EnerHarv 2024

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EnerHarv 2024 Keynotes:

Can the Electronic Shelf Label (ESL) Market be a Target Application Market for EH?

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Content of this presentation

- Electronic Shelf Labels : Market outlook
- Problem statement : Disposable batteries proliferation and workaround
- Is energy harvesting a candidate ? What energy source(s) ?
- State machine and energy budget
- Workable combinations
- Forward looking

ESL Market Outlook

What is an ESL ?

- **ESL = Electronic Shelf Label**
- **A Real-time retail display**
- **Having various display sizes**
- **Display = e-INK paper**
- **RF connectivity mostly**
- **Exposed to ambient environment**
  - Peculiarities :
    - Indoor
    - “Constant”
    - Timely lighting
- **Digital signage as a variant**

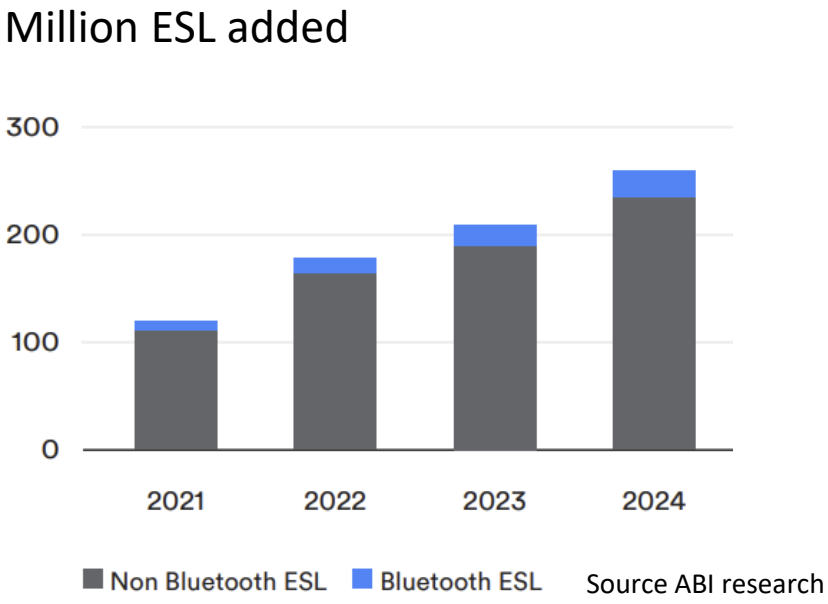
Market figures

Until 2023 :

- proprietary implementation have dominated
  - SubG or 2.4G or Light connectivity
  - For Messaging
  - For display refresh capabilities

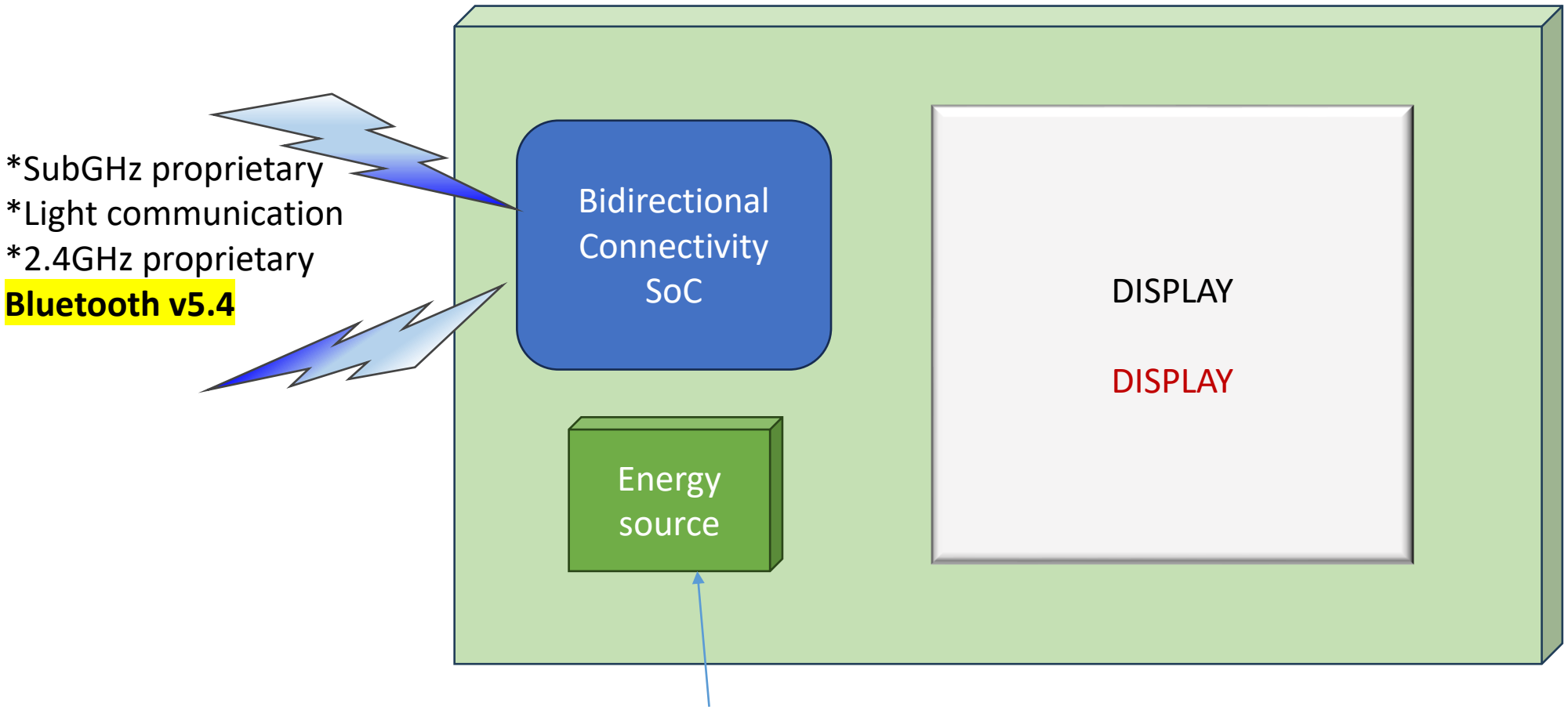
Bluetooth v5.4 release :

- transitioning to an ESL connectivity standard bringing system-level enhanced features



Source ABI research

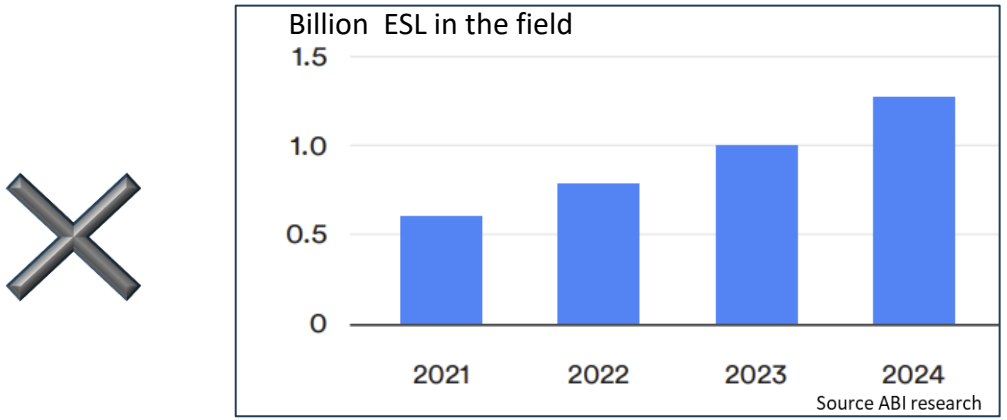
An ESL genuine block diagram



Problem :
ESL proliferation
⇔
Primary battery proliferation

Number of coin-cells per ESL

- **1 inch display : 1 to 2 CRxx**
- **2 inches display : 2 CRxx**
- **4 inches display : 4 CRxx**

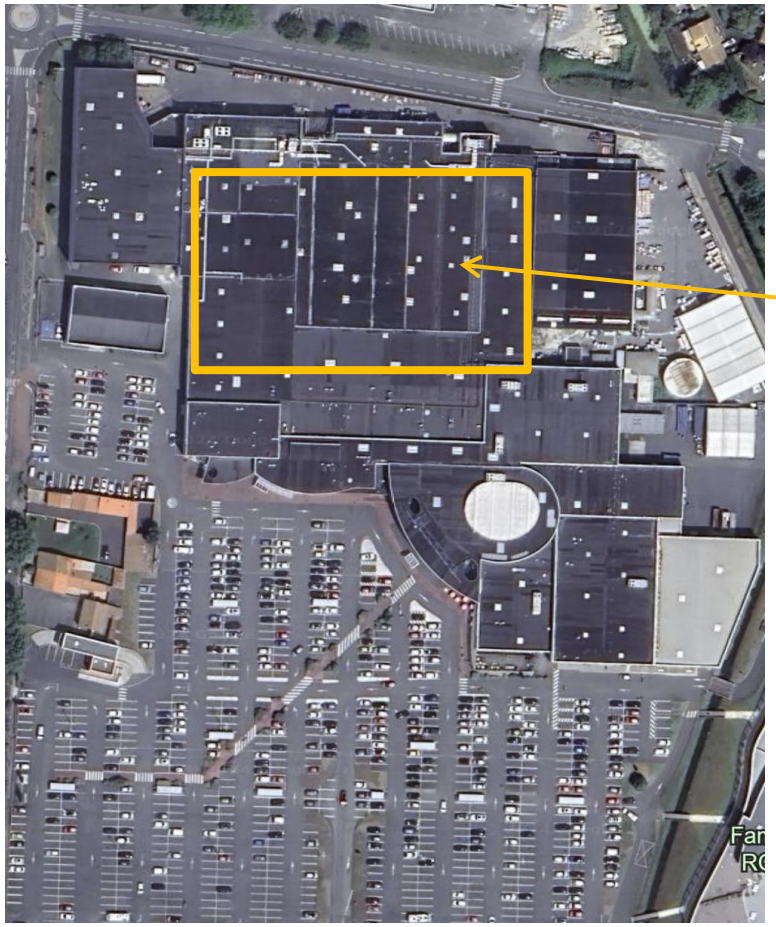


Assuming 1 to 3 updates per day / 7days a week

= A RECYCLING BURDEN !

A retail shop example :

Medium size super-market.



Contains ~30.000 ESLs
each of them with 2 x CR2450 Batteries
⇔ 60.000 coin-cells in one retail-shop

Disposable battery life-time

- **Disposable Battery is sized versus :**
  - Number for weekly updates
  - Size of display screen
  - Connectivity chipset performances
  - Battery specific capacity
  - Battery ESR (from milli Ohms to Several Ohms)
  - Battery quality grade (AQL)
  - Expected duration of service of 6 years (min) for disposable batteries
  - Various system parameters

⇒ Such wide spread of use-conditions leads to oversizing storage element

⇒ Market is looking for a more ecofriendly alternative

Is Energy Harvesting an alternative ?

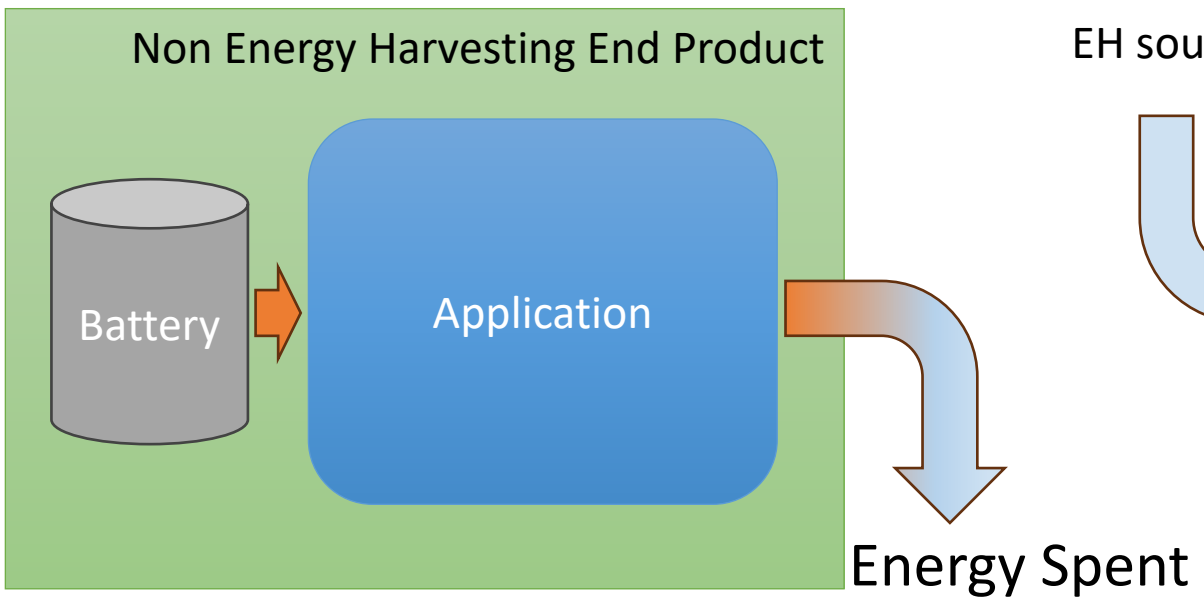
Ambient environment for ESL

- **Indoor retail lighting range : 200 to 700 lux**
  - Cold white
- **Day / night shifts (8 – 10 - 12 hours light-on)**
- **Week-end duration (0 - 1 day or 2 days)**

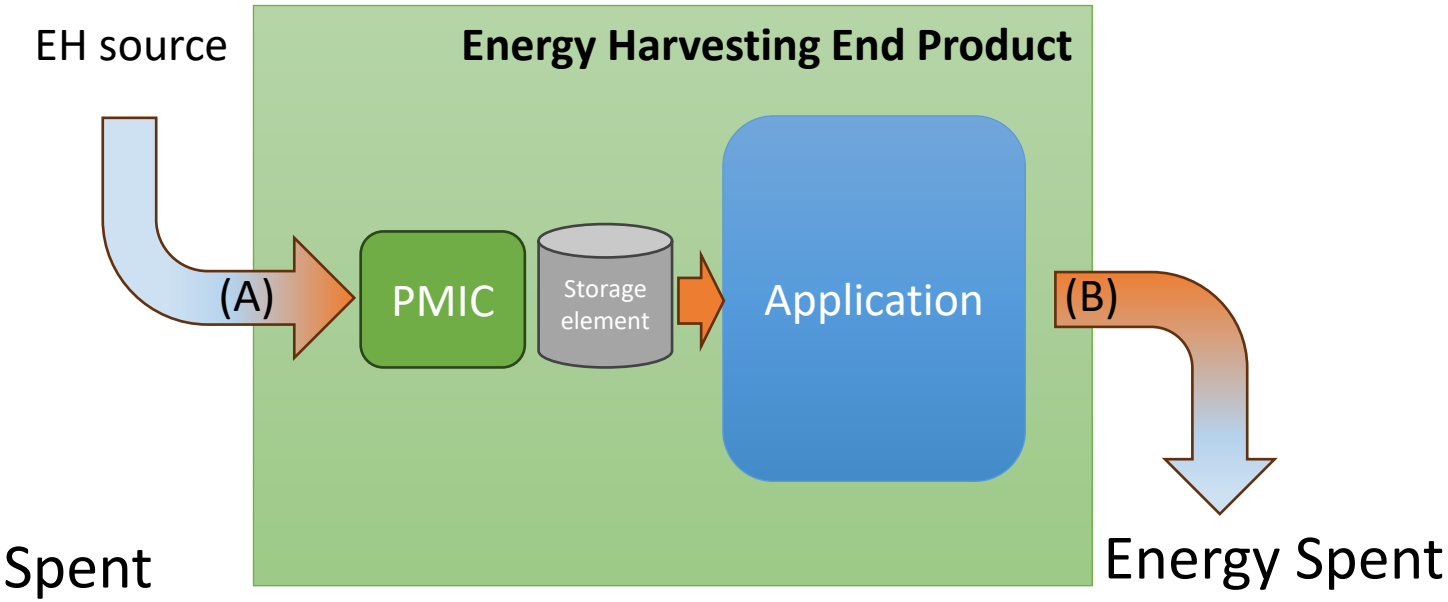
This is a “controlled environment” with wide range :
We are targeting a worst case of :

8-9 hours lighting per day
200-300 lux
3 days (or more) with no light

From closed to open Energy Source



CLOSED



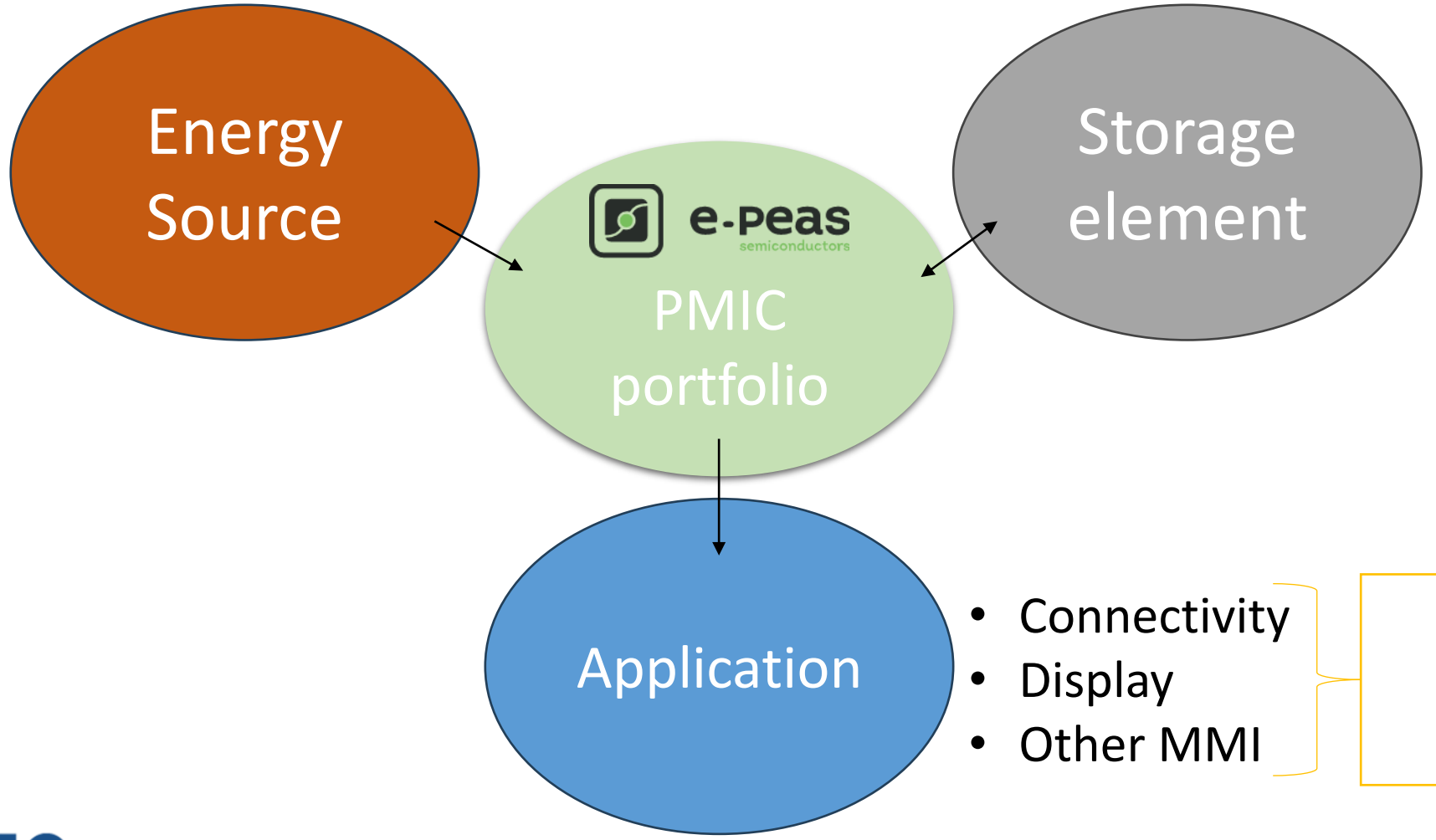
OPEN

- Rechargeable Storage element
- **Average(A) = Average(B) to make a well-balanced system**
- **Benefits :**
  - Downsized storage element
  - Improved QoS
  - Reduced TCO
  - Reduced weight

Ecosystem and partners for building an EH-based ESL

Energy Harvesting system landscape

- Indoor PV
- RF



- Lithium Ion
- NiMH
- Supercap
- ….

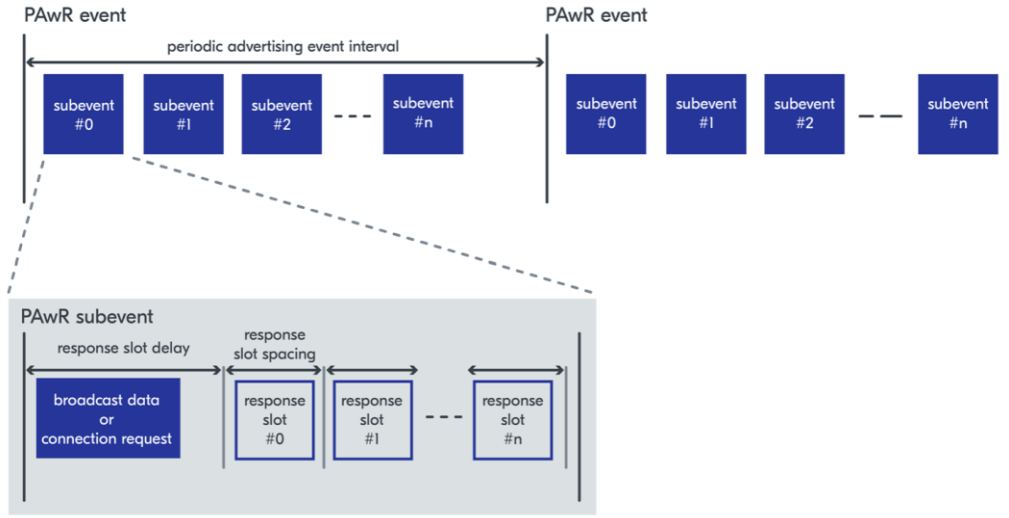
- Connectivity
- Display
- Other MMI

Let's consider Bluetoothv5.4 for test case of implementation…

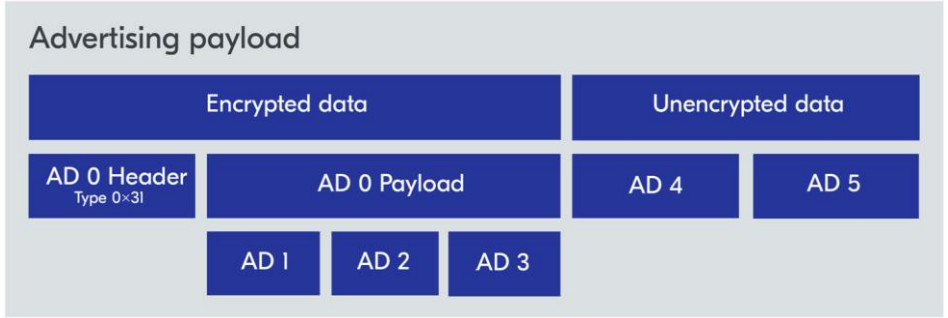
Bluetooth v5.4 for ESL

Periodic Advertising with Response

- PAwR



Encrypted payload



Electronic shelf label profile

- “Roles in the ESL profile are defined as Access Point (AP) and Electronic Shelf Label (ESL). AP corresponds to broadcaster in the PAwR context, and ESL corresponds to observer. To manage the network, a simple addressing scheme is introduced. Each ESL has an 8-bit ESL ID. Devices are grouped with 7-bit Group IDs. The Access Point can manage up to 32 640 devices.”

We are far from “dummy advertizing”

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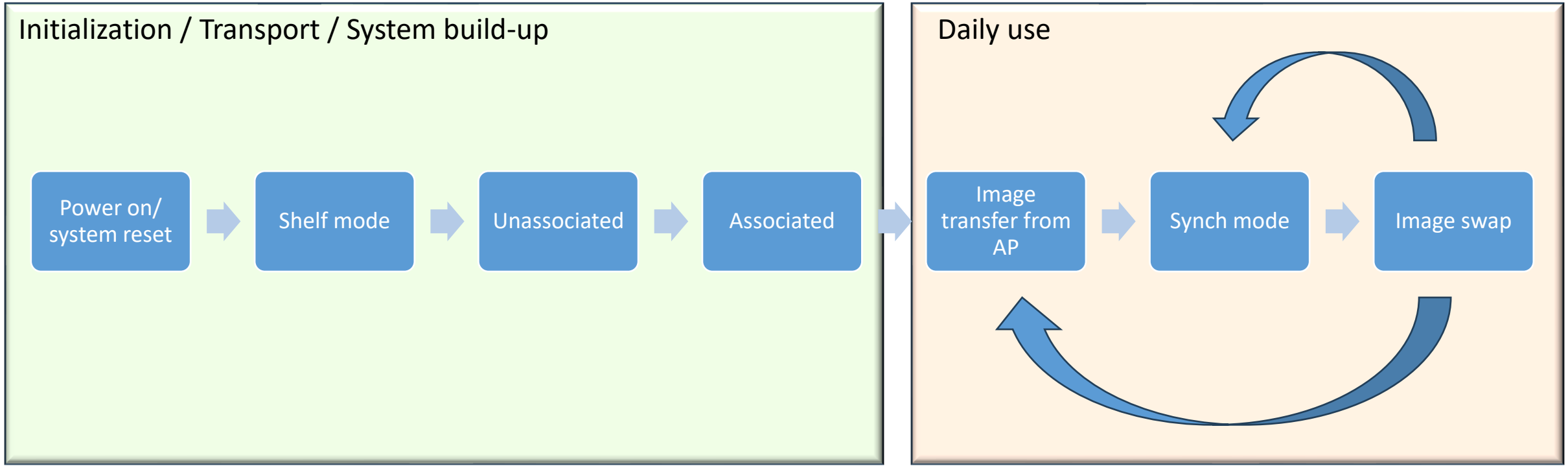
A typical ESL PaWR State machine



Energy requirements / daily use

- **“Synch-doing-nothing” : from 1,7 to 2,5 J per day**
- **“Image transfer from AP” : depends on display size / number of colors and #of downloads : from 10mJ to 0.5J**
- **“Image swap” : depends on display size / number of colors and #of refreshes: idem**

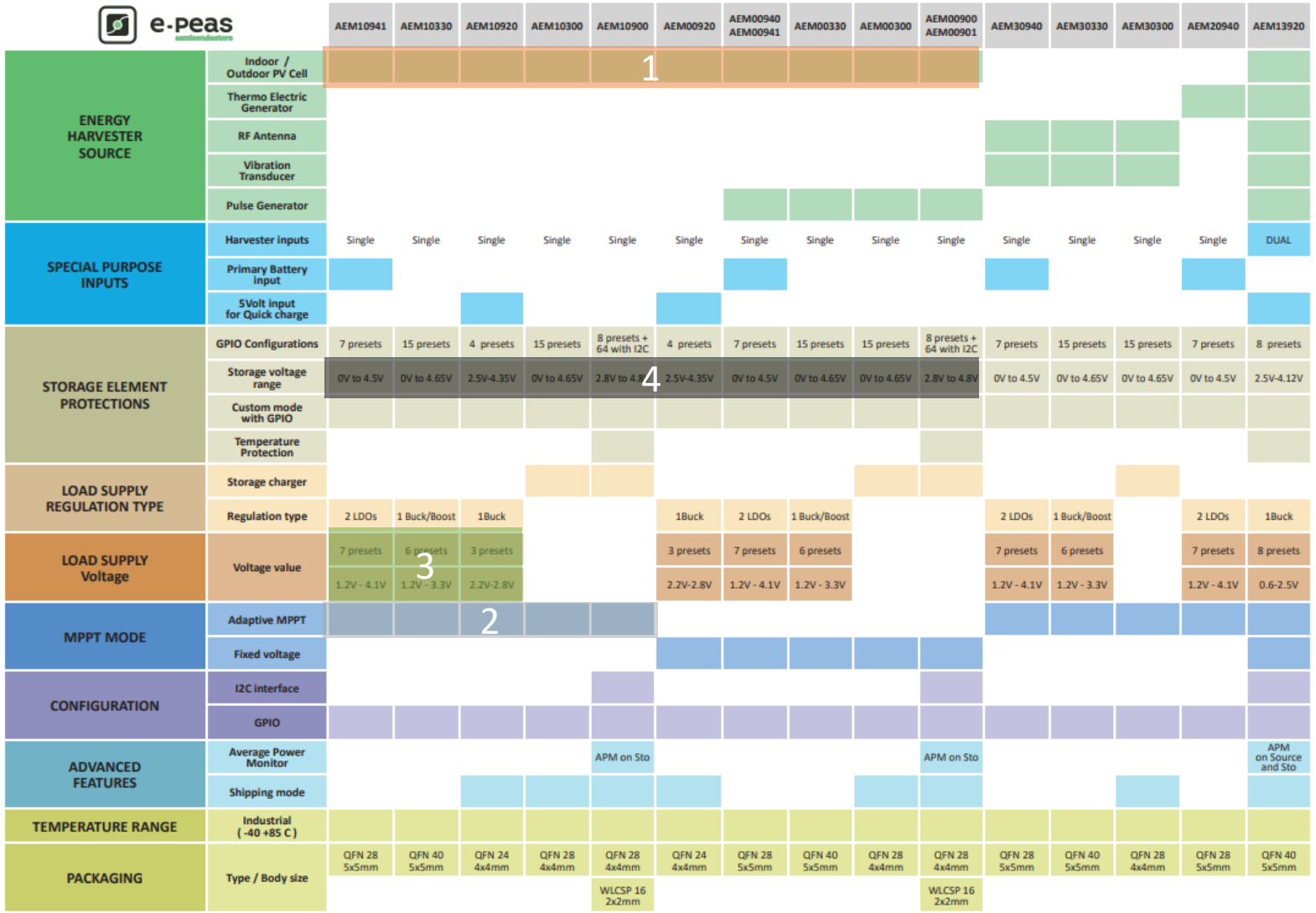
Design constraints for energy harvesting in ESL

- Small PV
- Indoor
- Higher efficiency at low lux
- Seamless integration in ESL design
- Cost sensitive design
- Small Storage element

Source Ambient Photonics

Source / PMIC / Storage combinations that work

Genuine e-peas PMIC portfolio



		AEM10941	AEM10330	AEM10920	AEM10300	AEM10900	AEM00920	AEM00940 AEM00941	AEM00330	AEM00300	AEM00900 AEM00901	AEM30940	AEM30330	AEM30300	AEM20940	AEM13920
ENERGY HARVESTER SOURCE	Indoor / Outdoor PV Cell	1														
	Thermo Electric Generator															
	RF Antenna															
	Vibration Transducer															
	Pulse Generator															
SPECIAL PURPOSE INPUTS	Harvester inputs	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	DUAL
	Primary Battery input															
	5Volt input for Quick charge															
STORAGE ELEMENT PROTECTIONS	GPIO Configurations	7 presets	15 presets	4 presets	15 presets	8 presets + 64 with I2C	4 presets	7 presets	15 presets	15 presets	8 presets + 64 with I2C	7 presets	15 presets	15 presets	7 presets	8 presets
	Storage voltage range	0V to 4.5V	0V to 4.65V	2.5V-4.35V	0V to 4.65V	2.8V to 4.8V	2.5V-4.35V	0V to 4.5V	0V to 4.65V	0V to 4.65V	2.8V to 4.8V	0V to 4.5V	0V to 4.65V	0V to 4.65V	0V to 4.5V	2.5V-4.12V
	Custom mode with GPIO															
	Temperature Protection															
LOAD SUPPLY REGULATION TYPE	Storage charger															
	Regulation type	2 LDOs	1 Buck/Boost	1Buck			1Buck	2 LDOs	1 Buck/Boost			2 LDOs	1 Buck/Boost		2 LDOs	1Buck
LOAD SUPPLY Voltage	Voltage value	7 presets	6 presets	3 presets			3 presets	7 presets	6 presets			7 presets	6 presets		7 presets	8 presets
		1.2V - 4.1V	1.2V - 3.3V	2.2V-2.8V			2.2V-2.8V	1.2V - 4.1V	1.2V - 3.3V			1.2V - 4.1V	1.2V - 3.3V		1.2V - 4.1V	0.6-2.5V
MPPT MODE	Adaptive MPPT	3		2												
	Fixed voltage															
CONFIGURATION	I2C interface															
	GPIO															
ADVANCED FEATURES	Average Power Monitor					APM on Sto					APM on Sto					APM on Source and Sto
	Shipping mode															
TEMPERATURE RANGE	Industrial (-40 +85 C)															
PACKAGING	Type / Body size	QFN 28 5x5mm	QFN 40 5x5mm	QFN 24 4x4mm	QFN 28 4x4mm	QFN 28 4x4mm WLCSP 16 2x2mm	QFN 24 4x4mm	QFN 28 5x5mm	QFN 40 5x5mm	QFN 28 4x4mm	QFN 28 4x4mm WLCSP 16 2x2mm	QFN 28 5x5mm	QFN 40 5x5mm	QFN 28 4x4mm	QFN 28 5x5mm	QFN 40 5x5mm

BOOST

- AEM10941 00940
- AEM10900 00900
- AEM10920 00920
- AEM20940 30940
- AEM13920

BUCK (/boost)

- AEM10300 10330
- AEM30300 30330
- AEM 00300 00330

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Product integration examples :

DSSC PV

Single element + NiMH

AEM00920

Organic PV

Dual element + LTO

AEM10920

Perovskite PV

4 element + LiPO

AEM10330

Most likely PMIC combinations for ESLs

BUCK
BOOST
BUCK/BOOST

PMIC selection	1cell (0.6V)	Dual Cell (1.2V)	Four Cells (2.2V)	Six cells (3.2V)	Comment
Super Cap	AEM00940/1 AEM00330/AEM00300	AEM10941/AEM00940 AEM10300/AEM00300	AEM10300/330 AEM00300/330	AEM10300/330 AEM00300/330	
Hybrid Cap	AEM00940/1 AEM0330/AEM00300 AEM00920/AEM10920	AEM10941/AEM00940 AEM10920/AEM00920	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10300/330 AEM00300/330	AEM13920 also OK
Single NiMh	AEM00940/1 AEM00330/AEM00300	AEM10300 AEM00300	AEM10300/330 AEM00300/330	AEM10300/330 AEM00300/330	
Dual NiMH /LTO 2.4V	AEM00330/AEM00300	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10300/330 AEM00300/330	AEM10300/330 AEM00300/330	
Triple NiMH	AEM00940/1 AEM00330/AEM00300 AEM00920/AEM10920	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10300/330 AEM00300/330	AEM13920 also OK
LFP	AEM00940/1 AEM00330/AEM00300 AEM00920/AEM10920	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10300/330 AEM00300/330	AEM13920 also OK
LiPo /LTO 3.8V	AEM00940/1 AEM00330/AEM00300 AEM00920/AEM10920	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10941/AEM00940 AEM10300/AEM00300 AEM00920/AEM10920	AEM10300/330 AEM00300/330	AEM13920 also OK

Check out Workshop of Day 2 for more insight

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Value proposition of energy harvesting based ESL

- **Maintenance-free**
- **Primary battery free**
- **Ecofriendly life-cycle**
- **Easy transportation (delivery to market)**
- **Light-weight**
- **More predictable energy budget and life-span**

Value proposition of e-peas EH PMIC

- **Higher energy conversion efficiency (90-95%)**
  - From Source to Storage
  - From Storage to Application
- **Flexibility of implementation thanks to wide Ecosystem**
  - Lithium or lithium-free storage elements
  - Multiple PV-cell architecture options
- **Flexibility of design (w or w/o DCDC converter for application)**
- **Optional 5V charger**
- **“Ship-mode” option for disabling PMIC Activity**

Forward looking :New display technologies

Display technologies :

- Segment Electrochromic displays vs Dot e-paper
  - Lower cost
  - Lower weight
  - Lower power
  - More ecofriendly
  - …but less display capability

How about an electrochromic display? (electronicsweekly.com)

Conclusions

- **Fully autonomous ESLs, powered by EH are demonstrated.**
- **PMIC based architectures contribute to best Energy conversion efficiency (95%)**
- **Boost or Buck architectures are available to support vast ecosystem combinations**
- **e-peas PMIC based architectures bring:**
  - High Efficiency
  - Small Size , Low weight
  - Superior product Quality of Service (QoS)
  - Cost controlled implementation
- **e-peas EH PMIC portfolio gives designers' a high degree of freedom of implementation .**
- **Check-out demo corner for more details**

References

- **Datasheets**
  - DS-AEM10941_QFN28-v2.1==REVc.pdf (e-peas.com)
  - AEM13920 Dual Source Energy Harvesting | e-peas
  - AEM10920 PMIC for RCUs & Keyboards | Energy Harvesting | e-peas
  - AEM00920 PMIC for remote control and keyboard | Energy Harvesting | e-peas
  - AEM10330 Solar Harvester | Photovoltaic Energy Harvesting | e-peas
  - Where to buy ?
  - e-peas Distributor | Mouser Belgique
- **Selector guide**
  - AEM Selector Guide - E-peas
- **Social Network**
  - e-peas | LinkedIn

Q & A

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Questions/comments???

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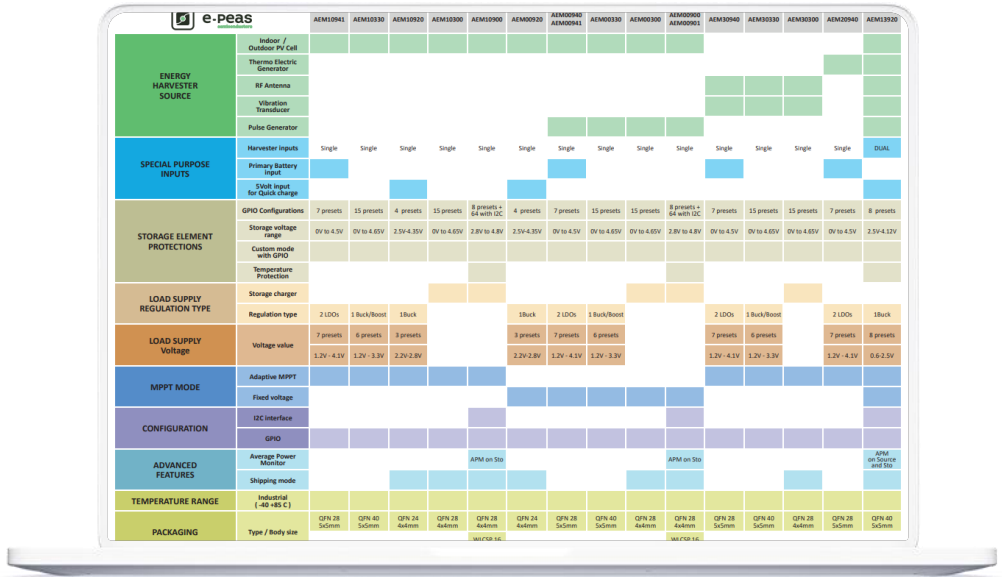
PMIC selection resources



- [AEM Selector Guide - E-peas]
- Interactive tool
- Brochure