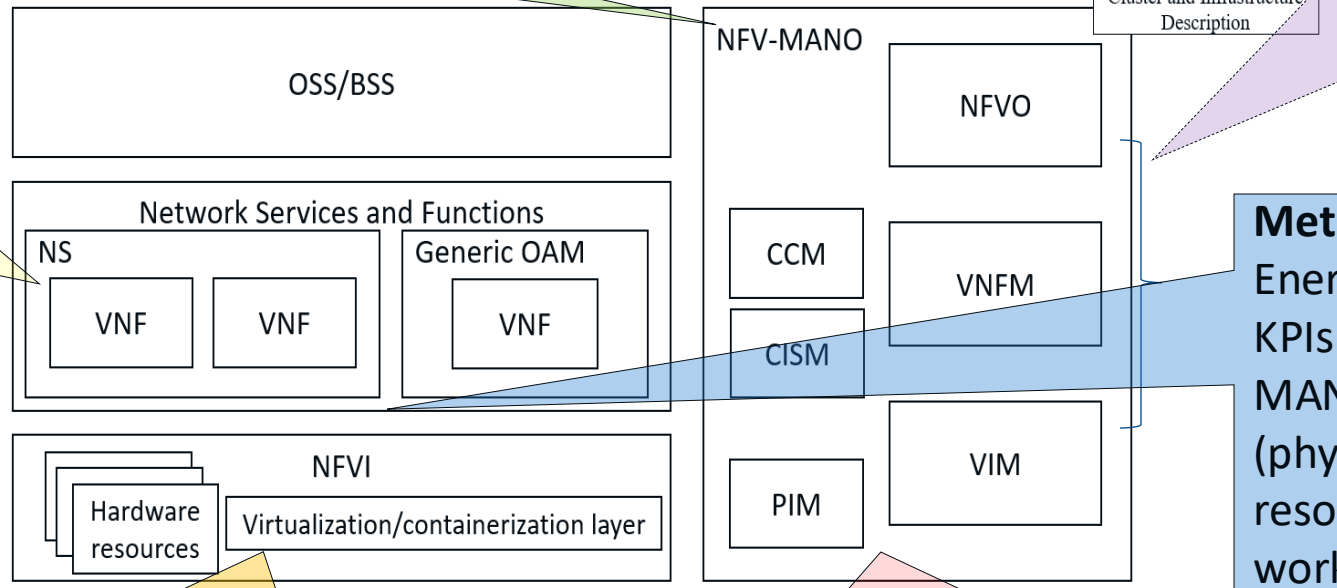
Support for energy efficiency on multiple levels

NFV-MANO
Energy efficiency policies, NFV-MANO power state management, NFV-MANO capabilities for energy efficiency

Descriptors
Power profiles for VNFs and infrastructure resources in their respective descriptors

Orchestration & lifecycle management
Power state aware orchestration and LCM of VNFs and NSs,
Resource reservation for VNFs under power management

VNF management
VNF power management, state & configuration management during VNF power management

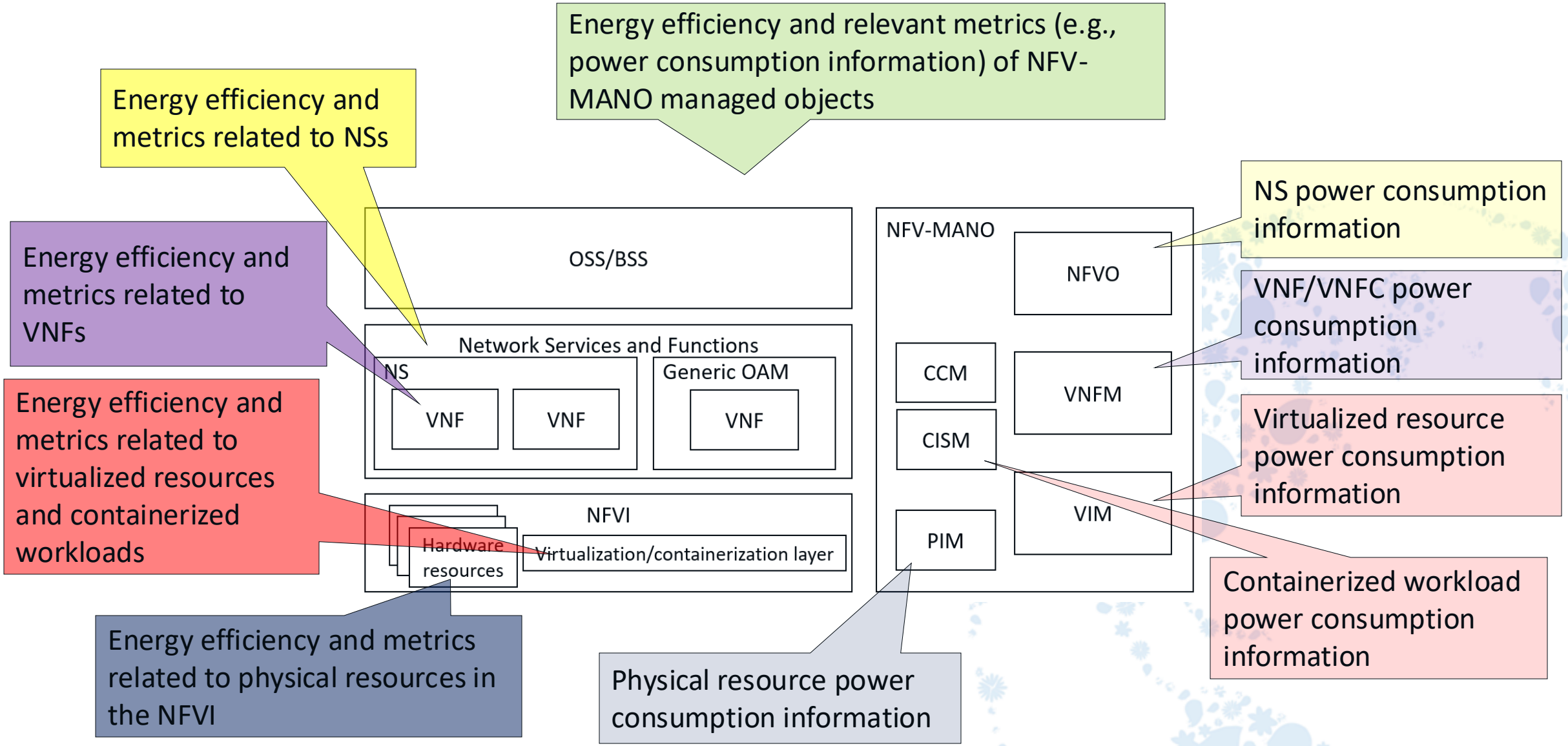


Metrics and KPIs
Energy related metrics and KPIs associated to all NFV-MANO managed objects (physical resources, virtualized resources, containerized workloads, VNF/VNFC, NS) --- see next slide

NFVI
Power state-based zones and resource pools, power state management of NFVI resources

Infrastructure management
Power state aware allocation of compute resources, topology and inventory management of NFVI resources

Energy monitoring across NFV deployments



Energy efficiency support in the underlying layers

Energy efficiency in the virtualization layer

- VM-based virtualization
  - Power state management of underlying physical cores as per power profiles of the VMs
  - Power aware scheduling of VMs on physical cores for overall energy-efficiency optimization
  - Optimal scheduling of heterogenous workloads with competing power profiles on physical cores
- OS container-based virtualization
  - Power profile aware scheduling of container tasks on physical CPU cores
  - Placement of application processes on CPUs with pre-determined power states
  - Workload consolidation across the cluster for optimal power consumption

Energy consumption measurement capabilities

- Capability to collect energy consumption data associated to:
  - Groups of one or more OS containers (Pods in case of Kubernetes®), and
  - VMs
- Energy consumption data can be derived from hardware provided capabilities or with ML-based power models (more accurate than estimated measurements)
- ETSI GS NFV-IFA 027 specifies measurements agnostic of any industry solution/implementation
- Measurements from the virtualization/cloud layer can be used to compute those of managed objects at higher levels of abstraction, e.g., a VNFC/VNF/NS.

Where to find further information

Backup Slides

NFV on YouTube:
https://www.youtube.com/user/ETSIstandards

ETSI NFV drafts and Releases documentation:
https://docbox.etsi.org/ISG/NFV/Open/

ETSI NFV published standards:
https://www.etsi.org/committee/1427-nfv

ETSI NFV blog:
https://www.etsi.org/newsroom/blogs/blog-nfv

ETSI NFV webpage:
https://www.etsi.org/technologies/nfv

Thank you for your attention

Follow us on:

Any further questions?

Contact us:

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Backup Slides

Energy efficiency use cases in NFV (1/2)

- ETSI GR NFV-EVE 021 documents important use cases that enable energy-efficiency in NFV deployments.

- Use case#1: Resources power saving management under different load conditions
  - NFV-MANO managing the power state of the NFVI resources based on traffic load supported by the VNF and NS instances. Resources can be put into a power state that results in less power consumption.
- Use case#2: Power saving management function under limited power supply
  - Change the power consumption rate consumed by VNF/NS, maintaining critical services, considering factors like power supply from natural sources, or limited supply by energy suppliers.
- Use case#3: Acquiring infrastructure power consumption data
  - Service provider can acquire infrastructure power consumption information to enable determining and executing energy efficiency policies, and determine if such policies are also delivering the expected result.
- Use case#4: Acquiring NFV power consumption data
  - Acquiring power consumption data for deployed virtualised resources, containerized workloads, VNF and NS instances, to determine whether the energy efficiency policies are having a desired effect.

Energy efficiency use cases in NFV (2/2)

- Use case#5: Processing power state driven VNF/NS deployment
  - Instantiation of VNF/NS instances considering power state characteristics of underlying compute infrastructure resources as per requirements of VNF/NSs to be deployed.
- Use case#6: Mapping local VNF/NS and physical resources for optimized power consumption
  - Determining VNF/NS resource placement optimizations in conjunction with power consumption saving targets. With help of NFV-MANO, generate a blueprint for feasible placement and NFVI resources configuration.
- Use case#7: Restoration from power saving situations with resource reservation
  - Manage the restoration of VNFs from power saving states by using reserved resources after setting them into power saving states.
- Use case#8: Dynamic power-state adjustment of compute resources for maintaining desired power budget
  - To achieve its overall power budget, NFV-MANO manages the CPU power states of the compute resources in a dynamic fashion, enabling smart energy usage in the NFVI potentially making use of AI/ML techniques.

Key issues related to energy efficiency in NFV

- ETSI GR NFV-EVE 021 documents several key issues, identified from the use cases and state of the art, to help design a comprehensive framework for energy efficient solutions.

Key issues on energy consumption

- Power consuming components in NFV deployments
- Changing power states in the NFV-based network deployments
- Power distribution in NFV environments

Key issues on energy efficiency management

- Management and orchestration processes considering energy efficiency
- Resiliency, availability and restoration during power management processes
- Efficient power state management of NFVI compute resources for heterogenous workloads

Key issues on energy efficient design

- VNF/NS driven energy efficiency design
- NFV-MANO driven energy efficiency
- NFVI driven energy efficiency

Key issues on energy related metrics and KPIs

Energy and power consumption related metrics and KPIs of

- Physical resources in the NFVI
- virtualised resources and containerized workloads
- VNF/VNFCs
- NSs

Solutions for energy efficient NFV framework

- ETSI GR NFV-EVE 021 proposes several potential solutions to address the key issues and identified gaps in the NFV framework.
- The wide range of solutions aim to cover different aspects of NFV deployments, ranging from VNF/NS design, descriptors to energy-efficient infrastructure management.
- Solutions targeting the following areas of NFV framework had been proposed:
  - NFV descriptors (VNF and infrastructure resource descriptors)
  - NFV-MANO capabilities and policies
  - Orchestration and lifecycle management of NSs and VNFs
  - Allocation and reservation of resources for virtualized and containerized workloads
  - Infrastructure management (virtual and physical)
  - VNF management and generic OAM
  - Acquisition of power consumption related data on all levels
  - Defining energy efficiency for all managed objects in the NFV and their associated metrics